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# **A critical analysis of participatory design processes leading to the employment of low-tech emerging building technologies**

by

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# A critical analysis of participatory design processes leading to the employment of low-tech emerging building technologies

## ABSTRACT

The study investigates the impact of industrialisation on an architects' roles, proposing a shift towards incorporating low-tech building technologies through participatory design processes. It critiques the shift from the architect as a master builder to a more fragmented role due to advances in industrial techniques. The research aims to re-establish architects as integral to the entire building process by emphasising sustainable, community-based, and culturally resonant construction methods. Modern design processes are linear and separated from the rest of the construction industry, where practitioners mainly use conventional technologies.

This research report explores the use of low-tech emerging building technologies and participatory design processes in a South African context. The focus will primarily be on hand-based, local and indigenous building technologies and how these methods could positively influence the design and construction processes. The main questions of this study deal with how a participatory design process can lead to the employment of low-tech emerging building technologies. The study focuses on when and why South African practitioners who follow a participatory design process employ low-tech emerging building technologies. It also explores the value of employing low-tech building technologies and how they could aid in better understanding the value of indigenous building technologies.

The methods used in this study to analyse data are as follows: Firstly, five themes were identified from the literature to assess different projects and practitioners in the South African context. These themes include unskilled and skilled participatory design and hand-based, local, and indigenous building technologies. Existing case studies in an emerging building technology catalogue format have been analysed according to the themes. The following practitioners who most resemble this specific study were chosen from the catalogue to be interviewed. Their feedback was analysed using the same categorisation tool for the themes. Finally, precedent studies were conducted on each interviewee's projects and analysed according to the themes. A better understanding of low-tech building technologies through the adoption of participatory design processes could lead to the adoption of it by more practitioners in the South African context. Thus leading to more cultural, economic, ecological, and socially sustainable design practices.

## KEY TERMS

**TECHNOLOGY:** Technology, originally derived from the word "technē," refers to the practical application of knowledge through constant experimentation and development of techniques (Louw, 2021:138). In modern usage, it is often associated with industrialised and mechanised production. Both indigenous and industrialised methods of construction can be considered technology, ranging from low-tech, hand-based practices using local knowledge and craft to high-tech, mechanised mass production methods (Louw, 2021:138; Crotch, 2010:7). The term has evolved, now also encompassing "architekton," meaning master builder. Technology thus signifies the mastery of techniques, the transfer of knowledge, and the continuous evolution of methods and skills (Schwartz, 2016:17).

**BUILDING TECHNOLOGIES:** Building technologies comprise materials, construction techniques and processes, and the structural systems used to build structures (Wu, Wei, & Peng, 2019:1). The surrounding environment could influence technological advances and the design concept (Wu, Wei, & Peng, 2019:7).

**EMERGING BUILDING TECHNOLOGIES:** Emerging building technology is a technology that does not fall into “standardised” construction and is usually created where there is a gap in current building practices (Mahachi, 2019:6). It falls out of the modern-day mainstream building practice, especially in South Africa (Mahachi, 2019:6). These technologies range from developing to developed and are not yet widely accepted (Jekot, 2007:67).

**LOW-TECH:** Low tech is a hand-based approach to creating, where natural, usually regional, materials are used to craft components (Louw, 2021:52).

**HIGH-TECH:** Industrialised modes of production usually include computational design, digital production techniques, mechanised production, and mass production (Crotch, 2010:7; Louw, 2021:138).

**INDIGENOUS:** Indigenous building technologies refer to traditional, hand-based modes of production that include indigenous skills and crafts (Louw, 2021:ix). The local craftsmen perfected this knowledge through generations, which is the optimal use of techniques, materials, and processes. Indigenous knowledge can also refer to the vernacular, which takes inspiration from the surrounding region and favours locally found materials and expertise in architectural practice (Salman, 2018:1; Adekunle & Odeyale, 2008:991). It reflects people, places, and culture. It has been developed to fulfil users' needs to the best of its ability. Thus, it has acquired a unique identity connected to the region (Salman, 2018:4). Indigenous technologies are usually self-reliant and create an honest representation of the culture or region (Nanda, 1995:57). Unlike modern architectural processes, it typically consist of participatory construction methods with the local community (Nemati, 2020:6). The struggle for all South African architects is to create contextually relevant architecture when so much of our indigenous knowledge has been lost due to colonisation. Understanding a site's socio-cultural practices is crucial when designing (Barker, 2015:19).

**LOCAL:** This refers to building methods related to the surrounding region, natural materials, locally available skills, and surrounding cultures (Louw, 2021:x).

**CIRCULAR DESIGN PROCESS:** The term 'circular design process' refers to an iterative design approach where work stages overlap, and earlier stages are revisited as new knowledge emerges. This allows for continuous feedback loops and the integration of knowledge across different fields, allowing the design to be continuously improved upon (Gerding, 2019:35). Participatory design is naturally a circular process through involving the local community and craftspeople (SCHMIDT, 2006:3; Gerding, 2019:36). It is also circular through the transferral of knowledge and constant back-and-forth between the practitioner and participant.

**PARTICIPATORY DESIGN:** Participatory design is defined as acts of collective creativity partaken throughout the design process (Sanders, 2008:6; Lee, 2006:55). Participatory design accumulates the knowledge of the designer and the users of the space (Sanders, 2008:7). Participatory design also entails the active involvement of all stakeholders in the design and construction process, including the partners, employees, end users, and the surrounding community (Fitchett, 2009:74).

**CRAFT:** The regional technologies used by local practitioners and craftspeople that usually refer to artisanal methods of making and, in modern terms, the skills needed for digital fabrication (Louw, 2021:ix). The indigenous skills are passed down by generations and are applied to smaller-scale construction with a limited number of makers. These local processes usually require the craftspeople to be a part of the entire design and construction process. This allows a connection between the acts of thinking and making of the practitioner (Louw, 2021:ix).

# 1. INTRODUCTION

## 1.1. INTRODUCTION

Historically, the role of an architect was described as the designer, craftsperson and builder, where the architect was involved in the entire building process as a master builder (Louw, 2021:ix). The purpose of this study is to inspire practitioners to practice in economically, socially and ecologically sustainable manners. This study highlights the industrialisation of building technologies that have negatively impacted the role of an architect. It intends to explore low-tech emerging building technologies informed by participatory design and construction processes. This could assist architects in situating themselves within the circular design and construction process and open up possibilities for them to return to their former master-builder title. In addition, it could provide a framework for South African practitioners to adopt circular design and construction processes, as the different manners of employing this will be explored. It will also explore the value of employing low-tech building technologies, specifically hand-based, local, and indigenous technologies. The intended result is to formulate a cohesive understanding of what strategies architects can implement in the future to have a more circular design process. This could fill the gap where South African technological advances were previously informed by global culture. It also gives the reader a view of what the future architecture in South Africa could hold if these strategies are implemented.

Building technologies have evolved significantly over time, shaped by advances in materials, construction techniques, and structural systems. The term "technology" itself, derived from the Greek words "technē" and "logos," reflects the fusion of craft, technique, and skills aimed at enhancing previous practices. In the context of building technologies, this encompasses everything from traditional hand-based methods using natural materials to highly industrialised modes of construction featuring digital production techniques, computational design and mass production (Louw, 2021:138; Crotch, 2010:7). This study focuses on low-tech building technologies, particularly emerging alternatives to mainstream industrial practices. Emerging building technologies often arise to fill gaps in current building practices and can range from developing to developed stages. These technologies have yet to be widely accepted or standardised, particularly in South Africa. They offer unique advantages regarding sustainability, cultural heritage, and community involvement.

Historically, building technologies have undergone significant transformations, influenced by socio-economic changes and technological revolutions (Louw, 2021:9). The Industrial Revolution marked a pivotal shift, introducing mass production, new materials, and mechanised construction processes. This period saw the rise of large multi-storey buildings made from structural steel and reinforced concrete, moving away from natural materials and hand-based methods. Despite the advancements brought about by industrialisation, there is a growing recognition of the value of indigenous and low-tech building technologies (Louw, 2021:22). These methods emphasise using local materials, sustainability, and community participation, often resulting in more environmentally friendly and culturally resonant structures. In modern architectural practice, there is an ongoing tension between high-tech industrial methods and low-tech hand-based approaches, each with its benefits and challenges.

This study focuses on the employment of low-tech building technologies through participatory design. Participatory design engages practitioners and participants throughout the design and construction process, promoting community involvement and economic benefits. Similar to traditional building practices, this method encourages knowledge transfer and collaboration among practitioners, including local craftspeople. Modern architecture often favours linear processes, but participatory design can revolutionise design by integrating local skills and technologies, aligning with sustainable development goals and improving economic conditions in low-income communities. These methods show how practitioners can adopt more circular, iterative design and construction processes.

This study explores how participatory design processes can lead to adopting low-tech emerging building technologies, explicitly focusing on South Africa. The study's methods included a literature review, the emerging building technologies catalogue, interviews, and precedent studies. This study hopes to achieve more circular and sustainable building practices through participation and low-tech building technologies. The outcome can inspire practitioners to practise more sustainable and socially inclusive building practices by involving local communities and leveraging indigenous knowledge. The ultimate goal is to provide economic, ecological, and socially sustainable design solutions that address the unique needs and challenges of the South African built environment.

## 1.2. BACKGROUND

Technology originates from “technē” and logos, which refers to craft, technique, and skills that can improve current practice (Louw, 2021:8). Building technologies comprise the materials, construction techniques and structural systems used to build a structure (Wu, Wei, & Peng, 2019:1). They could be influenced by the surrounding environment, technological advances, and the design concept (Wu, Wei, & Peng, 2019:7). Building Technology can refer to industrialised modes of construction, including mechanised production, computational design, and mass production (Louw, 2021:138; Crotch, 2010:7). It can also refer to low-tech construction, including using natural materials in the surrounding region's local knowledge and craft-based modes of practice (Louw, 2021:138; Crotch, 2010:7). This study specifically will focus on low-tech building technologies. Both indigenous and industrialised modes of construction can refer to technology and will find themselves at either end of the spectrum of high- and low-tech, as seen in Figure 1.

Emerging building technology is a technology that does not fall into “standardised” construction and is usually created where there is a gap in current building practices (Mahachi, 2019:6). These technologies range from developing to developed and have yet to be widely accepted (Figure 1) (Jekot, 2007:67). An example is a rammed earth wall constantly improving from its indigenous heritage to become more robust and durable. Developed technologies have reached the peak of what the materials or techniques can offer (Jekot, 2007:67). An excellent example is the humble brick wall, where, although bricks can be used innovatively, the central structure and method of use have mostly stayed the same. Emerging building technologies are the key to improving current linear building practices.

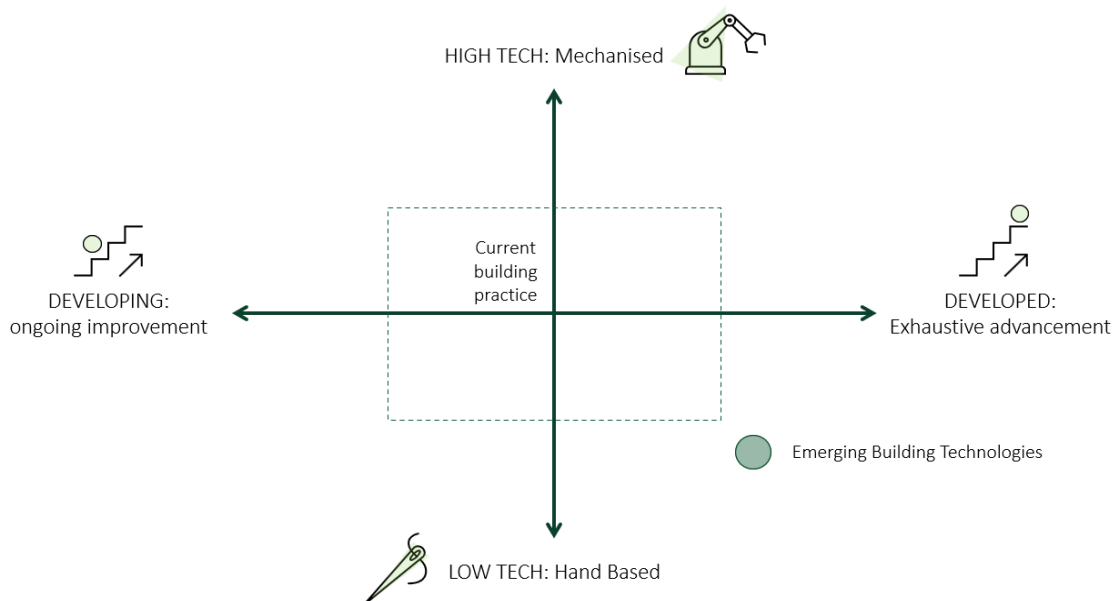


Figure 1: Technology spectrum, adapted from Bothma (2023)

Technological advances have driven significant changes in the building industry, creating a blend of new and traditional techniques but sometimes causing older methods to fade (Louw, 2021:9). The fourth industrial revolution, marked by digital and computational design, has mainly influenced modern architecture, often leading to repetitive designs and limiting collaborative opportunities (Louw, 2021:9; Nanda, 1995:8). Before the Industrial Revolution, buildings were commonly constructed with local natural materials and collective methods (Wu, Wei, & Peng, 2019:4; Schwartz, 2016:45). Factory production later replaced these practices, prioritising speed and efficiency to meet the high demand for buildings (Wu, Wei, & Peng, 2019:4). People have struggled to keep up with mass production since it facilitated cheap and quick manufacturing processes (Louw, 2021:46; Nanda, 1995:79).

Indigenous and modern cultures have always relied on “cross-fertilisation”, and the globalisation of all emerging building technologies is inevitable (Louw, 2021:40). Almost all regions have become globalised and, to some extent, have created a juxtaposition between the global and regional (Louw, 2021:40). There is a constant battle between indigenous and industrialised modes of production, where most practitioners have missed the opportunity to find the “space between them” (Nanda, 1995:8). Indigenous building technologies could be the key to a social, economic and culturally sustainable future.

### **1.3. RESEARCH PROBLEM**

The report's primary focus is to understand how participatory design processes lead to the employment of low-tech emerging building technologies. While highly industrial methods offer advantages in speed, scale, and sometimes cost, using hand-based methods and natural materials focuses on sustainability, cultural heritage, and the structure's location. It also offers social benefits as the local community might already have acquired the needed skills or the skills required for the construction can easily be transferred. This creates a level of participation from the local community.

Low-tech building technologies and participation applications for more circular processes are studied since modern design processes are linear and separate from construction processes. Architects have moved away from the Master builder and detached from the rest of the construction processes. The building industry has also moved away from low-tech building technologies, taking more inspiration from the global North.

This poses a problem as the building industry is moving away from hand-based manufacturing, as industrial machinery is faster and more precise. Using unsustainable materials like concrete has become the norm, and there is little incorporation of Indigenous Knowledge and Processes. This becomes problematic since the industrialisation of these methods loses a large part of labour-based job opportunities. There is a large amount of value in using natural, local materials and the skills of the surrounding area. Emerging Building Technologies can be used in these cases to solve some of our challenges, and Low-tech technologies can be employed to create more circular design and construction processes.

#### **1.3.1. RESEARCH AIM**

This study is done to provide economic, ecological, and socially sustainable design solutions for the South African built environment. It aims to critically analyse circular design processes through the lens of participatory design and low-tech building technologies. Understanding South African practitioners' participatory design processes will inform what value this construction method holds and how practitioners can employ it. A study of low-tech building technologies could aid in a more extensive adoption as the methods of applying this will be studied. This study contributes to educating practitioners on the economic,

ecological, and socially sustainable value created through circular design processes. It also contributes to the value gained in the design outcome through the influence of participatory design, the transfer of local (and indigenous) knowledge and the use of Low-tech Building Technologies.

### **1.3.2. RESEARCH TOPICS**

- Circular design and construction processes
- Participatory design processes
- Low-tech emerging building technologies
- Indigenous Building Technologies

## **1.4. RESEARCH QUESTION**

### **MAIN QUESTION:**

How can participatory design processes lead to the employment of low-tech emerging building technologies, including indigenous building technologies?

(Literature review)

### **SUB QUESTIONS:**

**1:** When and why do South African practitioners who follow a participatory design process employ low-tech emerging building technologies?

(Interviews + catalogue)

**2:** What is the value of employing low-tech emerging building technologies, and how will this employment aid in understanding the value of indigenous building technologies?

(Interviews + catalogue)

## **1.5. RESEARCH CONTRIBUTION**

- To understand the relationship between participatory design processes and low-tech emerging building technologies.
- To understand the value of participatory design processes.
- Observe what has been done in a South African context and determine its relevance.
- To demonstrate the value of adopting low-tech building technologies in the current building practice.
- Understanding the value of the re-emergence of indigenous building technologies

## **1.6. RESEARCH DESIGN**

For the research, the literature is reviewed and collated into a report. Information on the literature has been sorted into themes, as seen in Figure 2.



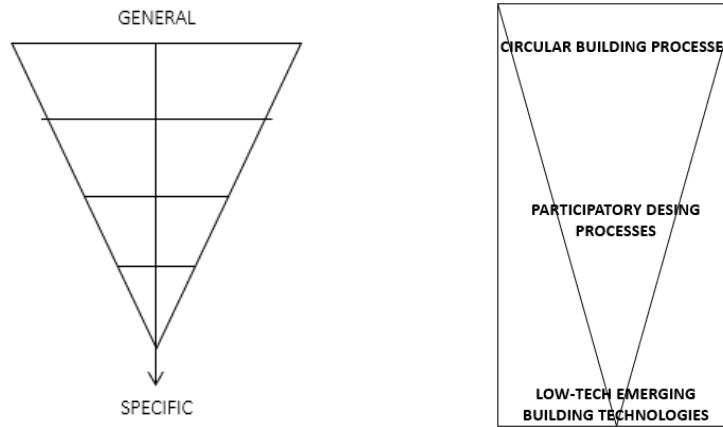


Figure 4.5: Research framework (Author, 2024)

## 1.7. LIMITATIONS, DELINEATION AND ASSUMPTIONS OF STUDY

This study is focused specifically on South African practitioners since a large part of it will discuss participation and indigenous knowledge in this context. Thus, this project will only discuss cases within this context. This project will also be done within a limited time frame. This study was conducted since limited research has been done on South African practitioners. Since the timeframe allowed for five interviews of renowned practitioners, they were chosen because they employ participatory design and low-tech emerging building technologies. An inductive process will be followed as it is assumed that the catalogue will grow and more practitioners will be interviewed. Finally, only a few practitioners employ methods resembling indigenous building technologies. Thus, the study focused more on projects and practitioners utilising this.

## 1.8. ETHICAL CONSIDERATIONS

This study had to consider ethics, as personal interviews were conducted throughout. The information was accumulated under the supervision of Prof. Arthur Barker, who already has an ethics pass. The interviewees had to sign an informed consent form to proceed with the interviews. The interviews were also conducted using a preestablished questionnaire form, which students could alter as needed in their study.

# 2. LITERATURE REVIEW

## 2.1. CIRCULAR DESIGN PROCESSES

### 2.1.1. INTRODUCTION

This section will explore circular design processes and explain the different phases in the design and construction process. It will also discuss how participatory design processes have aided in adopting more sustainable architectural processes. Finally, it will explore where modern architects could situate themselves in these processes.

## 2.1.2. LINEAR AND CIRCULAR DESIGN PROCESSES

A linear process will have to be explained to understand where the design process can be made more circular. The term 'linear design process' refers to a design approach where work stages are followed sequentially, with minimal or no opportunity for feedback to influence earlier stages (Gerding, 2019:36). This results in siloed work stages where different practitioner fields do not overlap. Thus, the architect becomes isolated from the craftsperson (Fig 6). The first phase of this design process, known as the fuzzy front end, can be uncertain and chaotic (Fig 7) (Sanders, 2008:7; Suib, 2020:115). The following phases become more apparent toward the end and consist of the ideas and design phases, where ideas can be tested, and knowledge can be shared, resulting in the final product (Sanders, 2008:7; Nitsche, 2018:1619).

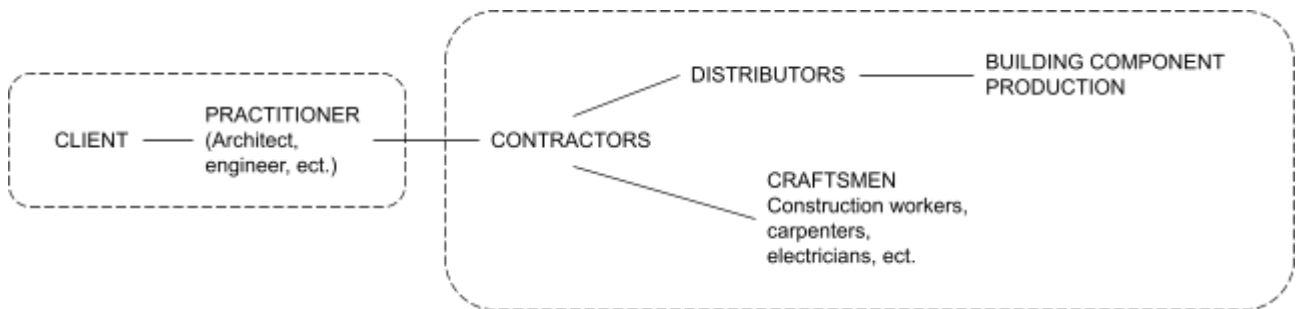


Figure 6: linear design process, based on an image from SCHMIDT (2006:3)

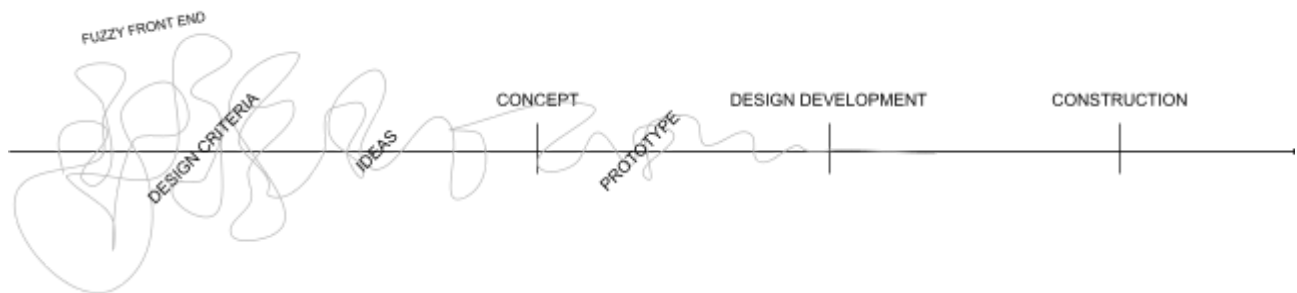


Figure 7: linear design process adapted from Sanders (2008:7)

The term 'circular design process' refers to an iterative design approach where work stages overlap and earlier stages are revisited as new knowledge emerges, as seen in Figure 8. This allows for continuous feedback loops and the integration of knowledge across different fields, allowing the design to be continuously improved upon (Gerding, 2019:35). In modern-day architectural practices, most practitioners do not explore the possibility of working in these circular manners. Practitioners could resubmerge themselves in the entire design and construction process, much like the master builder, when following circular design processes (Watson, Hook & Wardle, 2019: 108). Participatory design is naturally a circular process through involving the local community and craftspeople (SCHMIDT, 2006:3; Gerding, 2019:36). It is also circular through the transferral of knowledge and constant back-and-forth between the practitioner and participant (Fig 8).

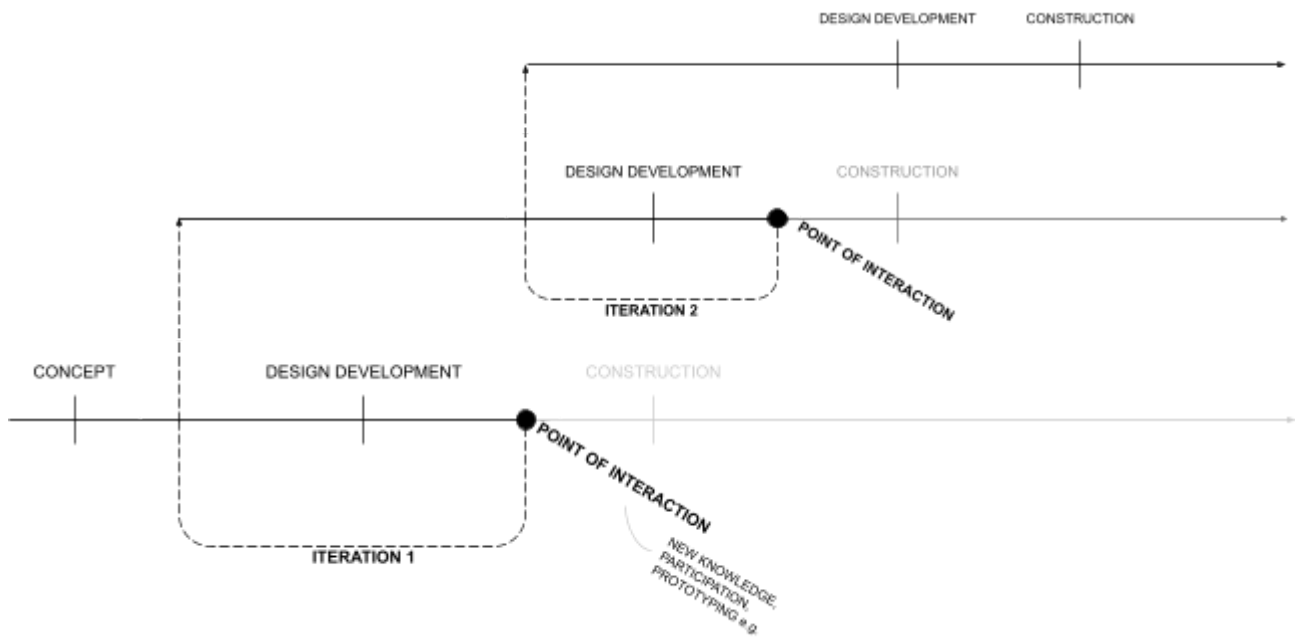


Figure 8: Iterative design process (Author, 2024)

This iterative thinking brings us back to more traditional building technologies, as Tan, Lu & Xue (2020:4) described. In indigenous construction methods, builders and craftspeople would have their knowledge passed down by generations that go through their trial-and-error phases. In this manner, the production and manufacturing processes become part of the design process (Tan, Lu & Xue, 2020:4). According to Low, implementing local technologies and skills in design on a participatory basis will significantly improve the direction of South African architecture (2014:6)

### 2.1.2. PARTICIPATORY DESIGN AND COLLABORATION

This section will discuss participatory design and how it can improve modern architectural practices. It will also discuss how participation can improve communities' economic state with the support of local craftsmen and hand-based manufacturers. Finally, it will explore how participatory design can be integrated into low-tech building technology processes.

According to Sanders, participatory design is defined as acts of collective creativity partaken throughout the design process (2008:6; Lee, 2006:55). Participatory design accumulates the knowledge of the designer and the users of the space (Sanders, 2008:7). Participatory design also entails the active involvement of all stakeholders in the design and construction process, including the partners, employees, end users, and the surrounding community (Fitchett, 2009:24). Participation is necessary for socially intelligent design processes (Hamdi, 2010:74). Unskilled participation refers to the involvement of community members in the design and construction process. While, skilled participation refers to the involvement of local practitioners, craftspeople, carpenters, and other hand-based labourers.

### 2.1.3. NEW CIRCULAR DESIGN AND CONSTRUCTION PROCESS

According to Chen & Li, building practices can become more circular by focusing not solely on the result but on the entire design and construction processes (2021:9). The re-emergence of participation in the design process will affect how designs are made, who makes them, and the tools and methods used in these processes (Sanders, 2008:15).

This process will become much more research-based towards the people who will be affected through the conduction of interviews (Hamdi, 2010:70; Sanders, 2008:15). Secondly, it is a co-creating stage where problems, opportunities, and concepts are established (Nitsche, 2018:1619). Knowledge exchange between practitioners and participants will influence this phase much more (Sanders, 2008:15). This is done through verbal instructions, diagrams and models (Hamdi, 2010:72; Lee, 2006:43). Thirdly, there is the co-design stage, where participants become more hands-on through sketches, models and prototyping (Fig 9) (Nitsche, 2018:1619; Sanders, 2008:15). Finally, there is a feedback stage, during which the participants evaluate the processes, outcomes, and shared knowledge (Nitsche, 2018:1619). The result hopes to formulate a new design process incorporating participatory design. The future might hold a much more diverse design team as various professionals and participants work together on a design (Sanders, 2008:15).

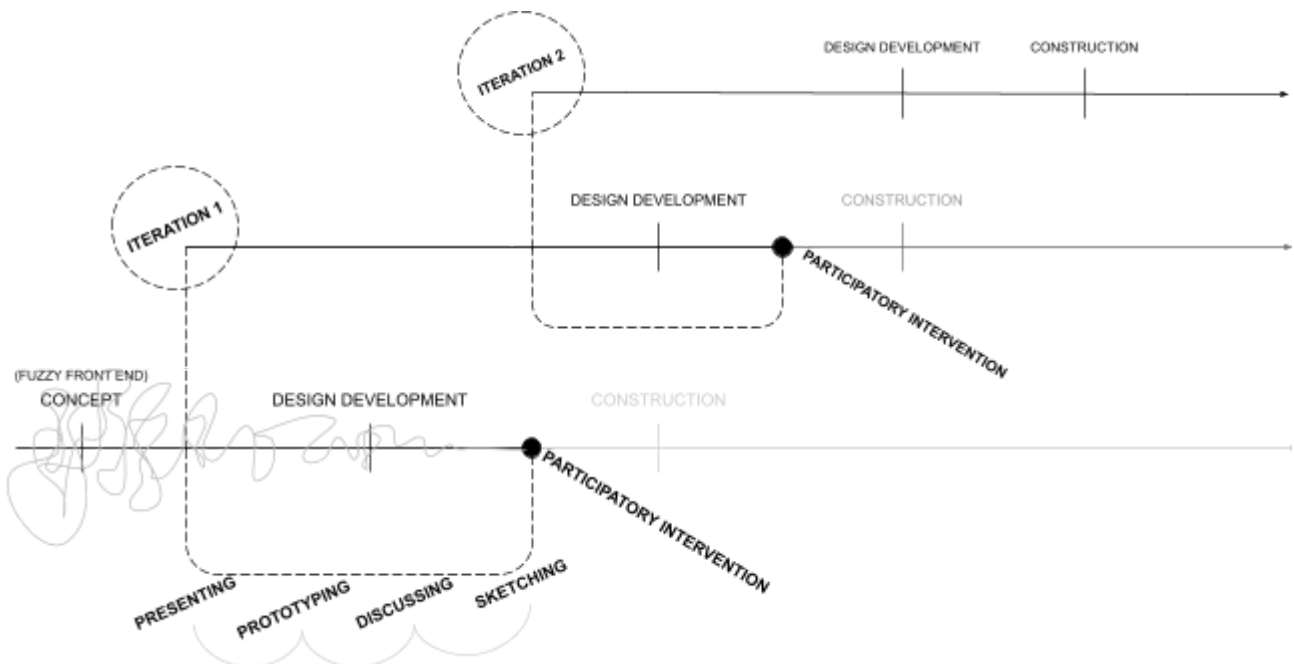


Figure 9: Improved design process, adapted from Nitsche (2018:1620)

#### 2.1.4. NEW APPROACHES TO A PARTICIPATORY DESIGN PROCESS

Growing concerns about sustainable development require new approaches to design processes, including participatory design. These approaches would include skilled and unskilled participants (Sanders, 2008:7; Hamdi, 2010:95). Participatory design is the collective solving of a design problem through sharing knowledge between the different parties for a similar language to be formed (Sanders, 2008:7; Nitsche, 2018:1615). The parties should not become experts but be able to understand the processes and the technologies used by the other (Nitsche, 2018:1613; Suib, 2020:115). This change can be implemented at any phase of the design process (Sanders, 2008:8). This new process becomes more sustainable since local skills and other technologies can be utilised.

Participatory design has taken some time to re-emerge due to the belief that not all people can be creative or benefit from the design process (Sanders, 2008:9). Participation also forms a new hierarchy in the design process, where the practitioner sits equal to the person who is participating (Hamdi, 2010:74; Sanders, 2008:9; Lee, 2006:46). In most cases, the participants are only included in the initial ideas phase and maybe later in creating building components due to the current authoritative relationship (Suib, 2020:113). According to Gerding, the involvement of craftspeople and hand-based manufacturers in the design process could

make it more circular as the constant back and forth of information sharing can inform a constant iterative design process (2019:36).

Participatory design is a powerful method of combining the skills and knowledge of a wide variety of practitioners, as mentioned by Van der Viejter (2019:25). Historically, many cultures have adopted a more collaborative approach to design, where skills are usually transferred (Mileto, 2022:704; Maina, 2010:146). The designer was probably also the builder, craftsperson and inhabitant of the space, thus a master builder (Mileto, 2022:704). This is in stark contrast to what modern-day architecture looks like. This is due to linear design processes not providing opportunities for feedback loops. Thus, participants have little say in the final design and won't have much freedom if influenced by different process stages. The roles of the participants in the design process could shift in the uptake of participation and consequently create circular processes, as seen in Figure 10 (Sanders, 2008:10).

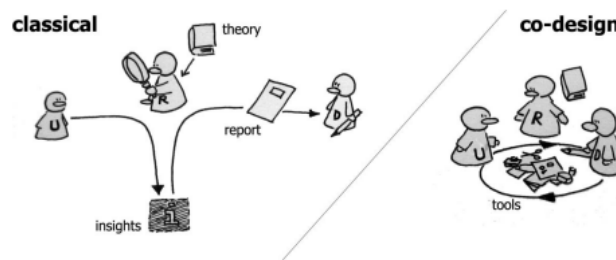


Figure 10: classical and co-design roles of different parties (Sanders, 2008:10)

Participation is a two-way development in which the practitioner (abstract space) and participator (concrete) enter each other's realms, as seen in Figure 11 (Lee, 2006:116).

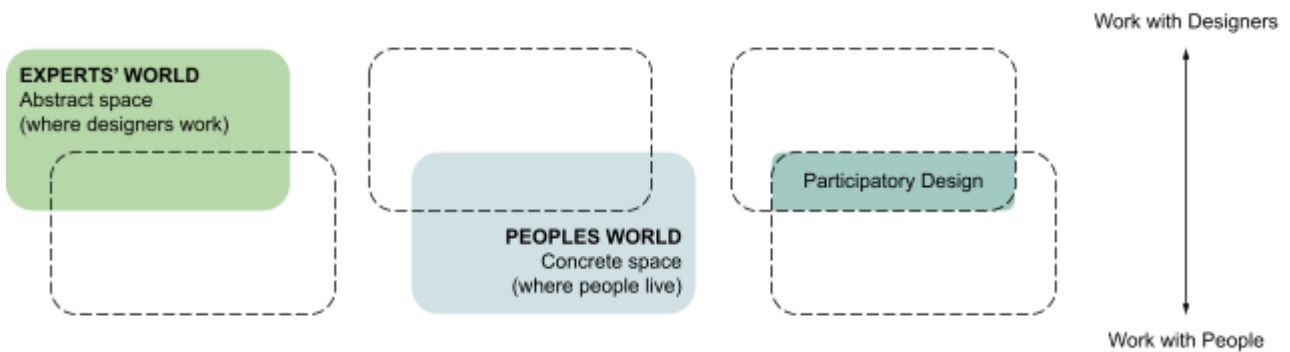


Figure 11: classical and co-design roles of different parties, based on a diagram from Lee (2006:67)

Unlike an architect's formal education, most craftspeople and hand-based labourers have learned their skills informally (Suib, 2020:124). This creates an exciting knowledge exchange process. It can inspire practitioners to explore roles beyond their traditional fields and encourage a broader, more interdisciplinary approach (Chen & Li, 2021:9). The role of an architect returns to a future version of a master builder, where they can also become a part of the manufacturing and building process. This could allow all parties to participate in the design and construction process (Chen & Li, 2021:9).

### 2.1.6. EMPLOYMENT THROUGH PARTICIPATORY DESIGN

Most of the literature on participation and job creation in the building industry has focused on housing schemes for lower-income communities (Fitchett, 2009:24; Nanda, 1995:75). The construction industry is the leading job-creation industry in South Africa and is the driving force for economic development (Fitchett,

2009:12; Osunsanmi, Aigbavboa & Oke, 2018; Nanda, 1995:12). Therefore, the economy can be improved by adopting more labour-intensive methods (Fitchett, 2009:12). Hand-based building technologies could be the solution as it is innately labour-intensive. One of the most significant struggles in South Africa is our poverty and unemployment rates, especially in rural areas (Nanda, 1995:63).

Most participatory initiatives are implemented in the construction of social housing (Fitchett, 2009:75). The jobs created through these housing schemes are not sustainable and do not result in enough skills being gathered that are marketable in other construction industries (Fitchett, 2009:25). This is due to the construction methods usually taught being inferior techniques and low-cost materials (Fitchett, 2009: 261). According to Walker, construction skills have also been in massive decline, especially under the younger tradition (2018:88). There is an enormous gap in the industry for these types of skills but few methods of acquiring it (Walker, 2018:88). Many construction workers learn their skills on-site, as they haven't had the opportunity to invest in vocational training, which has harmed the quality of work done (Suib, 2020:124; Nanda, 1995:75). Thus, teaching the community the necessary skills before and during construction is essential when incorporating participatory design. This could allow these skills to be duplicated on the following projects, which is essential.

### **2.1.7. SUMMARY**

The linear design process follows sequential stages with little feedback, resulting in isolated phases that must be fully integrated. In contrast, the circular design process is iterative, allowing continuous feedback and overlapping stages, fostering knowledge integration and improvement. Participatory design involves stakeholders throughout the design and construction process, enhancing community involvement and economic benefits. This method, reminiscent of traditional building practices, promotes knowledge transfer and collaboration among practitioners, including local craftspeople. Modern architectural practices often overlook circular methods, favouring linear processes. However, implementing participatory design can revolutionise design processes by integrating local skills and technologies, encouraging a collaborative process where ideas are developed. This interdisciplinary approach can transform architects into modern master builders involved in the construction process. The participatory design aligns with sustainable development goals, as it allows for integrating local crafts and labour-intensive methods, potentially improving economic conditions in low-income communities. It offers a robust framework for creating sustainable, community-centric architecture.

## **2.2. EMERGING BUILDING TECHNOLOGIES**

### **2.2.1. INTRODUCTION**

This section will explore emerging building technologies and explain the scale of high-tech, low-tech, developing, and developed on which these technologies sit. It will discuss how hand-based and indigenous building methods have declined over the years and how they can be implemented in modern-day architecture to ensure the conservation of our heritage. It will also discuss what methods could emerge from exploring indigenous methods and how the participation of craftspeople and other practitioners can benefit when adopting them.

According to Wu, Wei, & Peng, building technologies comprise the materials, construction techniques, processes, and structural systems used to create a structure (2019:1). They could be influenced by the surrounding environment, technological advances, and the design concept (Wu, Wei, & Peng, 2019:7). Emerging building technologies consist of high-tech and low tech technologies. Low-tech construction

consists of using natural materials found in the surrounding region's local knowledge and craft-based modes of practice (Louw, 2021:138; Crotch, 2010:7). Emerging building technology is a technology that does not fall into “standardised” construction and is usually created where there is a gap in current building practices. It falls outside the modern-day mainstream building practice, especially in South Africa (Louw, 2021:59; Mahachi, 2019:6). Before the Industrial Revolution, it was common to use natural materials easily found in the local area (Wu, Wei, & Peng, 2019:8; Schwartz, 2016:3). The collective mode of building and learning was later replaced by factory production, and the way components were made became more detailed and specialised (Wu, Wei, & Peng, 2019:8). There is a constant battle between indigenous and industrialised modes of production, where most practitioners have missed the opportunity to find the “space between them” (Louw, 2021:67; Nanda, 1995:8).

## 2.2.2. LOW-TECH BUILDING TECHNOLOGIES

Low-tech is a hand-based approach to creating, where natural, usually regional, materials are used to craft components (Louw, 2021:52). Low-tech building technologies also emphasise a human-centred design approach (Kazimee, 2010:348). According to Tanguy, Carrière & Laforest, low-tech is similar to no-tech (2023:1). The main principles low-tech building technologies consist of are as follows: it doesn't use many resources, especially non-renewable ones, it is skills that can easily be transferred, it is context-dependent, and it is not reliant on modern technologies (Fig 12) (Tanguy, Carrière & Laforest, 2023:6). Another principle is that low-tech technologies redefine the relationship between craftspeople and the techniques used to create elements. It is usually tailor-made to the location and uses (Tanguy, Carrière & Laforest, 2023:7). The final principle is that most low-tech buildings will be built with a group of people in a participatory manner and can thus adopt circular design and construction processes (Fig 12) (Tanguy, Carrière & Laforest, 2023:6).

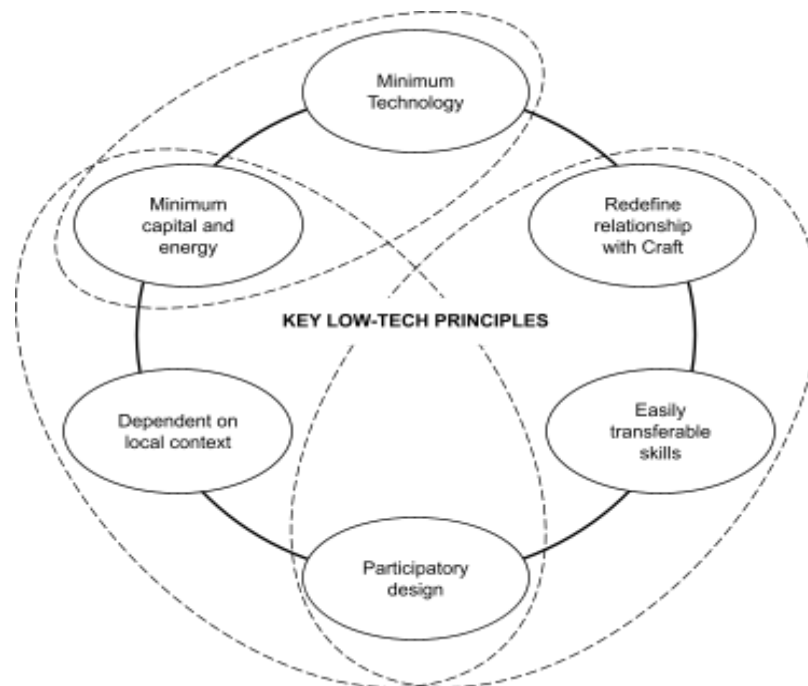


Figure 12: Seven critical principles of low-tech systems, based on a diagram from Tanguy, Carrière & Laforest (2023:6).

### 2.2.2.1. INDIGENOUS BUILDING TECHNOLOGIES

Indigenous building technologies (IBTs) refer to traditional, hand-based modes of production that include indigenous skills and crafts (Fig13) (Louw, 2021:ix). The local craftsmen perfected this knowledge through

generations, which is the optimal use of techniques, materials, and processes. Indigenous knowledge can also refer to the vernacular, which takes inspiration from the surrounding region and favours locally found materials and expertise in architectural practice (Salman, 2018:1; Adekunle & Odeyale, 2008:991). It reflects people, places, and culture. It has been developed to fulfil users' needs to the best of its ability. Thus, it has acquired a unique identity connected to the region (Salman, 2018:4). Indigenous technologies are usually self-reliant and create an honest representation of the culture or region (Nanda, 1995:57). Unlike modern architectural processes, it typically consist of participatory construction methods with the local community (Nemati, 2020:6). The struggle for all South African architects is to create contextually relevant architecture when so much of our indigenous knowledge has been lost due to colonisation. Understanding a site's socio-cultural practices is crucial (Barker, 2015:19). Understanding indigenous knowledge and building technologies could be the primary driver of circular and sustainable design.

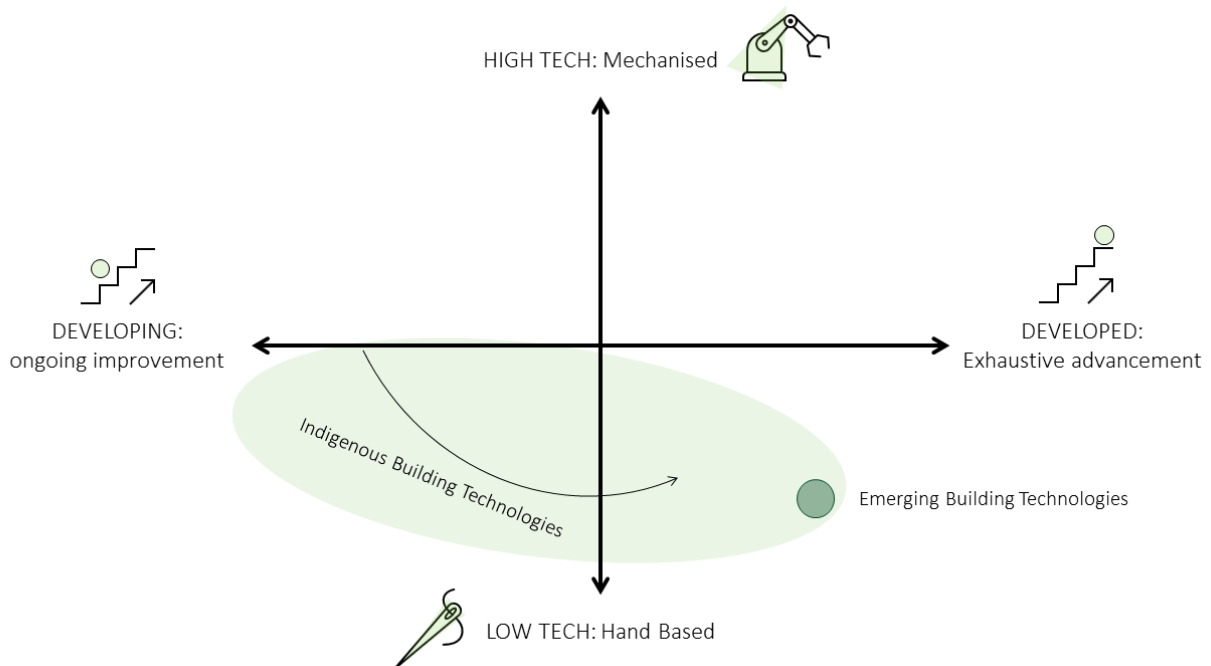


Figure 13: Technology spectrum, based on an image from Bothma (2023)

### 2.2.2.2. THE DOWNFALL OF INDIGENOUS TECHNOLOGIES TURNS TO THE DOWNFALL OF MODERN TECHNOLOGY

One of the critiques indigenous technologies have gotten over the years is that they won't be able to cater to society's fast-paced and economic needs (Nanda, 1995:79). Thus, we had to accept that indigenous skills are limited. Almost all of our indigenous roots in construction have been lost due to the rapid growth of industrialised building technologies. Mass production allows for components to be made cheaply and quickly (Nanda, 1995:79). A version of the survival of the fittest has occurred by using indigenous building technologies, as it needed to catch up with the needs of modern, fast-paced construction (Wu, Wei, & Peng, 2019:4). Historically, indigenous building technologies was always taught by masters in their fields and was restricted by regional and cultural factors (Wu, Wei, & Peng, 2019:9). The processes constantly evolved through mistakes made and new knowledge gathered (Wu, Wei, & Peng, 2019:9). Today's fast-paced building industry disrupted the slow growth of indigenous building technologies and disrupted their evolution.

### 2.2.2.3. LOW-TECH BUILDING TECHNOLOGIES FOR THE UPLIFTMENT OF THE SOUTH AFRICAN BUILDING INDUSTRY

Indigenous building technologies are the key to solving modern-day problems in the building industry. Most modern-day architecture conveys placelessness, as the region has no connection to the structure (Louw, 2014:32). Modern technologies lack the raw materials and skills to create “meaningful” architecture based on cultural values (Fischer, 2017:143; Crotch, 2010:1). Throughout the past thirty years, there has been a decline in craft-based and regional skills, especially in the construction industry (Nanda, 1995:3). Low-tech building technologies could significantly preserve craft-based traditions, which are being lost rapidly (Shaban & Datta, 2018:2). Lately, more practitioners have started to employ locally sourced materials and crafted items (Louw, 2014:3). They can also lead to shorter supply distribution networks, like locally manufactured elements and locally found materials (Fitchett, 2009:67). Emerging building technologies, such as CNC cutting, enable labourers to shift from traditional on-site work to learning and operating in a factory setting (Louw, 2021:51; Fitchett, 2009:47). Due to this, the place of craft in design is shifting (Nitsche, 2018:1611). Participation is also usually involved in low-tech methods, which can also aid in creating more circular design and construction processes.

### 2.2.2.4. A NEW CIRCULAR DESIGN AND CONSTRUCTION PROCESS

Indigenous processes usually require the craftspeople to participate in the entire design and construction process, leading to more circular outcomes (Louw, 2021:ix). This allows a connection between the acts of thinking and making of the practitioner (Louw, 2021:ix). The first phase involves the architect studying the crafted object, the workspace of the craftsman, and the processes they go through (Fig 14) (Nitsche, 2018:1613). The architect should experience the craft firsthand to develop a design language similar to that of the craftsman (Nitsche, 2018:1615). “Neither crafter nor designer were experts in the other’s domain. Consequently, the goal was to provide sufficient constraints yet leave enough room for crafter and designer to explore within their domain.” (Nitsche, 2018:1615). Then, an iterative design process is formed, where elements are tested and improved through a constant back-and-forth between craftspeople and architects (Fig 14) (Nitsche, 2018:1618).

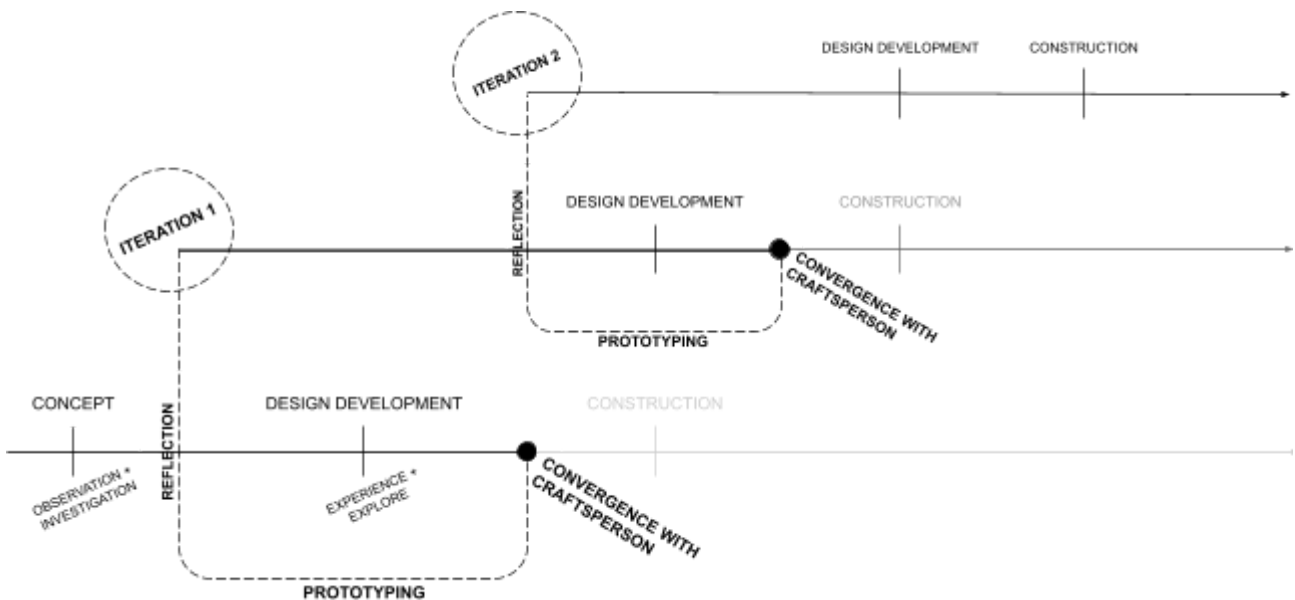


Figure 14: Improved design process, influenced by Nitsche (2018:1620)

### **2.2.2.5. SUMMARY**

Building technologies involve materials, construction techniques and structural systems that are influenced by the environment, technological advances, and design concepts (Wu, Wei, & Peng, 2019:7). Emerging building technologies include high-tech and low-tech methods, with low-tech methods relying on local materials and traditional crafts (Louw, 2021:138; Crotch, 2010:7). Before the Industrial Revolution, natural materials and collective building methods were common, but factory production later specialised and detailed component creation (Wu, Wei, & Peng, 2019:8; Schwartz, 2016:2). Low-tech building technologies emphasise minimal resource use, skill transferability, contextual dependence, and participatory construction (Tanguy, Carrière & Laforest, 2023:6). Indigenous building technologies are traditional methods perfected over generations, using local materials and reflecting regional culture and identity (Salman, 2018:4). Modern industrialisation has led to the decline of these traditional skills and knowledge (Louw, 2021:67; Nanda, 1995:8). Indigenous methods involve a more circular and participatory design process, integrating craftsmen throughout (Louw, 2021:ix; Nitsche, 2018:1613). Modern technologies, focused on speed and efficiency, often need help to create meaningful architecture connected to cultural values (Fischer, 2017:143; Crotch, 2010:1). Promoting low-tech and indigenous technologies could help address modern building challenges and preserve cultural heritage.

## **3. RESEARCH METHODOLOGY**

### **3.1. INTRODUCTION**

This study aims to promote sustainable practices in design by integrating low-tech emerging technologies and participation. The research design involves case studies compiled in a catalogue, interviews, and precedent studies of each practitioner's projects. According to Candy, research can be practice-based or practice-led (2006:1). This study is practice-led, as it analyses specific practitioners' design and construction processes and architectural philosophies (Candy, 2006:1).

The research is constructed as follows (Fig 15): Five main themes were identified from the literature for the data analysis. They comprise unskilled and skilled participatory design, hand-based building technologies, and local and indigenous building technologies. The following emerging building technology catalogue, interviews, and precedent studies are then analysed according to these themes, as seen in Figure 15. Case studies from the catalogue, interviews with practitioners found in the catalogue, and precedent studies on projects from these practitioners are analysed according to the given themes. The data is sorted into a table, and an explanation is given for how it applies to it. Next, information gathered from the interviews and precedent studies on projects from these practitioners is assessed similarly (Fig 15).

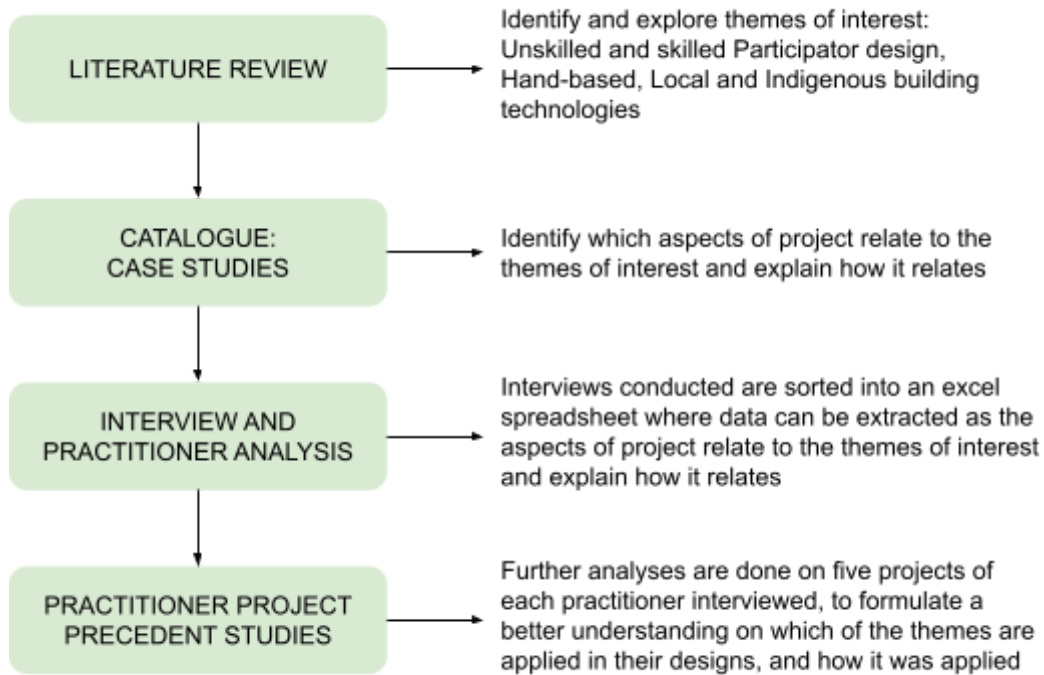


Figure 15: Research design process (Author, 2024)

All the data gathered is mainly qualitative. It mostly follows a phenomenological approach, especially with the interviews conducted. By conducting in-person interviews, the research aims to gather rich, in-depth data that would not always be available on online resources. Case studies were used to provide concrete examples of how these methods were applied to specific architectural projects. Similar to the literature review, it will be conducted in a South African context. These qualitative methods were chosen for their effectiveness in eliciting detailed information. The qualitative data collected has also been transformed into quantitative data to assess the number of projects involving specific processes. The research follows a constructivist paradigm based on particular individuals' experiences and projects.

This study aims to understand participatory design and how low-tech building technologies can benefit from these processes. The intended result is to formulate a cohesive understanding of what strategies architects can implement in the future to have a more circular design process. It also gives the reader a view of what the future architecture in South Africa could hold if these strategies are implemented. The research process was non-linear and constantly influenced by a feedback loop that allowed for the iteration of existing research.

### 3.2.1. LITERATURE REVIEW

In this section, a desktop literature review was conducted on studies relating to each central theme by classifying it accordingly. The themes include skilled and unskilled participatory design and hand-based, local, and indigenous building technologies. This establishes a theoretical framework for the data collected by analysing the themes discussed in the papers. The literature review also explores how South African practitioners implement and benefit from these processes. The themes were classified mainly through literature reviews on documents found in Google Scholar, the UP Library A-Z Database and the UP Repository. Specific search terms relating to the themes were used to find suitable literature, including indigenous, circular processes, participation and low-tech.

### 3.2.2. CATALOGUE AND CASE STUDIES

Students from the previous year's research unit set up a Catalogue of accumulated case studies dealing with emerging building technologies in South Africa. This data was collected and described in an Excel spreadsheet according to relevant information. The categorisations convey essential information, including what components of the building fall under emerging building technologies, whether low-tech or high-tech processes are used, and their developmental status. This catalogue will be built, improved, and reused in the following years for the researchers to apply to their studies. The gathered data would be reliable since it would be collected through trusted sources and created and checked in a group formation.

Case studies were chosen from the catalogue to illustrate the application of low-tech emerging building technologies and participatory design. These precedents will enhance the discussion in the literature review by providing real-life instances where these methods have been implemented. The information on the case studies in the catalogue is organised in a table (Table 1).

Emerging Building Technologies			Modes of Production		Developmental Status		Value	
Material	Construction Techniques	Structural Systems	Low-Tech	High-Tech	Developing	Developed	Economic	Socially Responsible
X				X	X		X	
	X	X	X			X	X	X

Table 1: Catalogue, adapted from Bothma (2023)

These case studies were contextualised through literature on this topic and visual searches on architectural websites, award programs, and architectural journals. They were conducted on buildings in South Africa to better understand the approaches taken when low-tech building technologies are used or where participation is involved in the process (Figure 16).



Entry Number	Images & Diagrams	Year of Completion (2008-2023)	Location (GPS coordinates)	General Project Description	Emerging building technology			Mode of production		Developmental status		
					Building material (B)	Construction technique (C)	Structural system (S)	Low-tech (traditional or hand-crafted)	High-tech (industrialised)	Developing	Developed	
1		2023	Walden Cape, Cape Town, SA Hempden Street 33° 55' 46.82389° S 18° 55' 46.82389° E	<b>Residential/ Commercial:</b> 10-storey Apartment Building in Cape Town constructed using Hempcrete materials.  Bla, aka wattle, (Blechnum, Manis & Isacco, Vogel, 2014)  Blocks made from the woody core of the cannabis plant and a formwork and mix. (Jampert, n.d.)	<b>Hempcrete blocks for formwork/bracing walls.</b> <b>Bio-composite building material made from a mixture of hemp fibres, Bla, aka wattle, (Blechnum, Manis &amp; Isacco, Vogel, 2014)</b>  Blocks made from the woody core of the cannabis plant and a formwork and mix. (Jampert, n.d.)			<b>Low-tech (traditional or hand-crafted)</b>	<b>High-tech (industrialised)</b>	<b>Developing</b>	<b>Developed</b>	
2		2023	Limpopo, Hoedsburo 30°15' 51.7"	<b>Residential:</b> with view over the Blyde River Canyon mountain range	<b>Formed Earth walls are made by compacting timber formwork, Earth is mixed with smaller amounts of cement and water, and then pressed into formwork. The mixture is then compressed and shaped. This is done in layers, and compressed until the desired height of the structure is achieved.</b> <b>Earthen floor also known as a clay floor or a mud floor, is a type of natural flooring made from a mixture of clay, sand, and sometimes other organic materials</b>			<b>Soil form site is dug up, stabilised layer and base technique used. The mixture and formwork is very important.</b>			<b>Developing</b>	<b>Developed</b>

Figure 16: Case study extractions (Bothma, 2023)

The case study information was then collated further regarding the specific themes found in this study. The number of projects that have adopted the methods has been analysed. If a project has applied the particular theme, it will be marked with an X (Table 2). The total of all the projects will then be collated into a chart indicating the relationships of the data gathered (Chart 1) (Tanguy, Carrière & Laforest, 2023:9).

Unskilled Participation	X
Skilled Participation	
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	X

Table 2: Themes (Author, 2024)

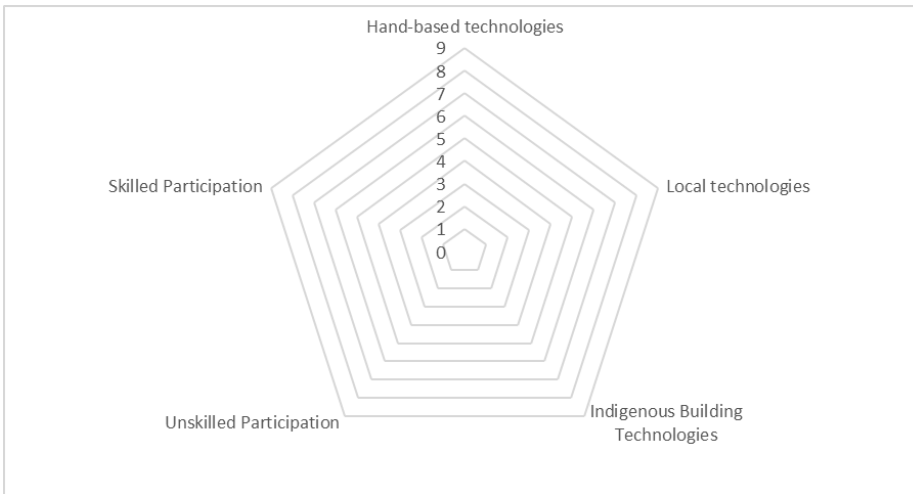


Chart 1: Data interpretation (Author, 2024)

### 3.2.3. INTERVIEWS

Five influential architects in the South African context were chosen from the catalogue to be interviewed. They specialise in participatory design processes and low-tech building technologies. Interview questions were set up beforehand as a blueprint. The questions could be adapted or removed to suit the specific research study better. The practitioners could look at the type of questions asked beforehand to get an idea of the research topics and how they fit into their architectural philosophy. Some generic interview questions were asked, and some were specifically catered to each practitioner.

The interview information was used by transcribing what was said, sorting it according to the question, and placing it into an Excel spreadsheet to easily access all the needed information (Fig 17). The table's contents can then be used as required for the study as a physical table, as well as direct quotes and the writer's interpretation of them.

Questions	Jaco Booysens	Earthworld (translated from Afrikaans to English)	Peter Rich	Kate Otten
Where were you born? How did you end up in architecture?		Braam: My path into architecture was quite unexpected. For the first two years, I found myself in the Reef in this army job. But before I embarked on my studies, I had a chance encounter with the Department of Architecture. It was there that I met Roger Fisher and Schalk, who would become our lecturers.		
Were there any hobbies that you undertook that were influential in your choice to become an architect?			Drawing basically, because drawing is both a hobby and it's a meditation. I'm giving a lecture next week at the Indian Institute of Architects awards of excellence and I'm just showing what I've learned through sketching by being in India for over a 10-year period, and how it's become relevant to my African discourse. Okay, so and Dosh wrote the foreword to my book, and that sort of poppins, again, and how did one get into that hobby. I was dyslexic at school. At that age, you were the dreamer, the artist, the clown, that was your best school report. So drawing was the way you escaped to deal with what you had to deal with. Okay.	
Did you study architecture directly after leaving secondary school? If not, what other activities did you pursue?		Braam: I played the violin so I was very interested in music; I think there's a correlation between music and architecture in form and composition. A cardinal part of our thoughts is through our eyes, we are constantly busy looking at and observing our surroundings. I draw and paint as well. "The act of creating starts with the eyes." "You know to see it and then translate it to your hands. You should also always visually take in your social and environmental contexts." - Listen to young people		
Did you have a year-out during your studies? If so, did you work (and if so where) and did you travel?			If only became memorable to me And Tukis at that time because of this house because it had some Afrocentric bells ringing and therefore it was a first of its kind. Okay. And I got, I've got to go I kept up keeping a low profile after graduating, you know, you go through, you go through a period of... we weren't millennial kids, we didn't have to be successful immediately.  Max was the architect of assist and seconds. And he ran a one-man practice and he did the quantity surveying and civil engineering and the architecture and the town planning. And everyone who went to work with him, I started shaking when I put sugar in my tea because he was like, if your drawing wasn't good, it ended up in the wastepaper basket and he stayed up to come and say next is very kind: He just walked into his practice from veld. You, you had a, you had a he was a man. He taught me absolute integrity. He was fantastic liberal human being. And actually, Tom Chapman doesn't ring a bell. Tom Chaplin. Tom Chapman has just done a thesis at the ETH in Zurich on max. And he's just taken, you know, Cape Town collected. Seven lectures of	

Figure 17: Interviews (Author, 2024)

This method was chosen to gather data since it is the most reliable way of accumulating personal data. It is also because the research studio can build up information over time. As this studio could use data from the previous year's catalogue, the next would be able to access the further data accumulated this year through case studies and interviews.

For this specific study, the answers given in the interviews were collated according to the adopted themes that have been identified (Table 3). Quotes have been extracted from the interviews to explain why it was chosen to represent specific themes.

<b>Unskilled Participatory design process</b>	
<b>Q1</b>	Do you have a particular architectural philosophy? Can you explain it?
A1	
<b>Skilled Participatory design process</b>	
<b>Q2</b>	Do you work alone or with or involve the local communities / local businesses in your design? Are they influential in your thinking, and if so, how? Does the surrounding community, cultures, and indigenous knowledge impact your designs?
A2	
<b>Hand-Based Emerging Building Technologies</b>	
<b>Q3</b>	Do you ever consider more low-tech (hand-based/ craft-based) approaches to design?
A3	
<b>Local Building Technologies</b>	
<b>Q5</b>	So then, regarding the constructions for the South, what have you learned by doing these constructions throughout the years?
A5	
<b>Indigenous Building Technologies</b>	
<b>Q4</b>	What do you envision the future of (South Africa's) architecture would look like?
A4	

Table 3: Interviews (Author, 2024)

Finally, a summary will be given to relate the findings to the previous data, and the data will be transformed into a graph (Table 2, Chart 1).

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	X

Table 2: Themes (Author, 2024)

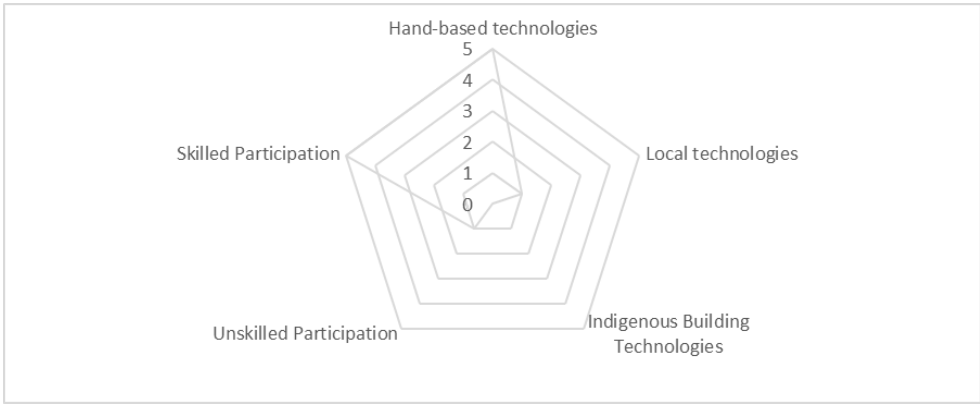


Chart 1: Data interpretation (Author, 2024)

### 3.2.4. PRACTITIONER PROJECT ANALYSIS

In this section, a precedent study examines five projects from each practitioner interviewed. The purpose is to gain insight into the technologies utilised and identify how often they are implemented in their architectural practice. Each project is assessed for the presence or absence of the identified themes and marked with an X accordingly, and a description of the technology is given (Table 2). The findings from each practitioner's five projects are then compiled into a radar chart, offering a more precise visual representation of the results (Chart 1).

Unskilled Participation	X	
Skilled Participation	X	
Hand-based technologies / Craft	X	
Local technologies	X	
Indigenous Building Technologies	X	

Table 2: Themes (Author, 2024)

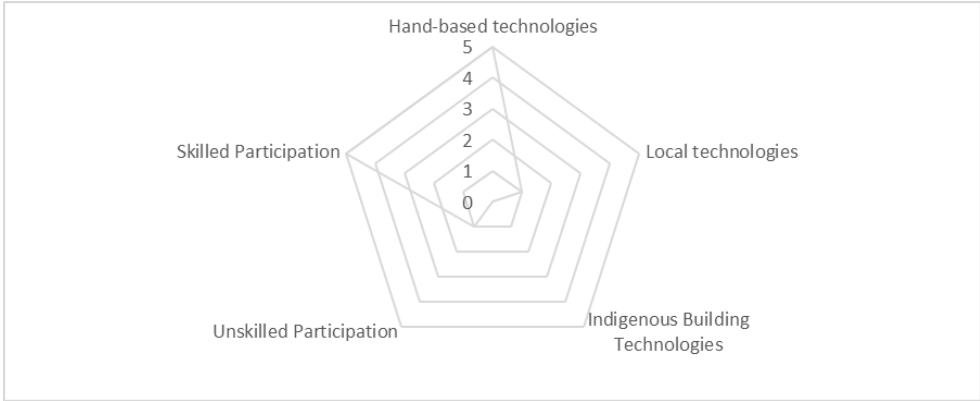


Chart 1: Data interpretation (Author, 2024)

## 4. DATA COLLECTION AND ANALYSIS

### 4.1. THEORETICAL FRAMEWORK

From the literature, five main themes were identified for the data analysis. These themes either fall under participatory design processes or low-tech emerging building technologies. The five themes are unskilled and skilled participatory design and hand-based, local and indigenous building technologies. The unskilled participatory design includes local communities in the design and construction process, facilitating skills transfer. Skilled participatory design involves employing local craftspeople, carpenters, indigenous builders, and not necessarily skilled construction workers. Hand-based building technologies refer to any building technology (material, construction technique or structural system) that can be done manually. Local building technologies refer to materials or skills in and around the structure's location. Finally, Indigenous building technologies refer to technologies deeply rooted in the cultural heritage of the region where the structure is based. The catalogue, interviews, and precedent studies done on the projects by the specific practitioners are then analysed according to these chosen themes. The data analysis of the catalogue, interviews and precedent studies involves organising information in a table and categorising it according to specific themes or questions. The datasets are then transformed into a radar chart for a better visual understanding. All of the studies are based in the South African context.

### 4.2. EMERGING BUILDING TECHNOLOGY CATALOGUE

#### 4.2.1. INTRODUCTION

This section will analyse the catalogue as a whole. The catalogue will represent an overview of the emerging building technologies used, their frequency, and their value for this study.

Previous students in this research unit created a catalogue of case studies on emerging building technologies in South Africa. The data, organised in an Excel spreadsheet, was categorised by themes such as technologies implemented, technology types (low-tech or high-tech), and developmental status. This categorisation helps convey essential information and makes the data applicable for further studies.

The catalogue categories that are of value for this study are emerging building technologies, low-tech building technologies, and whether the design process has been socially responsible. In the catalogue, fifty-one out of seventy studies have been found to use low-tech building technologies, accounting for 48,6% of the precedents (Fig 18).

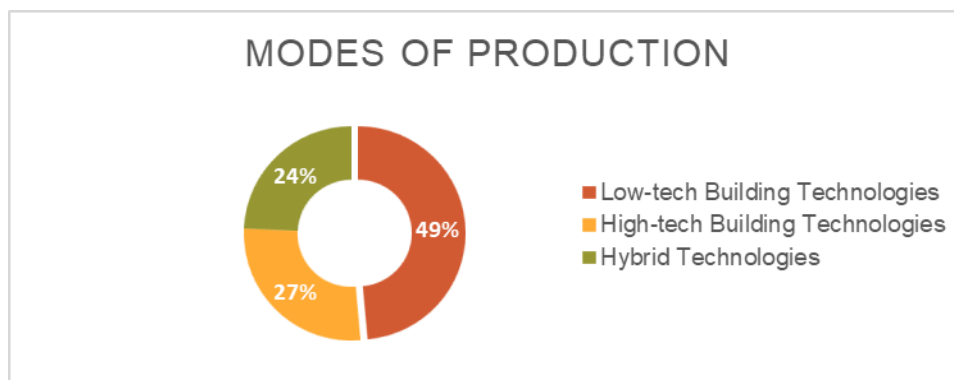


Figure 18: percentages of the modes of production (Author, 2024)

Of the low-tech building technologies, forty-six projects were emergent in their construction techniques, accounting for 51% of the precedents (Fig 19).

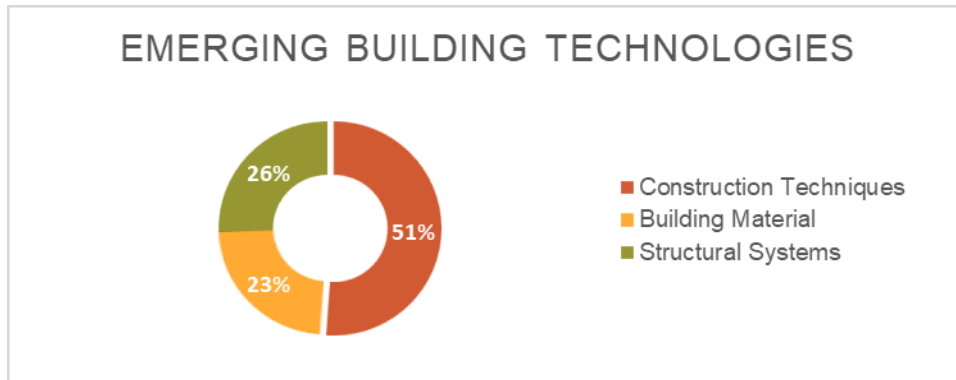


Figure 19: percentages of Emerging Building Technologies (Author, 2024)

Thirty-six precedents, accounting for 38% of the low-tech building technologies, were still in their developmental phase (Fig 20).

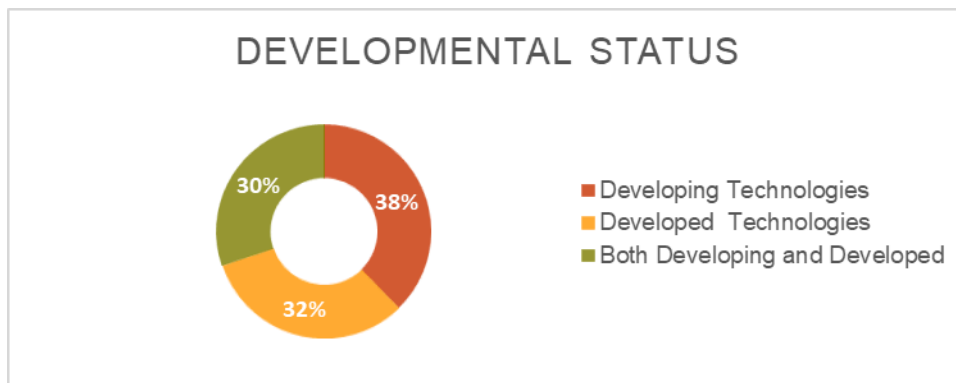


Figure 20: percentages of the development status (Author, 2024)

Further, forty-three of the total low-tech projects (fifty-one) were socially responsible, accounting for 84% of the total low-tech projects (Fig 21).

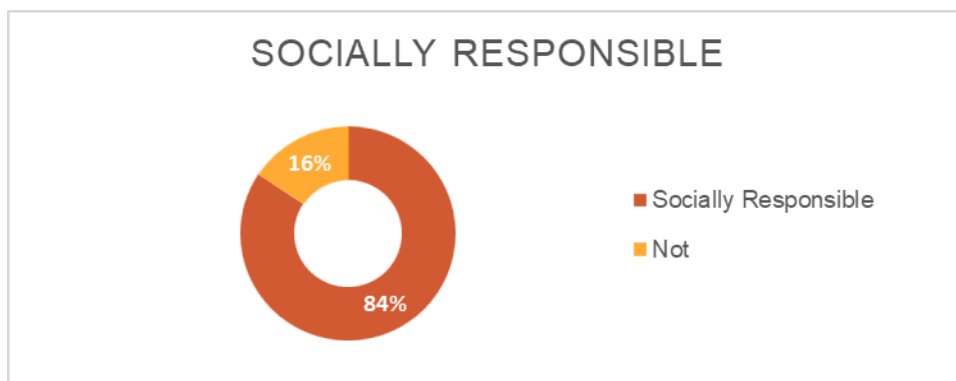


Figure 21: percentages of the social responsibility (Author, 2024)

The description identifies specific projects found to be socially responsible as having conducted participatory design processes. Case studies from the catalogue that involved participatory design and low-tech building technologies were then chosen to be analysed further.

## 4.2.2. CASE STUDIES

This section extracted case studies involving participatory design and low-tech building technologies for further catalogue analysis. Each project was rated according to its theme, identified by extracting information from the descriptions.

### 4.2.2.1. Oppie Koppie Creche - Design. Develop. Build: RWTH Aachen University - nr. 68

Emerging Building Technologies			Modes of Production		Developmental Status		Value	
Material	Construction Techniques	Structural Systems	Low-Tech	High-Tech	Developing	Developed	Economic	Socially Responsible
Adobe brick: Earth with high clay content, straw and sand			Local materials Found on site Manual brick press Done on-site			Adobe - employed by various indigenous cultures Not commonly used	Durable, cost-effective, locally sourced, job-creation	Preserves indigenous knowledge, labour-intensive, community involvement, skills-creation
	Upcycling fruit crate for cladding		Hand-based processing		Upcycling of pallets is rare.		job creation, cost-effective	labour-intensive, community involvement, job-creation, skills-creation
	Prefabricated timber roof			On-site assembly				
	Participatory construction		Hand-based construction technique		Not commonly used in current building practice		job creation	community involvement, skill development

Table 4: Catalogue entry 68 (Bothma, 2023)

The Oppie Koppie Creche was designed and built by Design. Develop. Build in 2010. The building is a school based in the Western Cape. The building material consists of locally found sand, straw, and clay-rich soil used to make adobe bricks, which is a low-tech building technology as the materials are pressed through a manual brick press. The local community was involved in the construction process by pressing and laying the adobe bricks. Earthen construction is an indigenous building technology passed down and developed through generations.

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	X

Table 2: Themes (Author, 2024)

### 4.2.2.2. Environmental Education Center, O.R. Tambo Cultural Precinct - Odyssey Architects and Andy Horn from Eco Design Architects - nr. 64

Emerging Building Technologies			Modes of Production		Developmental Status		Value	
Material	Construction Techniques	Structural Systems	Low-Tech	High-Tech	Developing	Developed	Economic	Socially Responsible
Straw-bale: bundles of wheat/barley (agricultural bi-product)			Locally sourced material Bales are dry-packed			Well developed internationally	Low-cost	Local unskilled participation
Natural plaster materials, lime + cow dung			Traditional techniques practised locally raw, local materials			Indigenous to SA	Low-cost	Employs local community
	Cob "butabtu" technique (similar to rammed earth)		Traditional, locally sourced material			Indigenous to SA	Local materials	Local unskilled participation

	layers of mud mixed with cement							
	Rammed Earth: earth, sand, gravel, and stabilisers Packed within a formwork		Hand-based construction technique local materials			Indigenous to SA	It is cost effective Low to no maintenance	Labour-intensive, local unskilled participation

Table 5: Catalogue entry 64 (Bothma, 2023)

Odyssey Architects and Andy Horn designed the Environmental Education Center in 2013. The building is a Heritage Centre based in Gauteng. Straw bales, made from local agricultural byproducts, are an emerging low-tech technology. Elements such as cob and natural plaster made of lime and cow dung are all hand-based technologies in the local area. These methods don't require skilled participation and have been passed down as indigenous knowledge.

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	X

Table 2: Themes (Author, 2024)

#### 4.2.2.3. Project Kagiso - University of Nottingham and Design + Build Studio - nr. 60

Emerging Building Technologies			Modes of Production		Developmental Status		Value	
Material	Construction Techniques	Structural Systems	Low-Tech	High-Tech	Developing	Developed	Economic	Socially Responsible
EcoBricks: (PET bottle packed with used plastic)			Hand-based, domestic production		Gaining traction in SA Not widely implemented			Unskilled participation
Sandbags: (stacking earth-filled plastic bags)			Hand-based, domestic production					Unskilled participation
	Participatory construction		Hand-based construction technique		Not commonly used in current building practice		Job creation	Unskilled local participation, skills creation
		timber frame construction						

Table 6: Catalogue entry 60 (Bothma, 2023)

Project Kagiso was designed by the University of Nottingham and Design + Build Studio in 2014. It is an educational space based in Limpopo, made from EcoBricks and Sandbags. Sandbags are grain bags filled with soil, and eco-bricks are bottles filled with used plastic. These methods are both hand-based and can be easily replicated by the local communities with little skill set.

Unskilled Participation	X
Skilled Participation	
Hand-based technologies / Craft	X
Local technologies	
Indigenous Building Technologies	

Table 2: Themes (Author, 2024)

#### 4.2.2.4. House Schutte - Kate Otten Architects - nr. 42

Emerging Building Technologies			Modes of Production		Developmental Status		Value	
Material	Construction Techniques	Structural Systems	Low-Tech	High-Tech	Developing	Developed	Economic	Socially Responsible

	Rammed Earth: earth, sand, gravel, and stabilisers Packed within a formwork		Hand-based construction technique local materials			Indigenous to SA	It is cost effective Low to no maintenance	Labour-intensive, local unskilled participation
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Table 7: Catalogue entry 42 (Bothma, 2023)

Kate Ottens House Schutte residence was built in 2017 in Gauteng. It is made from rammed earth, a construction technique in which a mixture of earth, sand, gravel, and stabilisers is compacted in formwork. This low-tech technique can easily be taught to unskilled labourers. It is based on an indigenous method of construction where materials found on-site can be used.

Unskilled Participation	
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	
Indigenous Building Technologies	

Table 2: Themes (Author, 2024)

#### 4.2.2.5. Future Africa Campus - Earthworld Architects - nr. 30

Emerging Building Technologies			Modes of Production		Developmental Status		Value	
Material	Construction Techniques	Structural Systems	Low-Tech	High-Tech	Developing	Developed	Economic	Socially Responsible
Polycarbonate Panel			Hand-based installation	Factory cut		Commonly used in SA	Cheaper than glass	
	Plywood portal frame structures: CAD drawings to programming code for CNC cutting Hand assembly			Industrialised: CAD, BIM	CAD + BIM to CNC cutting not widely used		Coding ensures minimal waste.	
	Prefabrication: Plywood column components		Hand-based assembled in factory + installed on site	Industrialised		Timber construction is commonly used globally.	Minimal waste	
		Mass Timber Construction: CNC-cut plywood components	Hand-based assembled in factory + installed on site		Not widely used at this scale in SA		Environmentally friendly	

Table 8: Catalogue entry 30 (Bothma, 2023)

The Future Africa Campus, based in Gauteng, was designed by Earthworld Architects in 2018. It is an educational space for postgrad students made from hand-assembled polycarbonate and plywood components reinforced with steel. The lightweight CNC-cut components can easily assembled by skilled labourers.

Unskilled Participation	
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	
Indigenous Building Technologies	

Table 2: Themes (Author, 2024)

#### 4.2.2.6. Spring of Hope Permaculture Centre - Tove Design Studio - nr. 22

Emerging Building Technologies			Modes of Production		Developmental Status		Value	
Material	Construction Techniques	Structural Systems	Low-Tech	High-Tech	Developing	Developed	Economic	Socially Responsible

	Rammed Earth: earth, sand, gravel, and stabilisers Packed within a formwork		Hand-based construction technique local materials			Indigenous to SA	It is cost effective Low to no maintenance	Labour-intensive, local unskilled participation
	Earthen floor: clay, sand, + other organic materials		Hand-based construction technique with local materials			Indigenous to SA	job creation	local unskilled participation, skills creation
	Participatory construction		Hand-based construction		Not commonly used in the current building practice			
		Loadbearing Rammed earth: Walls serve as both structural elements and enclosure	Hand-based construction technique local materials		The load-bearing capabilities of rammed earth walls are still developing in SA.		It is cost-effective. Durable, low to no maintenance	Labour-intensive, local unskilled participation
		Reciprocal roof: Rafters are arranged in a spiral so each rafter rests on the previous one	Hand-based construction technique			Indigenous to SA, not widely adopted	Job creation Naturally stable	local unskilled participation

Table 9: Catalogue entry 22 (Bothma, 2023)

Tove Design Studio built the Spring of Hope Permaculture Centre in 2020. It hosts a community centre in the Mpumalanga heartland. Load-bearing rammed earth walls and earthen floors were constructed for its hand-based properties and use of local materials. Earthen construction is an indigenous method that can attract both traditional and unskilled participants.

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	X

Table 2: Themes (Author, 2024)

#### 4.2.2.7. Buffelsdrift Farm - SAOTA & Jaco Booyens Architect - nr. 21

Emerging Building Technologies			Modes of Production		Developmental Status		Value	
Material	Construction Techniques	Structural Systems	Low-Tech	High-Tech	Developing	Developed	Economic	Socially Responsible
	Cob: clay-like soil, sand, and straw		Traditional, locally sourced material			Indigenous to SA	Local + abundant materials, job opportunity	
	Catenary arch: vaulted brick structure	Catenary arch: Parabolic compression	Unskilled labour, low-tech equipment	Plywood support structure prefabricated through CAD	Construction techniques not commonly used in SA		Cost-effective	Labour-intensive low-skill participation employs local craftspeople.
		Load-bearing soil walls: 1,2. Thick with steel tension rods	Hand-based construction technique local materials		Structural systems are not commonly used in SA.		Soil is an abundant resource.	

Table 10: Catalogue entry 21 (Bothma, 2023)

The Buffelsdrift Farm was designed by Jaco Booyens in 2020. It is a leisure accommodation space based in the Western Cape. The building was constructed from cob with steel tension rods for loadbearing capabilities. This low-tech building technology employs local materials and indigenous knowledge. Unskilled labourers constructed the cob walls, while local craftspeople built the catenary arch roof.

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X

Indigenous Building Technologies	X
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Table 2: Themes (Author, 2024)

#### 4.2.2.8. Angel's View Earth House - Peter Rich Architects - nr. 15

Emerging Building Technologies			Modes of Production		Developmental Status		Value	
Material	Construction Techniques	Structural Systems	Low-Tech	High-Tech	Developing	Developed	Economic	Socially Responsible
	Rammed Earth: earth, sand, gravel, and stabilisers Packed within a formwork		Hand-based construction technique local materials			Indigenous to SA	It is cost effective Durable, low to no maintenance	Labour-intensive, local unskilled participation
		Loadbearing Rammed earth Walls serve as both structural elements and enclosure	Hand-based construction technique local materials		The load-bearing capabilities of rammed earth walls are still developing in SA.		It is cost-effective. Durable, low to no maintenance	Labour-intensive, local unskilled participation
	Catenary arch: vaulted brick structure	Catenary arch: Parabolic compression	Unskilled labour, low-tech equipment	Plywood support structure prefabricated through CAD	Construction techniques not commonly used in SA		Cost-effective	Labour-intensive low-skill participation employs local craftspeople

Table 11: Catalogue entry 15 (Bothma, 2023)

The Angels View Earthen House, designed by Peter Rich Architect in 2021, is a leisure accommodation space based in Graskop Mpumalanga. The building was constructed from load-bearing rammed earth to counteract a clay brick catenary arch roof. These low-tech building technologies attracted local craftspeople and unskilled participants alike.

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	

Table 2: Themes (Author, 2024)

#### 4.2.2.9. Guga S'Thebe - Carin Smuts Architects - nr. 2

Emerging Building Technologies			Modes of Production		Developmental Status		Value	
Material	Construction Techniques	Structural Systems	Low-Tech	High-Tech	Developing	Developed	Economic	Socially Responsible
Adobe packed insulation panels			Hand-based, local materials		the use of "eco-materials" as a means of insulation	Manufacturing Adobe by hand	Upcycled materials + simple construction	Unskilled community participation
	Shipping containers		Hand-based local assembly					Community involvement

Table 12: Catalogue entry 2 (Bothma, 2023)

Guga S'Thebe, designed by Carin Smuts Architect in 2015, is a cultural theatre space in the Western Cape. The building was constructed out of packed adobe panels, a hand-based building technology. The local community designed and built the structure of this project, reinforcing its social impact.

Unskilled Participation	X
Skilled Participation	
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	X

Table 2: Themes (Author, 2024)

#### 4.2.2.10. TOTAL RESULTS

The resulting theme analysis indicates that all case studies employ hand-based technologies, and most employ skilled participation. This is due to the way in which the case studies were chosen. Many projects also employ local technologies and unskilled participation, indicating that most projects consider the local environment. Lastly, few projects employ Indigenous building technologies, as seen in the table and chart below (Table 13; Chart 2).

Project/Precedent number	68	64	60	42	30	22	21	15	2
Unskilled Participation	X	X	X			X	X	X	X
Skilled Participation	X	X		X	X	X	X	X	
Hand-based technologies / Craft	X	X	X	X	X	X	X	X	X
Local technologies	X	X				X	X	X	X
Indigenous Building Technologies	X	X				X	X		X

Table 13: Total themes analysis of case studies (Author, 2024)

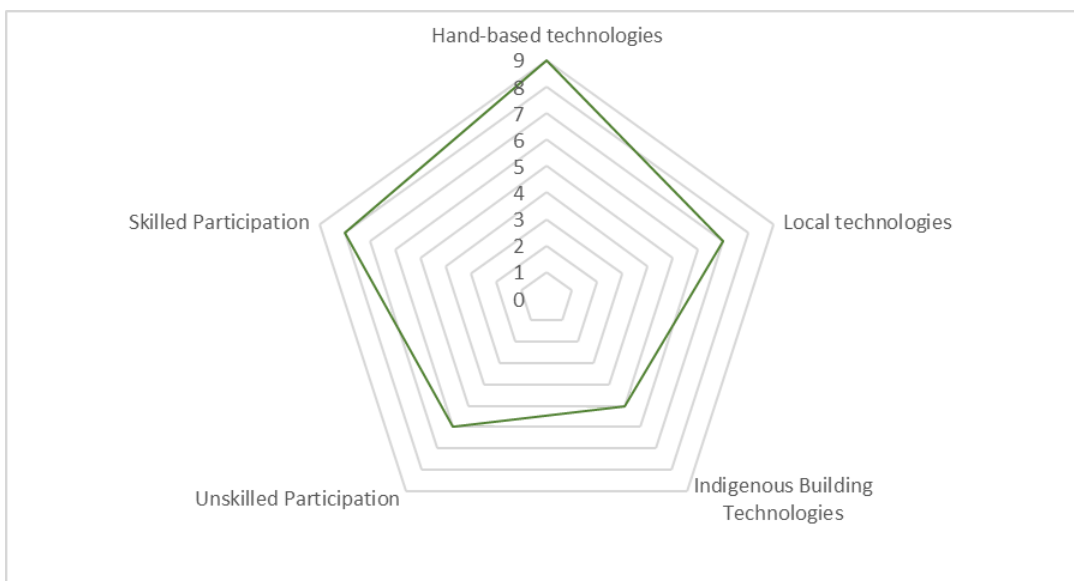


Chart 2: Total themes analysis of case studies (Author, 2024)

#### 4.2.3. DISCUSSION

As mentioned above, 48.6% of the catalogue case studies employ low-tech building technologies, and 51% employ emergent construction techniques. Further, 84% of the low-tech projects were socially responsible, indicating a significant impact on the local community, often involving participation. This suggests that low-tech building technologies can significantly influence local communities and lead to circular design and construction processes through participation.

Due to how the studies were selected for analysis, all the chosen case studies adopted hand-based technologies. Most projects involve skilled participation, an unusual finding since most low-tech skills can easily be transferable. Additionally, many projects incorporate local technologies and unskilled participation, reflecting the South African practitioner's value of local skills and technologies. This could aid in the uptake of indigenous building technologies, as they are not widely used in these projects. The findings show that the literature has correctly stated that indigenous building technologies have not yet been widely implemented in South African Architecture.

### 4.3. PRACTITIONER INTERVIEWS

Specific practitioners were interviewed from the case studies analysed above. The practitioners were chosen based on their project implementation of participatory design and low-tech building technologies. These interviews and further discourse analyses helped to better understand how practitioners have applied each theme.

#### 4.3.1. INTRODUCTION

The layout of the interview analysis is as follows:

An explanation of why a specific practitioner was chosen and an introduction to the types of questions asked was given. Then, a background study was done on each practitioner. Finally, questions and their related answers are organised in a table according to the themes each practitioner applies to, as seen in the table below (Table 14).

	<b>Unskilled Participatory design process</b>
<b>Q</b>	Do you have a particular architectural philosophy? Can you explain it?
	<b>Skilled Participatory design process</b>
<b>Q</b>	Do you work alone or with or involve the local communities/businesses in your design?
	<b>Hand-Based Emerging Building Technologies</b>
<b>Q</b>	Do you ever consider more low-tech (hand-based/ craft-based) approaches to design?
	<b>Local Building Technologies</b>
<b>Q</b>	Regarding the constructions for the South, what have you learned by doing these constructions throughout the years?
	<b>Indigenous Building Technologies</b>
<b>Q</b>	What would the future of (South Africa's) architecture look like?

Table 14: Interview example (Author, 2024)

Below, additional discussions and information provided by the practitioner that would benefit the study may be added. To conclude the interviews, a summary of the information and the practitioner's normative stance will be given, and a summary of the datasets will be made to better relate to the previous study.

Unskilled Participation	X
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Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	X

Table 2: Themes (Author, 2024)

### 4.3.2. CARIN SMUTS

An interview with Carin Smuts was conducted on April 26, 2024. The questions aim to better understand her process of integrating local people into the design process and what value can be found in the result. They also look deeper into the strategies when incorporating the community into the design.

This practitioner was selected for their conscious integration of participation, craftsmanship and hand-based emerging building technologies in their design and construction process. Smuts is renowned for actively involving local communities in her designs, which form part of an interactive and participative process. She specifically examines the community's needs, skills, and opportunities and lets that drive the designs (CSSTUDIO, 2010). Smuts also values the project's locality and frequently pulls from these indigenous or emerging local methods when designing (CSSTUDIO, 2010). She believes these circular design and construction processes add more value to the projects, which will continue to uplift the community even after the project has been concluded (CSSTUDIO, 2010).

#### TABLE OF QUESTIONS

<b>Unskilled Participatory design process</b>	
<b>Q</b>	Do you have a particular architectural philosophy? Can you explain it? (This was explicitly aimed at participatory design)
	“When we engage people, they are part of the design process, and in the long term, they will probably be engaged in the building project itself.” “We also involve children, often if possible, in mosaic work.”
<b>Q</b>	Do you ever consider more low-tech (hand-based/ craft-based) approaches to design?
	“For us, the people are far more important than the technology and the building itself. So we sometimes spend up to two years building people's capacity to participate properly with us and to be able to articulate what they want.” “We build abstract cardboard models that deliberately facilitate people engaging with us.”
<b>Q</b>	Do you usually design more with natural or manmade elements?
	“We think we should make the building as labour-intensive as possible so local people can build it.”

<b>Skilled Participatory design process</b>	
<b>Q</b>	Do you have a particular architectural philosophy? Can you explain it? (This was explicitly aimed at participatory design)
	“...if people are not builders but may be artists, they can get involved.” “...they will often do mosaics and decorative handrails...”

<b>Hand-Based Emerging Building Technologies</b>	
<b>Q3</b>	Do you ever prototype or test out new ideas when designing?
	“Like in Lynsberg, we made handrails with recycled steel that we picked up on the farms around the building. Then, we made a frame with the rebar and folded the framework to make an example, with the help of Billy Bester (a renowned local artist), of how you can make a creative thing. Then the participants made all the handrails and all the railings beautifully.”
<b>Q</b>	How would you usually choose participants in your design and construction process? (this conversation led to the type of materials used)
	“We usually need to think of quite robust solutions...” “That’s why we often use a simple face brick, usually the cheapest one you can find.”

<b>Local Building Technologies</b>	
<b>Q</b>	Do you usually design more with natural or manmade elements or a mixture?
	“When we work in a rural area, or there is sand, like the work we did in Kommengas, we’ve made all the bricks from the local sand on-site.” “So we try to use resources that are close to the site. One of our policies is to try and use what is around.”

<b>Indigenous Building Technologies</b>	
<b>Q</b>	You have spoken quite a few times about the in-between spaces in your buildings, the more sociable spaces. How has that impacted your designs?
	“I think the influence of traditional architecture provides space for significant social and cultural activities.” “Like with Guga Sithebe, which is a tiny little building, but 1000s of people visit it because it has space in between. People can hang out in courtyards and outdoor amphitheatre spaces.”

<b>Other information of value</b>	
<b>Q</b>	How would you usually choose participants in your design and construction process?
	“Normally, we make a project management committee. Have a tea. Then, we will make a building committee of three to five people. And that committee will find the participants...” “... and they will work with the community liaison officer to source people.” “Then we will build sample panels so that the people will return to the quality of the sample.”

Table 15: Interview Smuts (Author, 2024)

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	X

Table 2: Themes (Author, 2024)

**DISCUSSIONS AND ADDITIONAL INFORMATION**

In the interview with Smuts, she states that her architectural firm highly values people's participation in the design and building processes. Some participants would have construction skills, but others could be more creative and participate in a craft-based manner. This engagement with the community builds a steady base for future architectural interventions. Community involvement begins with forming a project management committee that collaborates with a community liaison officer to engage local participants. During the design process, visual aids should communicate ideas clearly, which ensures that participants feel comfortable sharing their ideas and skills, as some might lack construction experience. Sample panels are also created to provide high-quality work in the construction phase.



Smuts states, "One of our policies is to try and use what is around." This is especially true when structures are built in rural areas. She also states that "the skills are more important than the materials." Thus, she often sources materials provided and hand-manufactures them by the local community, trying to make the structure as labour-intensive as possible. She describes a project in Lainsburg where locals creatively crafted handrails from farm-sourced steel, enhancing their economic prospects through this skill (Fig 22). One indigenous aspect that influences her design is the use of "in-between spaces" that facilitate "social and cultural activities" as in the structure GOOGA Sitebe. The creation of small gathering spaces is valuable for the community to be able to come together.

Figure 22: Decorative handrails (CSSTUDIO, 2010)

Finally, Smuts envisions the future of South African architecture involving the creation of safe spaces with defined urban quality, which can only be achieved with the collaboration of the local communities.

**4.3.3. KATE OTTEN**

An interview with Kate Otten was conducted on April 3, 2024. The questions aim to better understand her process of integrating local people and hand-based building technologies into the design process. It also explores what value can be found in the result.

This practitioner was selected for her conscious integration of participation, craftsmanship and hand-based emerging building technologies in her design and construction process. In most instances, she has also involved local craftsmen, labourers and manufacturers in her designs as she deeply values craft and making in her designs (KOA, 2010). This is directly translated into her rich use of materials specific to each project. She often employs locally available materials and skills to create more meaningful designs. Otten believes in the 'construction of self' and frequently experiments with emerging building technologies (KOA, 2010).

**TABLE OF QUESTIONS**

Unskilled Participatory design process	
Q	Do you work alone or with or involve the local communities / local businesses in your design?
	"I think it's very particular to a project." "The art therapy centre in Soweto was very much a hands-on thing."

	The Threads project tells a story about Johannesburg's true meaning, specifically the laboratory of the future. What is your view of what architecture should be like in South Africa in the future?
	"It's this idea about connecting craft with making with handmaking with certain engagements with people and humanity."

<b>Skilled Participatory design process</b>	
<b>Q</b>	Do you work alone or with or involve the local communities / local businesses in your design? Are they influential in your thinking, and if so, how?
	<p>"The art therapy centre in Soweto was very much a hands-on thing. The Rowe house was a very hands-on thing with the actual builders who are on site." "In this people who were skilled plasters..." "...we were trying to get them to unlearn their skills to achieve the desired results." (here, Otten was explaining how skilled practitioners had to unlearn skills to experiment with new outcomes)</p> <p>"For example, with the bricklaying at the Art Therapy Center. It was a kind of disorderly patent brickwork, and we discussed this with two bricklayers." "And then you can see where one worked and where the other person worked, like decisions they made to make it all happen, which was wonderful."</p>

<b>Hand-Based Emerging Building Technologies</b>	
	In terms of construction for the South, what have you learned from doing these constructions? (deals with experimentation and prototyping)
	"Take Lulu Kati Kati, for example..." "...you'll find that a lot of recycled stuff is used in a relatively new way." "It's all leftover bits. I'm a terrible hoarder because I see these things as possibilities of making something fantastic. But they're all amazing and interesting and have their possibilities."
	The Threads project tells a story about Johannesburg's true meaning, specifically the laboratory of the future. What is your view of what architecture should be like in South Africa in the future?
	"It's a wonderful summary of my work in this practice. Because it's about craft, it's about woman, and it's about layers landscape." "It's this idea about connecting craft with making with handmaking with certain engagements with people and humanity."

<b>Local Building Technologies</b>	
	You said the design process was an organic response to the existing conditions at House Rowe. Then, the building progressed as new objects and elements were found that needed to be included. Can you elaborate on this? (also deals with experimentation)
	<p>"They had a bunch of stuff like doors and windows that they'd salvaged from some warehouses downtown."</p> <p>"... they know many kinds of artists, they would make the lamp fittings from interesting materials, and they were a lot of the mosaic work." "So there was this lovely, intuitive, organic process." "For example, there's that beautiful tower with these creeks on it. So we did over-plaster it, and the plaster all slumped and revealed those bottles that are the twinkling lights on the staircase."</p>

	“So working with Shawn and Alice was very nice to experiment.”
<b>Q</b>	Do you work alone or with or involve the local communities / local businesses in your design? Are they influential in your thinking, and if so, how? (speak specifically about local skills)
	“For example, at the Wits Rural Facility, we may have wanted to have been more experimental in doing certain things, but those skills did not exist in the area. So, it was also valuable to use things that the communities surrounding the facility were able to do. So their skills could be used to build the building. So I think it's taking those skills and pushing them further beyond their comfort zone.”

Table 16: Interview Otten (Author, 2024)

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	

Table 2: Themes (Author, 2024)

## DISCUSSIONS AND ADDITIONAL INFORMATION

Otten explains that the existing skills of the surrounding community should be prioritised instead of experimenting, as most innovative skills won't exist yet. From there, the participants can be pushed slightly out of their comfort zone to create emerging technologies instead of complete innovation. The involvement of hand-based skilled labourers is just as crucial as unskilled labour. As in the case of the Art Therapy Centre, where the bricklayers had to artistically lay the bricks as they saw fit (Fig 23). This “instruction for self” empowers the builder to completely engage in what they are creating.



Otten often enjoys experimenting with different materials, mainly found materials or those connected to the context. An example is the construction of Lulu Kati Kati, which was based on the construction of the Women's Jail but used opposing materials. She speaks of how her architecture responds to context, as the bay windows and corrugated iron components in this building are linked to historic Melville construction. The corrugated iron sheets are also cut in such a manner to imply the use of “leftover bits”. This amplifies her statement of the use of found building material.

Figure 23: Art Therapy Centre (KO, 2024)

Otten highly values connecting “...with craft, making, handmaking, certain engagements with people and humanity.” Through the Threads project, she speaks more about what she values in design: “...it's about craft, it's about women, it's about landscape, it's about, but layers of landscape.” In this, her architecture creates a truly (South) African Result.

### 4.3.4. EARTH WORLD ARCHITECTS

This interview was conducted on April 4, 2024, with Mr. A. Eksteen, B. de Villiers, and Ms. L Lamprecht. The questions aim to better understand how they integrated workmanship into the design process and what value

can be found in the result. It also encompasses a deeper look into how hand-based building technologies were incorporated into the design.

Earthworld Architects were chosen for their conscious integration of participation, craftsmanship, and hand-based emerging building technologies in their design and construction process in a way different from previously explored. They value craft related to the hand-based labour industry and workmanship “In the making of meaningful things...” as stated on their website (Ewarch, 2024). They often design buildings that are easily hand-assembled through a ‘kit-of-parts’. Earthworld architects value hybrid technologies that combine high-tech design and manufacturing methods with low-tech construction and assembly methods (Ewarch, 2024). This allows them to follow a more circular design and construction process since components must be prototyped beforehand. This will enable components to still be designed where others are prototyped, thus creating an iterative process.

### TABLE OF QUESTIONS

<b>Unskilled Participatory design process</b>	
Q	How does your design process usually start?
	“And then what's your social approach to what you're going to do?” “How can the building be the catalyst for social change?”
Q	Explanation of research topics (Nel)
	“I can use future Africa as an example. One thing is the idea of building with plywood layers, combining them, and hand-assembling them. But I believe the true innovation was the discovery that could be done with unskilled labour.”

<b>Skilled Participatory design process</b>	
Q	Explanation of research topics (Author)
	“What is important to me is the exchange between craftspeople and practitioners, where there is a collaborative notion and exchange.”
Q	How do you consider people who are involved in the building process?
	“Craftsmanship is of the utmost importance. The material is one of the first things we think of in the design process, and with that comes how the building is put together. Having small, light components that two people can lift is important. That was the integral concept of the plywood designs instead of designing a large CLT building.”

<b>Hand-Based Emerging Building Technologies</b>	
Q	Explanation of research topics (Nel)
	“I can use future Africa as an example. One thing is the idea of building with plywood layers, combining them, and hand-assembling them.”
Q	In terms of craft, where would this fall in your philosophy as an architect, and is it relevant to philosophy?

	“When we studied at Tukkies, it was a very strong school of making things, especially with Joe Kemp and Hans Wegelin.” “There was a solid emphasis on the building technology of things and the making of it.”
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<b>Local Building Technologies</b>	
<b>Q</b>	How does your design process usually start?
	“I think the most important thing, firstly, is context to understand the context.” “This means that just by looking at the environment around you, you can get a lot of clues...” “And then the textures and the site specifics, what's this potential?”

<b>Other information of value</b>	
<b>Q</b>	How do you consider people who are involved in the building process? (Extra information in their view on the modern hand-based labour industry)
	“There is a dwindling skills market, meaning there aren't many hand-based labourers/ craftspeople/ carpenters anymore; most craftspeople are self-taught and only specialise in what they know. There has to be respect for the craftsman and how a building is put together. Most young people have more practical experience, whereas older generations learn from their forefathers. Younger workers are usually more creative when solving problems. As an architect, you should design for this divergent thinking. You should allow yourself to explore through architecture.”
<b>Q</b>	What is a traditional architect?
	“The traditional architect is a master builder, but the modern architect is a professional consultant. And that's where architects have lost their foothold because now they have become pen pushers rather than true craftsmen.” “But what I think is also interesting now is that these CNC technologies give us the answers and tools we can if we can more so that we can be relevant in the profession again. But if we are merely, you know, Building Consultants.”

Table 17: Interview Earthworld (Author, 2024)

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	

Table 2: Themes (Author, 2024)

## DISCUSSIONS AND ADDITIONAL INFORMATION

In the interview with Eksteen, de Villiers, and Lamprecht, they mentioned they highly value hand-based learning and doing. When Eksteen and de Villiers were still in architecture school, they were taught the value of “the making of things” by Ora Joubert. These influences have formed a base for their architecture.

They believe true innovation lies in the hybrid methodology of plywood construction. Where components are computationally designed and CNC cut. After that, the components are hand-assembled, usually by unskilled labourers. It's essential to have small, light components that two people can lift and assemble on-site. This is done by designing a kit of parts that would easily fit together. They value workmanship and craftsmanship. In

contrast to Carin Smuts, the materials are one of the first things they think of, accompanied by the design process and how the building is put together.



Eksteen notes a decline in skilled hand-based labourers and craftspeople, many of whom are self-taught and limited in expertise, posing challenges for the building industry. However, he emphasises that the creativity of the self-taught younger generation should be leveraged in design.

Figure 24,25: CNC cut and sanding (Author, 2023)

Finally, Earthworld envisions the future of South African architecture as a "Modern Vernacular," emphasising context-driven design and a prominent "self-build culture" focused on the manufacturing process. They believe architects could evolve into modern master builders through CNC technologies and active participation in the design and construction process.

#### 4.3.5. PETER RICH

An interview with Peter Rich was conducted on March 15, 2024. The questions aim to better understand his process of integrating local people into the design process and what value can be found in the result. It also examines how low-tech and indigenous building technologies were applied to the structures.

This practitioner was selected for their conscious integration of participation, craftsmanship, and hand-based emerging building technologies in their design and construction process. Rich’s projects usually involve a sensitive site study and an understanding communities’ needs (Noble, 2020). He finds much inspiration from indigenous building technologies and often reinterprets them in his designs.

#### TABLE OF QUESTIONS

Unskilled Participatory design process	
Q	How would you describe your work with hybridity, whether in the design process or the technical application?
	“... If you take Mapungubwe and Alex.” “How do you fly soil in the air using an ancient technique? Everyone’s too scared to do it because they have forgotten how...” “So that was it, and you had to work with local unskilled and unemployed labour to train them...” “The same thing happened in Alex, but because Alex is urban, I knew that if we put a steel building up, it could be about accurate. The unskilled labour would have something accurate to fill or to clad.”
Skilled Participatory design process	
Q	Your book mentions in the Alexandria interpretation centre that the community referred to the book In Material Collage as jazz architecture. So, what specific aspects of the surrounding environment and cultural influences inspired this unique approach?

	“And then those glass info panels, you know, you put out an advert in the press for artists to come and work with some Dutch guy who knows how to weld glass, and he wants to do something for the community.”

	<b>Hand-Based Emerging Building Technologies</b>
<b>Q</b>	Your house is influenced by your journey as an architect, so it shows the spirit of your work. So, what can you say about articulating symmetry between the sites and its potential to be used in modern architecture because it was a buildup of buildings over time?
	“Because I had told us who arrived who knew how to dry bricks, but they couldn't read and draw it.” “So, building your own house is a perfect thing.”
<b>Q</b>	Where would this fall in your philosophy as an architect? And is craft relevant to your philosophy?
	“I think architecture and arts and crafts have to do with making. One of the things I love about India is that they have a more profound skill set than we have in terms of their diversity.” “And because the money is not valuable, as I keep saying to them, the world is interested in seeing what you can do with craft.”

	<b>Local Building Technologies</b>
<b>Q</b>	How would you describe your work with hybridity, whether in the design process or the technical application?
	“So that was it, and you had to work with local unskilled labour and unemployed labour to train them...” “...and the same thing happened in Alex, but because Alex is urban, I knew that if were put a steel building up that it could be about accurately and the unskilled labour would have something accurate to fill or to clad...”

	<b>Indigenous Building Technologies</b>
<b>Q</b>	How did this cross-cultural view of architecture affect your process? Would you say that culture plays a role in both environment practice and how so?
	“Yes. Well, firstly, it's building respect for culture. When I went into communities from the very beginning, I didn't go as the professor or professional architect; I just went as a normal human being to talk to the grannies and the mothers and the children as this quite eccentric sort of person who was interested in what they were doing. Then through that, I gained friendship and competence, whether it was an Alexandra, in more dangerous territory, or rural concerns.”
	“Doshi looks for clues in people's lives to design buildings that can enable people. Can you elaborate on physical examples and what he means by this since you've worked and admired him?”
	“The first one is the Ndebele matriarch. We see what we want to see and make it our own, which is seminal because it's what we do we reinterpret.” “It means seeing with some understanding, reinterpreting, and investing it with symbolism. It can have other meanings relevant to your time and place, and therefore, it becomes changed.”
<b>Q</b>	I have read that you are very interested in Ndebele culture. What influences do you use most in your architecture?

	<p>“Well, this house in my books. I was visiting the Ndebele each weekend.” “I was going frequently and trying to articulate what Ndebele space is and what an African space is, and I came up with a house that is not a home unless it’s a village. They don’t see a building as an object as we do...” “They see that this is your muzi, your building.: “In a nutshell, two separate pavilions articulate space open at the corners of a courtyard. The open at the corners creates the village.” “In our contemporary work, we do that.”</p>

Table 18: Interview Rich (Author, 2024)

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	X

Table 2: Themes (Author, 2024)

**DISCUSSIONS AND ADDITIONAL INFORMATION**

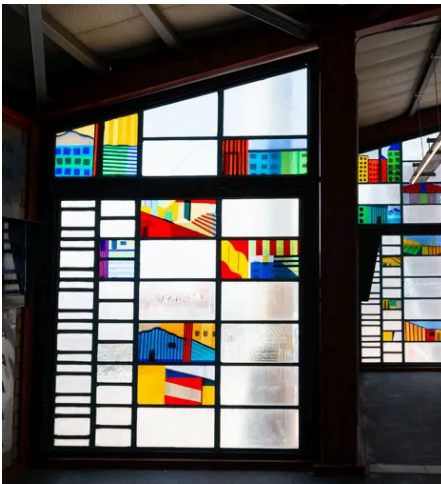


Figure 26: Alexandria glass panels (PRA, 2020)

In his interview, Rich stated that he highly values participants' engagement in the design and construction processes and draws inspiration from Indian architecture for its diverse and skilful craftsmanship. He states that it is essential to approach communities without believing you are more knowledgeable. He applies a holistic design approach to unskilled participation and knowledge transfer. He also often involves skilled craftspeople, as he did with the glass panels at the Alexandra Heritage Centre (Fig 26). Rich states, “I think architecture and arts and crafts have to do with making.” thus, he often employs hand-based technologies in his designs. Rich draws inspiration for his designs from indigenous spaces. He does this by understanding why certain design decisions were made and reinterpreting them. This includes the rituals created through architecture, which are especially prominent in the Ndebele culture.

Finally, Rich invented the statement, “a house that is not a home unless it’s a village, ” which directly relates to the influence of traditional rituals and practices in his designs.

**4.3.6. JACO BOOYENS**

An interview with Jaco Booyend was conducted on March 20, 2024. The questions aim to understand his mindful use of materials and experimentation. They also encompass how he employs circular design strategies through hand-based architectural strategies and what value can be found in the result. This practitioner was selected for his experimental methods of employing hand-based building technologies to better understand the design and construction processes used to achieve this. Booyens is renowned for working on remote sites that are difficult to access (Booyens, 2005). This allows him to explore earth, clay, and site-specific materials to create a “self-sufficient” construction process (Booyens, 2005). Booyens is also very involved in hand-based components in architecture, as he is trained in carpentry, welding, and hand-based labour, such as constructing rammed earth or adobe structures (Booyens, 2005). He believes good architecture encloses a space with the least amount of material by understanding the materials and creating the structure (Booyens, 2005).

**TABLE OF QUESTIONS**

Hand-Based Emerging Building Technologies	
Q	Is prototyping appropriate in architectural design? (describing how he tested new methods in his projects)
	“I made my first mud wall for a client in on the experiment. And I made my walls for myself.” “With Buffelsdrift, I have a client willing to look the other way when I make a mistake. So, the way to control it is to know what materials can do.”
Q	If you were to consider prototyping, would you say it has to happen early in the design process to eliminate risk? (describing how he tested new methods in his projects)
	“I’ve recently told the client I want to build walls, which the Europeans called Cyclopean concrete.” “...that you make a very big mass wall. With the stuff you can get together, stones and rubble pieces of concrete don’t matter, and you primitively cast them layer by layer with some concrete in the middle or even clay.”

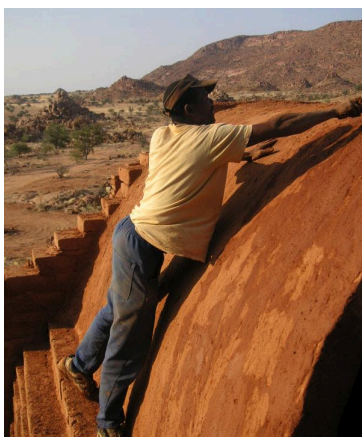
Local Building Technologies	
Q	Is prototyping appropriate in architectural design? (describing how he tested new methods in his projects)
	“I made my first mud wall for a client in on the experiment. And I made my walls for myself.”
Q	If you were to consider prototyping, would you say it has to happen early in the design process to eliminate risk? (describing how he tested new methods in his projects)
	“...Cyclopean concrete.” “...you make a massive mass wall. With the stuff you can get together, stones and rubble pieces of concrete don’t matter, and you primitively cast them layer by layer with some concrete in the middle or even clay.” “And we went out on the road and went to an old vineyard. And the farmer pushed all the rocks to the side because it was in his way when he ploughed the land. And we built just two shutter boards: 1.2 by 2.4, the wall, and this little thing took us two/three hours.”

Table 19: Interview Booyens (Author, 2024)

Unskilled Participation	X
Skilled Participation	
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	

Table 2: Themes (Author, 2024)

## DISCUSSIONS AND ADDITIONAL INFORMATION



In the interview, Booyens stated that he is interested and trained in various hand-based methods and values, exploring materials and details in his designs. Booyens is renowned for his work in remote sites where hand-based building technologies and local communities had to be employed.

He speaks of his experimentation, especially with mud walls, and how it led to the positive outcome of the Buffelsdrift project. He mentions that understanding the properties of materials is essential for the outcome to be successful.

Figure 27: Mud walls (Booyens, 2005)

He often employs materials that can be found in the surrounding area and even uses them in unusual manners. He speaks of the project done with Cyclopean concrete, where he found stones from a local vineyard to be cast in concrete in layers similar to rammed earth.

Finally, Booyens believes that innovation cannot occur without taking risks. This standpoint is evident in his architectural processes and the technologies he employs.

### 4.3.7. DISCUSSION

In the interviews conducted, it is prominent that participation and low-tech building technologies hold vastly different meanings to each practitioner, and each practitioner also applies these methods differently. Although this is true, each has its contribution to creating more circular design and construction processes for a more sustainable future, especially in South Africa. Below, the specific methods will be analysed in how the practitioners undertake participatory design and low-tech emerging building technologies.

Smuts believes there is value in accommodating local communities through participatory design. She also frequently involves local artists and hand-based labourers in constructing their structures. Locally sourced materials are commonly used for construction, intended to be as labour-intensive as possible (Table 2). This indicates how low-tech methods could aid in adopting participation in design and thus create more circular processes. She also employs indigenous methods through the creation of “in-between” spaces. Smuts is a well-rounded architect who employs circular design and construction processes through participatory design processes.

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	X

Table 2: Themes (Author, 2024)

Otten values the community's existing skills over experimentation, as innovative skills are often undeveloped and gradually extend their capabilities to create emerging technologies. Hand-based skilled and unskilled labour is crucial, as demonstrated by the Art Therapy Centre, where bricklayers artistically laid bricks. She enjoys experimenting with locally sourced materials and often uses leftover bits, as seen in Lulu Kati Kati. Using found and local materials emphasises the value of hand-based building technologies (Table 2). By adopting these methods, a more circular design and construction process could be implemented in South Africa.

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	

Table 2: Themes (Author, 2024)

Earthworld Architects integrates craftsmanship and hand-based building technologies to uplift unskilled labourers in their designs. They emphasise using a kit-of-parts design strategy, allowing easy on-site assembly (Table 2). This indicates how low-tech methods could aid in adopting participation in design and thus create more circular processes. They envision a context-driven ‘Modern Vernacular’ architecture in

South Africa, with architects deeply involved in the design and construction process as modern master builders. All of the above translates into a more circular design and construction process.

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	

Table 2: Themes (Author, 2024)

Rich emphasises the value of participatory engagement in the design and building process and draws inspiration from skilled craftsmanship. He stresses the importance of approaching communities as equals, especially with unskilled labourers who require training. Rich draws inspiration from indigenous technologies, understanding and reinterpreting traditional architectural components and rituals (Table 2). He believes that “a house that is not a home unless it’s a village”. Thus, this way of thinking can create a more circular future for design processes by employing indigenous technologies through participatory processes.

Unskilled Participation	X
Skilled Participation	X
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	X

Table 2: Themes (Author, 2024)

According to the interview conducted and background search done, Booyens often employ hand-based technologies and local technologies in his designs. He also sometimes employs local communities to aid in the construction process (Table 2). This is due to his projects being located on rural sites that are hard to access. Booyens is skilled in many hand-based methods and usually conducts his experiments, especially with hand-based technologies. These hand-based methods could lead to more circular processes as it become iterative in their experimentation. It also becomes more circular in his uptake of local skills and technologies.

Unskilled Participation	X
Skilled Participation	
Hand-based technologies / Craft	X
Local technologies	X
Indigenous Building Technologies	

Table 2: Themes (Author, 2024)

In total, all of the practitioners have employed hand-based technologies, local building technologies, and unskilled participation. Most employed skilled participants except Booyens; only Smuts and Rich employed indigenous building technologies.

Smuts is renowned for her mindful inclusion of local unskilled communities in the design and construction process (Table 20, Chart 3). Leading to the employment of low-tech building technologies through labour-intensive methods. This process becomes more circular as the community’s skills and involvement in the design usually lead to iteration in the original proposition.

Earthworld architects adopt participation and hand-based technologies through hybrid methods (Table 20, Chart 3). Building components are usually computationally manufactured but hand-assembled. This process has allowed the architect to become a modern master builder by becoming part of the entire design and

construction process. The process has also become more circular through iterations made within the construction phase when prototyping.

Booyens is renowned for his work in rural areas, often employing local, hand-based skills and technologies (Table 20, Chart 3). Otten employs local skills and technologies through ‘found’ objects and adopts styles similar to those of the surrounding areas (Table 20, Chart 3). Otten and Rich both value craftsmanship and hand-based technologies (Table 20, Chart 3). Otten often urges craftspeople to follow their means when participating in a project. Leading to a design and construction process where the architect is not the only designer.

Rich and Smuts both value indigenous technologies, usually carrying their ethos, but they have yet to fully adopt it in their designs. This amplifies the statement that indigenous building technologies are not utilised in South Africa.

Practitioners	Smut	Otte	Eart	Rich	Booy
Unskilled Participation	X	X	X	X	X
Skilled Participation	X	X	X	X	
Hand-based technologies / Craft	X	X	X	X	X
Local technologies	X	X	X	X	X
Indigenous Building Technologies	X			X	

Table 20: Total themes (Author, 2024)

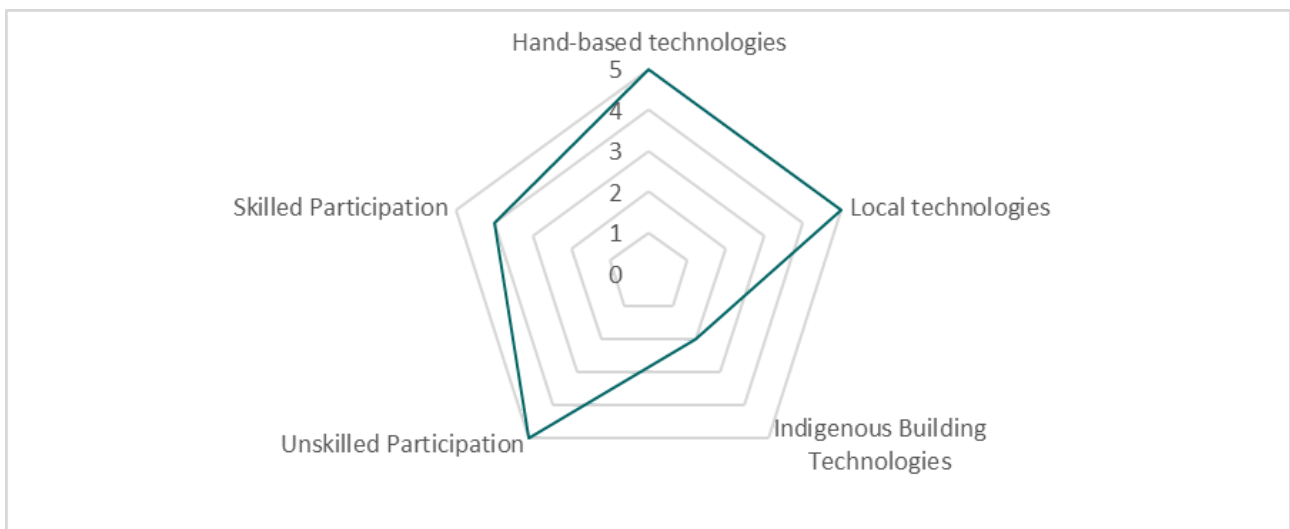


Chart 3: Total themes (Author, 2024)

In conclusion, South African practitioners implement participatory design and low-tech building technologies in various ways. These methods create a more circular design and construction process, which can inspire other practitioners to practise more economically, socially, culturally, and ecologically sustainable practices.

#### 4.4. PRACTITIONER PROJECTS

A further study was conducted on specific projects done by the chosen practitioners. This study identified the number of times they used the chosen themes relating to participatory design and low-tech building technologies in their designs. This is done to better understand the methods and accurately assess when certain building technologies are used.

#### 4.4.1. INTRODUCTION

This section conducts a precedent study on five of each practitioner's projects. Each project is rated according to whether it does or does not employ specific building technologies and is marked with an X accordingly (Table 21). Then, the results of each practitioner's five projects are compiled into a radar chart for a better visual understanding of the results.

Unskilled Participation	X	
Skilled Participation	X	
Hand-based technologies / Craft	X	
Local technologies	X	
Indigenous Building Technologies	X	

Table 21: Themes explanation (Author, 2024)

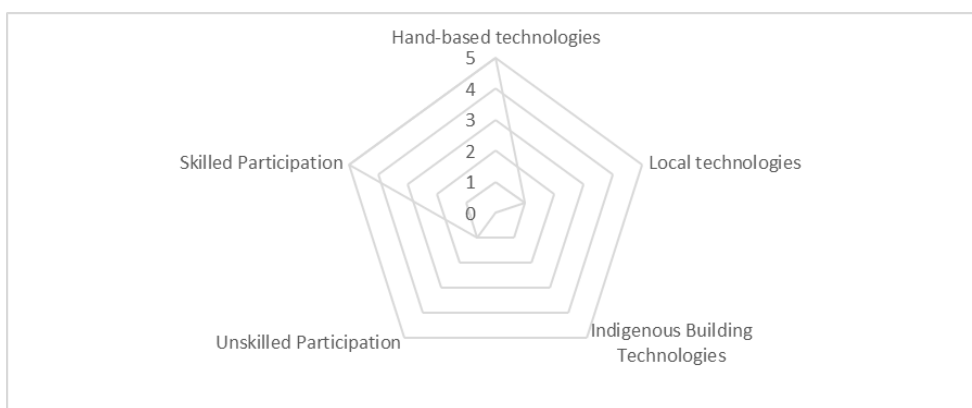


Chart 1: Themes (Author, 2024)

#### 4.4.2. CARIN SMUTS

##### Guga S'thebe 1996-2015

Guga S'thebe is an arts, culture, and heritage community centre. The local community had the most significant say in the structure's design, and many community members acquired new skills by being involved in the construction process (CSSTUDIO, 2010). Local artists made ceramic components for the building, a small local company made adobe-packed panels on site, and local carpenters were involved in the construction process (CSSTUDIO, 2010).

Unskilled Participation	X	Local community
Skilled Participation	X	Adobe panel makers
Hand-based technologies / Craft	X	Adobe + Ceramics
Local technologies	X	Adobe + Ceramics
Indigenous Building Technologies	X	Adobe

Table 22: Themes explanation Smuts (Author, 2024)

##### David Klaaste Multi-Purpose Centre 2002-2005

The David Klaaste Multi-Purpose Centre is a community centre based in Laingsburg. The local community was involved in the project by participating in the design through a series of workshops (CSSTUDIO, 2010).

Skilled local artisanal metalworkers were involved in the structure's construction, and many of the metals used were scraps found in the surrounding area and nearby farms (CSSTUDIO, 2010).

Unskilled Participation	X	Local community
Skilled Participation	X	Local artisanal metalworkers
Hand-based technologies / Craft	X	Local artisanal metalworkers
Local technologies	X	Found materials - metal
Indigenous Building Technologies		

Table 23: Themes explanation Smuts (Author, 2024)

### Uthango Lotyebiselwano 1989-1995

Uthango Lotyebiselwano is an art and cultural learning centre based in Nyanga, Western Cape. Smuts worked closely with the local community organisation on the design of this project, and further workshops with the community were initiated (CSSTUDIO, 2010). Unfortunately, the building was demolished in 2005 for political reasons, but Smuts has since rebuilt it. In the rebuilt project, the rubble of the old structure was used as infill for the designed gabion walls (CSSTUDIO, 2010).

Unskilled Participation	X	Workshops with community
Skilled Participation		
Hand-based technologies / Craft		
Local technologies	X	Reuse of site construction rubble
Indigenous Building Technologies		

Table 24: Themes explanation Smuts (Author, 2024)

### Ulwasi 1989-1998

The Ulwazi Youth Centre is based in Langa, Cape Town, an informal settlement with no public facilities. Multiple meetings with the community (including the gangs and youth) were initiated to facilitate their needs (CSSTUDIO, 2010). Local female contractors were also used to construct this building (CSSTUDIO, 2010). Some existing structures and components, like steel components, were reused (CSSTUDIO, 2010).

Unskilled Participation	X	Local community
Skilled Participation	X	Local female contractor
Hand-based technologies / Craft	X	Reuse of materials on-site
Local technologies		
Indigenous Building Technologies		

Table 25: Themes explanation Smuts (Author, 2024)

### Eerste Treetjies 1986-1990

The Eerste Treetjies Community Centre is based in a rural village in Namaqualand. As in most of Smuts's projects, the community was consulted before any design decisions were made (CSSTUDIO, 2010). The community decided that the structure would resemble the structures built by the nomadic herdsmen, who lived in round huts covered in animal skins (CSSTUDIO, 2010). Local unemployed labourers were involved in making local river sand and cement blocks, and local artists made local wool tapestries for sound insulation on the back wall (CSSTUDIO, 2010).

Unskilled Participation	X	Local community
Skilled Participation	X	Local unemployed labourers
Hand-based technologies / Craft	X	Making and packing blocks
Local technologies	X	Resembling vernacular arch

Indigenous Building Technologies	X	Resembling vernacular arch
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Table 26: Themes explanation Smuts (Author, 2024)

### Total Projects

Smuts’s projects involved the local community, primarily unskilled community members and skilled labourers or craftspeople. Most projects used hand-based and local technologies, mainly locally found materials. Lastly, a few projects involved indigenous building technologies.

PROJECTS	1	2	3	4	5
Unskilled Participation	X	X	X	X	X
Skilled Participation	X	X		X	X
Hand-based technologies / Craft	X	X		X	X
Local technologies	X	X	X		X
Indigenous Building Technologies	X				X

Table 27: Total themes explanation Smuts (Author, 2024)

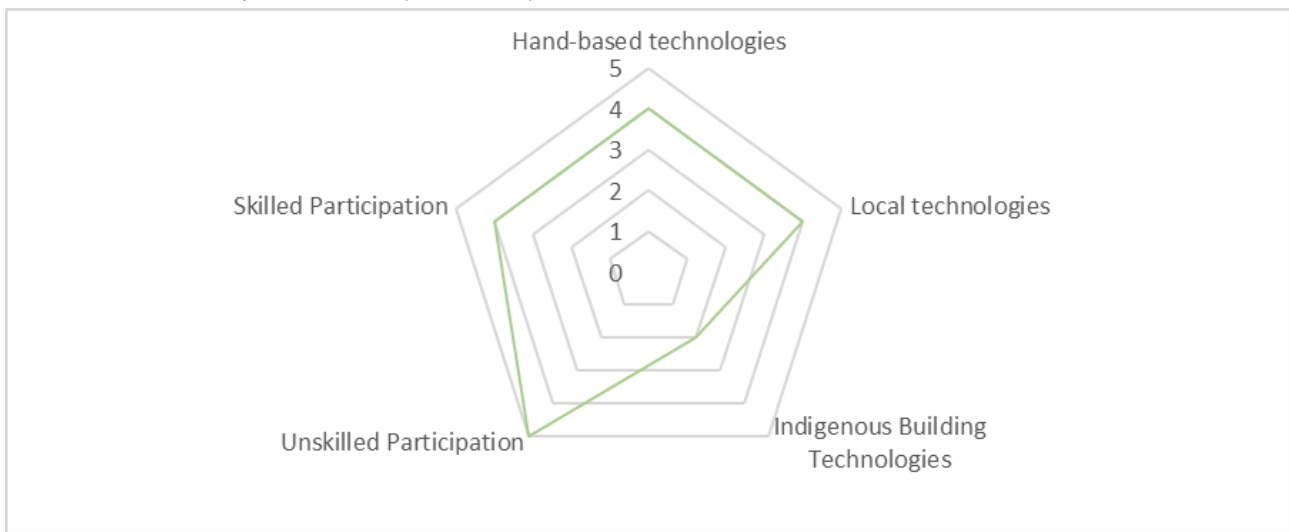


Chart 4: Total themes (Author, 2024)

### 4.4.3. KATE OTTEN

#### House Schutte 2017

House Schutte is a residential property in Midrand. It is mainly made of natural materials and low-tech technologies. The main focal point is a rammed earth wall constructed alongside stone and clay brick (KOA, 2010). Many of the materials used were found on-site (KOA, 2010).

Unskilled Participation		
Skilled Participation	X	Construction labourers – rammed earth
Hand-based technologies / Craft	X	Rammed earth + packed brick
Local technologies		
Indigenous Building Technologies		

Table 28: Themes explanation Otten (Author, 2024)

#### Lulu Kati Kati

Lulu Kati Kati is a residence turned architecture studio based in Melville, Johannesburg. This project emulates natural components like large gum poles from which the structure is suspended (SCAPE, 2024). It

also consists of a patchwork steel sheet façade inspired by the original Melville structures, which were constructed similarly. Many building components were scavenged and reused from other structures (SCAPE, 2024).

Unskilled Participation		
Skilled Participation		
Hand-based technologies / Craft	X	Steel patchwork
Local technologies	X	Steel patchwork
Indigenous Building Technologies		

Table 29: Themes explanation Otten (Author, 2024)

### Wits University Rural Campus

The Wits University Rural Campus is located in a rural part of the Limpopo province. The building is made from locally found materials to resemble its natural surroundings best (KOA, 2010). Local skills and labour were used to construct this building, and the programme itself was created to uplift the local community (KOA, 2010).

Unskilled Participation		
Skilled Participation	X	Local labourers and established skills
Hand-based technologies / Craft	X	Local labourers and established skills
Local technologies	X	Locally found materials
Indigenous Building Technologies		

Table 30: Themes explanation Otten (Author, 2024)

### House Rowe

House Rowe is an artist's residence based in Sandton. This project is 'handcrafted,' where the labourers work with natural materials to create organic shapes (KOA, 2010). Local artists were also approached to participate in this project (KOA, 2010).

Unskilled Participation		
Skilled Participation	X	Local labourers and artists
Hand-based technologies / Craft	X	Natural materials
Local technologies		
Indigenous Building Technologies		

Table 31: Themes explanation Otten (Author, 2024)

### Art Therapy Centre

The Art Therapy Centre is based in Soweto. This project was conceived as a sculpture, and many local artists and people partaking in therapy at this space were involved in its construction (KOA, 2010). Local labourers were given artistic freedom to create specific components as they wished, something most had not experienced before (KOA, 2010). One of these components is how the bricks were laid in particular patterns for the main tower structure of this building.

Unskilled Participation	X	Participants from the therapy centre
Skilled Participation	X	Local labourers and artists
Hand-based technologies / Craft	X	Artisanal laying of bricks
Local technologies		
Indigenous Building Technologies		

Table 32: Themes explanation Otten (Author, 2024)

### Total Projects

Otten’s projects involved hand-based technologies and sometimes ‘found’ objects and local technologies. Most of her projects involve local skilled labourers or craftspeople but do not involve unskilled participation as much. None of the projects analysed involved indigenous building technologies.

PROJECTS	1	2	3	4	5
Unskilled Participation					X
Skilled Participation	X		X	X	X
Hand-based technologies / Craft	X	X	X	X	X
Local technologies		X	X		
Indigenous Building Technologies					

Table 33: Total themes explanation Otten (Author, 2024)

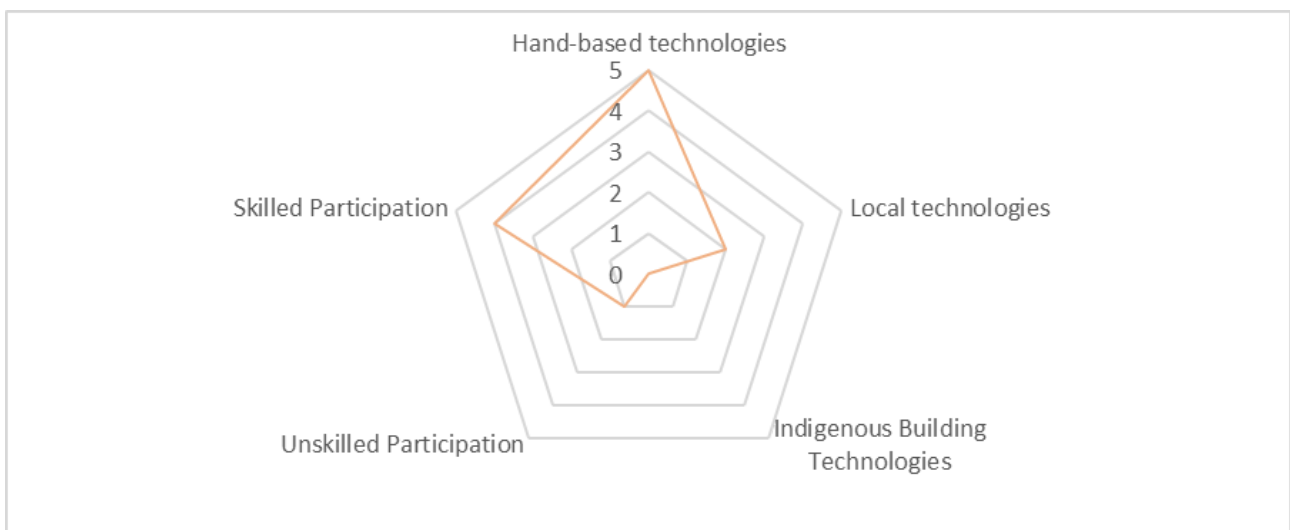


Chart 5: Total themes (Author, 2024)

### 4.4.4. EARTH WORLD ARCHITECTS

#### Future Africa Innovation Campus 2018

The Future Africa Innovation Campus was built for the University of Pretoria postgraduate students. Digital CAD drawings were made for the plywood portal frame structures, which were converted to a digital programme and CNC cut (Ewarch, 2024). Because plywood is a lightweight material, the sanding, joining, and on-site assembly could be done by hand (Ewarch, 2024). This method allowed Earthworld to accumulate labourers and teach them new skills in this niche construction method.

Unskilled Participation		
Skilled Participation	X	Plywood construction and assembly
Hand-based technologies / Craft	X	Assembly of components
Local technologies		
Indigenous Building Technologies		

Table 34: Themes explanation Earthworld (Author, 2024)

### House Dreyer 2017

House Dreyer is a residence based in Pretoria. In this project, laminated saligna panes were CNC-cut into modular components (Ewarch, 2024). These components were hand-assembled on-site and, since they are light in weight, could be easily transported to the destination (Ewarch, 2024).

Unskilled Participation		
Skilled Participation	X	Wood construction and assembly
Hand-based technologies / Craft	X	Assembly of components
Local technologies		
Indigenous Building Technologies		

Table 35: Themes explanation Earthworld (Author, 2024)

### KoSPAZA 2021

The KoSPAZA is a pop-up restaurant with many other uses. It has a complete plywood structure that has been hand-assembled (Ewarch, 2024). The plywood components, similar to the Future Africa Campus, have been computationally drafted to be CNC cut (Ewarch, 2024).

Unskilled Participation		
Skilled Participation	X	Plywood construction and assembly
Hand-based technologies / Craft	X	Assembly of components
Local technologies		
Indigenous Building Technologies		

Table 36: Themes explanation Earthworld (Author, 2024)

### House Visser 2000

House Visser is a residential structure with the Union Building as a backdrop. This structure was renowned for effectively using each material, especially brick (Ewarch, 2024). The sizeable vaulted brick barrel-vaulted roof forms the main shell of the structure (Ewarch, 2024). This project allowed the designers to become more involved in constructing the structure (Ewarch, 2024). With this, the designers could take on a more circular design process, as more detailed components could only be finalised after certain elements were built (Ewarch, 2024). This also allowed the client to be more involved in the design and construction process (Ewarch, 2024).

Unskilled Participation	X	Client become involved
Skilled Participation	X	Architects become more involved
Hand-based technologies / Craft	X	Brick barrel vault
Local technologies		
Indigenous Building Technologies		

Table 37: Themes explanation Earthworld (Author, 2024)

### Highveld house

Highveld House is situated in Mpumalanga. The main structure comprises stereotomic stone walls (Ewarch, 2024). The roof is supported by plywood rafters constructed like the Future Africa campus and CoSPAZA (Ewarch, 2024).

Unskilled Participation		
Skilled Participation	X	Plywood construction and assembly
Hand-based technologies / Craft	X	Assembly of components + stone
Local technologies	X	Stone Construction

Indigenous Building Technologies		
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Table 38: Themes explanation Earthworld (Author, 2024)

### Total Projects

Most of Earthworld Architects' projects follow hybrid construction methods. They use a few unskilled participants and local technologies, but this is because of this hybrid construction method. Earthworld shines in using skilled labourers in niche construction methods, and all of the precedents studied involved hand-based methods. Earthworld is the leading company in testing these circular design and construction methods.

PROJECTS	1	2	3	4	5
Unskilled Participation				X	
Skilled Participation	X	X	X	X	X
Hand-based technologies / Craft	X	X	X	X	X
Local technologies					X
Indigenous Building Technologies					

Table 39: Total themes explanation Earthworld (Author, 2024)

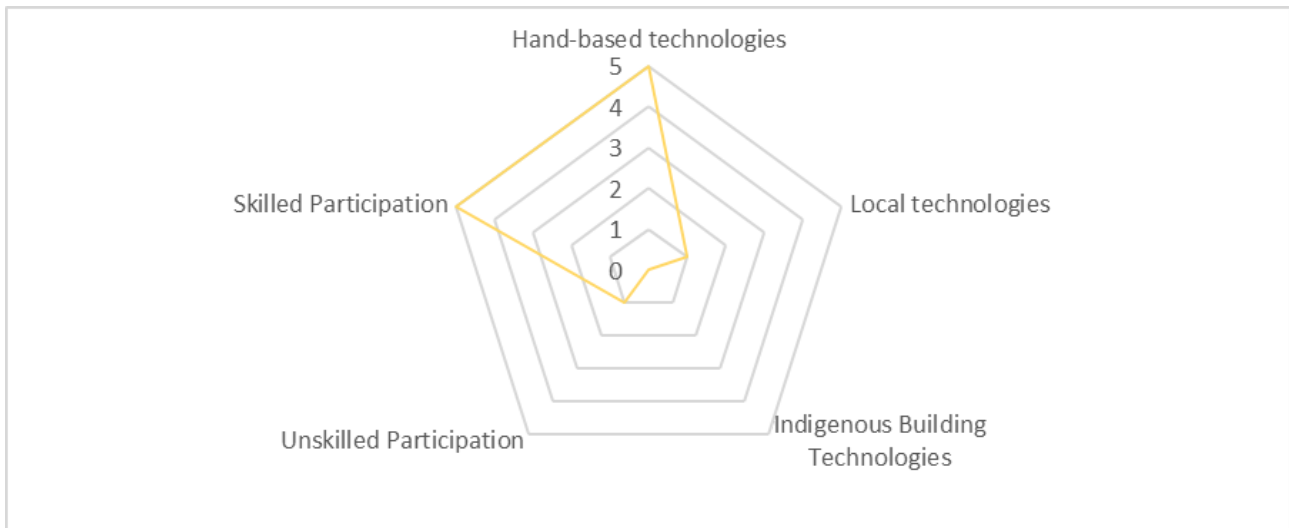


Chart 6: Total themes (Author, 2024)

### 4.4.5. PETER RICH

#### Angels View Earthen House 2021

The Angels View Earthen House is a getaway accommodation. It is made of load-bearing rammed earth and supports a catenary arch constructed by local craftsmen (PeterRichArchitects, 2020). Local materials were used, and unskilled labourers were involved in the construction of this project (PeterRichArchitects, 2020).

Unskilled Participation	X	Unskilled labourers
Skilled Participation	X	Local craftspeople
Hand-based technologies / Craft	X	Rammed earth
Local technologies	X	Local materials
Indigenous Building Technologies		

Table 40: Themes explanation Rich (Author, 2024)

### Mapungubwe Interpretation Centre 2009

The Mapungubwe Interpretation Centre is a cultural interpretation centre based in the Mapungubwe National Park, Limpopo. Hand-pressed soil tiles were used to create freestanding vaulted structures by placing the tiles using a latticework method (PeterRichArchitects, 2020). The soil from these tiles was found in the surrounding area (PeterRichArchitects, 2020). This structure was built by local skilled and unskilled labourers, both gaining skills in a new construction method (PeterRichArchitects, 2020).

Unskilled Participation	X	Making soil tiles and constructing
Skilled Participation	X	Making soil tiles and constructing
Hand-based technologies / Craft	X	Sun-dried soil tiles
Local technologies	X	Locally found soil
Indigenous Building Technologies		

Table 41: Themes explanation Rich (Author, 2024)

### House Kemp

House Kemp is a wooden holiday house in the Western Cape. In its layout and other details, the structure was designed to resemble the Ndebele traditional method of building (PeterRichArchitects, 2020).

Unskilled Participation		
Skilled Participation		
Hand-based technologies / Craft	X	Timber construction
Local technologies		
Indigenous Building Technologies	X	Ndebele layout and construction

Table 42: Themes explanation Rich (Author, 2024)

### Alexandra Heritage Centre

The Alexandra Heritage Centre is based in Alexandra Township in Johannesburg. It is designed to host an exhibition hall and civic spaces. The building is constructed from a steel framework and a facade with a patchwork of different materials, including metal and polycarbonate sheets, to resemble the structures in the surrounding area (PeterRichArchitects, 2020). The local community was actively involved in construction (PeterRichArchitects, 2020). Soil bricks made from local soil were also used in this structure, and community members were encouraged to make collages with cutoff marble, stone and masonry (PeterRichArchitects, 2020).

Unskilled Participation	X	Local community
Skilled Participation		
Hand-based technologies / Craft	X	Soil brick + offcut collage
Local technologies	X	Soil brick + found materials
Indigenous Building Technologies		

Table 43: Themes explanation Rich (Author, 2024)

### Westridge House

The Westridge House is an edition and redesign of an existing home based in Parktown, Johannesburg. The existing structure, made of brick and corrugated iron roof sheeting, is usually seen in the surrounding area (Nobile, 2018). The redesign of the structure and garden has been greatly influenced by African Indigenous architecture, especially the gridded geometry inspired by Ndebele architecture (Nobile, 2018).

Unskilled Participation		
Skilled Participation		
Hand-based technologies / Craft	X	Brick

Local technologies	X	Vernacular inspiration
Indigenous Building Technologies	X	African (Ndebele) inspiration

Table 44: Themes explanation Rich (Author, 2024)

### Total Projects

It is evident that Rich values tradition, vernacular and low-tech building technologies. He often uses natural materials that can be found in the surrounding areas. Since Rich is fascinated with indigenous construction methods, he has the opportunity to explore this even more.

PROJECTS	1	2	3	4	5
Unskilled Participation	X	X	X	X	
Skilled Participation	X	X			
Hand-based technologies / Craft	X	X	X	X	X
Local technologies	X	X		X	X
Indigenous Building Technologies			X		X

Table 45: Total themes explanation Rich (Author, 2024)

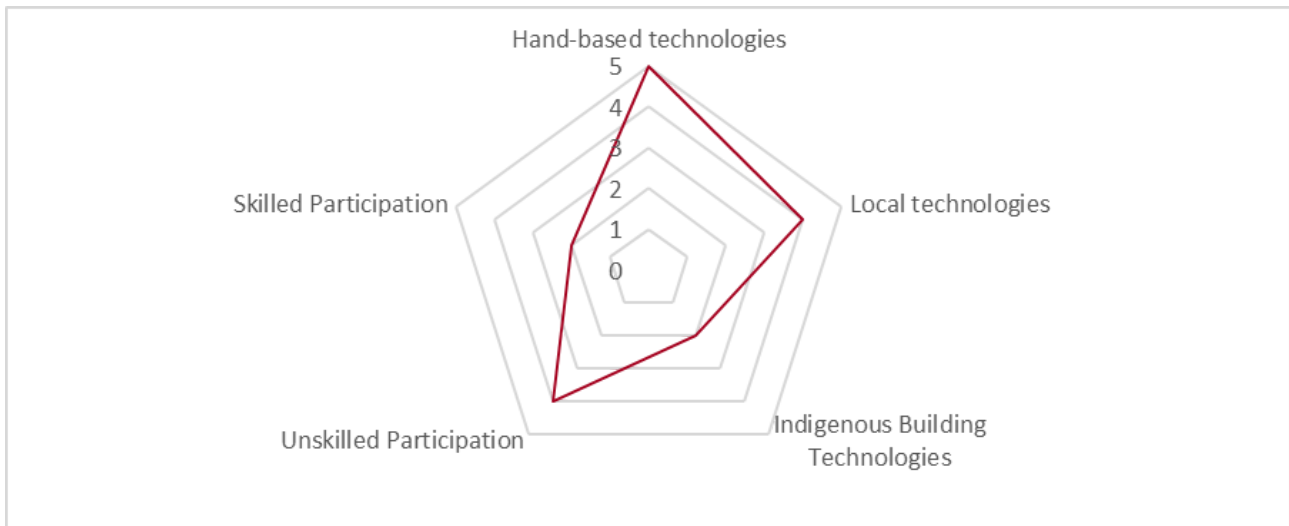


Chart 7: Total themes (Author, 2024)

### 4.4.6. JACO BOOYENS

#### Buffelsdrift farm 2020

Buffelsdrift Farm is a leisure accommodation in the Western Cape. Its structure consists of a poured mud, cob, and brick vaulted roof (Booyens, 2005). The catenary arch is constructed from brick by skilled craftsmen (Booyens, 2005). Accompanying this, load-bearing cob walls with steel tension rod insertions were created by skilled labourers (Booyens, 2005). Cob is a traditional construction method, and labourers are already experienced in it.

Unskilled Participation		
Skilled Participation	X	Cob construction + brick arch
Hand-based technologies / Craft	X	Cob construction + brick arch
Local technologies	X	Local skill in cob construction
Indigenous Building Technologies	X	Local skill in cob construction

Table 46: Themes explanation Booyens (Author, 2024)

### Subsistence Farm Rysmierberg 2013

The Subsistence Farm is based in Rysmierberg, Western Cape. It is built with materials found on-site with minimal labour as it is based far from other local communities (Booyens, 2005). Cob walls were constructed using the butabtu method of layering the cob and adding cement (Booyens, 2005). Members of the local community based close to the site were involved in constructing this building (Booyens, 2005).

Unskilled Participation	X	Community participation
Skilled Participation		
Hand-based technologies / Craft	X	Cob construction
Local technologies	X	Cob construction
Indigenous Building Technologies		

Table 47: Themes explanation Booyens (Author, 2024)

### Damaraland Clay project 2005-2006

The Damaraland Clay project is based in Namibia. It's constructed from sun-dried bricks made on-site from nearby found materials (Booyens, 2005). Unskilled labourers built the building, and since it was designed with a free vaulting roof, the construction methods had to be trial-and-error (Booyens, 2005).

Unskilled Participation	X	Unskilled labourers
Skilled Participation		
Hand-based technologies / Craft	X	Sun-dried brick, surrounding material
Local technologies	X	Sun-dried brick, surrounding material
Indigenous Building Technologies		

Table 48: Themes explanation Booyens (Author, 2024)

### Off-grid house Lowerland Prieska

The Off-grid house is a farm residence in Lowerland Prieska. It was constructed from stone and clay, easily found on the nearby river banks (Booyens, 2005). Large soil berm buffers were also built as shelter from the constant wind (Booyens, 2005).

Unskilled Participation		
Skilled Participation		
Hand-based technologies / Craft	X	Stone and clay construction
Local technologies	X	Stone and clay construction
Indigenous Building Technologies		

Table 49: Themes explanation Booyens (Author, 2024)

### Fort Haasbroek

Fort Haasbroek was constructed from earthen materials, including clay, mud, and rammed earth (Booyens, 2005). For this building, cement did not have to be mixed with the rest of the rammed earth, as it had enough clay (Booyens, 2005). Wood found washed up in the nearby body of water was also used for the columns (Booyens, 2005).

Unskilled Participation		
Skilled Participation		
Hand-based technologies / Craft	X	Rammed earth
Local technologies	X	Locally found materials
Indigenous Building Technologies		

Table 50: Themes explanation Booyens (Author, 2024)

**Total Projects**

It is evident that Booyens values locally found natural materials in his designs. He also often uses hand-based local building technologies. Since his projects are usually in more rural areas, he often uses unskilled labourers. Booyens has employed indigenous building technologies and has the opportunity to explore this even more.

PROJECTS	1	2	3	4	5
Unskilled Participation		X	X		
Skilled Participation	X				
Hand-based technologies / Craft	X	X	X	X	X
Local technologies	X	X	X	X	X
Indigenous Building Technologies	X				

Table 51: Themes explanation Booyens (Author, 2024)

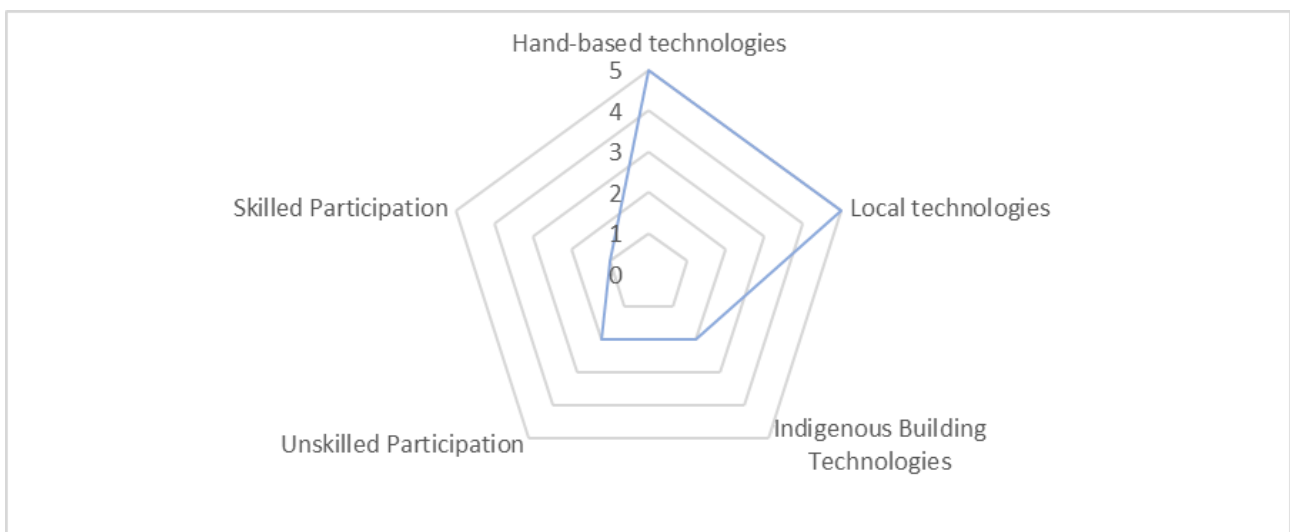


Chart 8: Total themes (Author, 2024)

**4.4.7. PRACTITIONERS COMBINED**

The findings show that all the practitioners chosen used hand-based building technologies in most, if not all, of their projects. Many practitioners employed skilled practitioners and local technologies in their design and construction process (Chart 9). Most practitioners were chosen because they often use these technologies; thus, the findings have backed up the estimated outcome. Only some practitioners employ unskilled practitioners on the lower end of the scale, and few have employed indigenous building technologies in their designs (Chart 9).

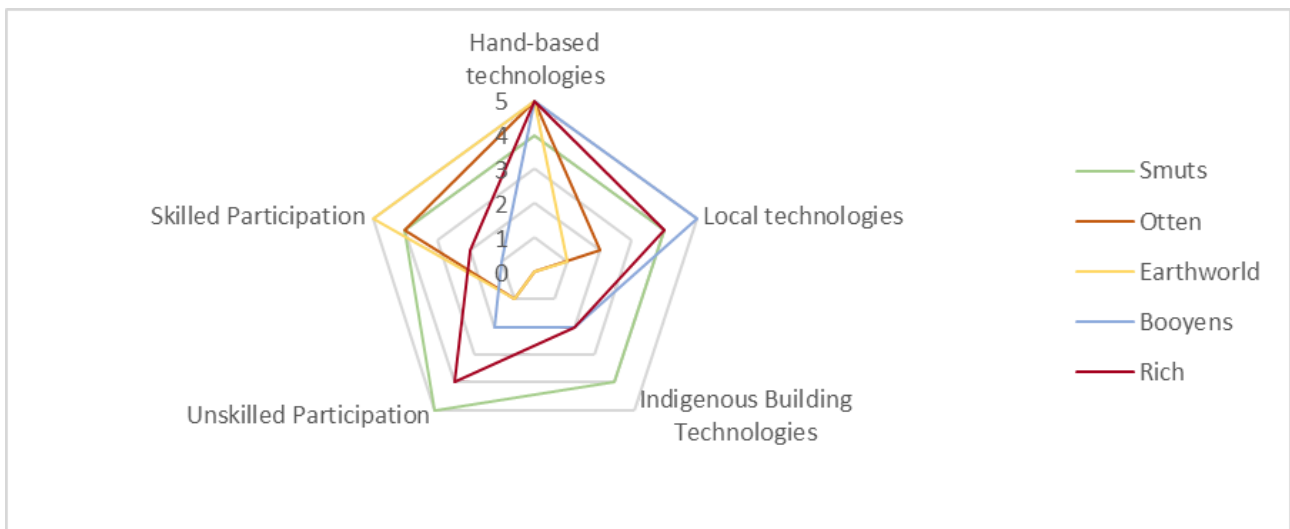


Chart 9: Total themes of all practitioners (Author, 2024)

#### 4.4.8. DISCUSSION

It is evident in Smuts' work that she employs both unskilled and skilled participants regularly in her design and construction process. This makes sense since she is renowned for community involvement in her structures. Her company's design and construction process becomes more circular through this involvement. This is due to her process being more iterative because the community needs to be considered, and the design changes accordingly. This also translates into the construction process, as local craftspeople are usually pushed to decide on specific design components. This results in buildings that are original to their location and the people involved.

Otten often employs hand-based technologies and values craft and the act of making in her designs. This translates into her rich understanding and thoughtful use of materials in her designs. For instance, in the construction of Lulu Kati Kati, she used found offcut pieces of metal and assembled them to resemble the local patchwork homes of Melville. This is also translated into her employment of skilled practitioners, like local craftspeople, to design and construct her structures.

Earthworld's design and construction process mainly uses hand-based technologies and skilled participation as building technologies. Although they lack other themes in this study, like indigenous building technologies, they use specific, hybrid methods to create a more circular design and construction process. Their hybrid construction method mainly focuses on the computational design of modular components that can be later hand-assembled. This specific process allows them to design while building and creating component prototypes. This is the only way to know if a component is intended one hundred per cent correctly, thus creating an iterative process.

Rich's work demonstrates his use of hand-based and local technologies, such as materials readily available in the surrounding area. This can be seen in his Mapungubwe Interpretation Centre, where hand-pressed soil tiles were created from soil found in the surrounding area. He often employs unskilled labour in his projects to develop a co-design environment where skills can be transferred. Indigenous technologies deeply influence Rich's architecture, and he strives to create designs that emulate this, although abstractly. There is an opportunity for Rich to use more indigenous methods of construction in his designs for more circular outcomes.

Booyens employs hand-based and local technologies in all of the projects analysed. This is due to many of his projects being located in remote areas. Because of this, he had to use the materials and skills that were available at the location. This led to him employing more unskilled participants than skilled participants, which resulted in a construction process where he had the opportunity to experiment with unusual methods. Booyens has employed some indigenous technologies but not widely in his designs. Since most of his projects are based in rural areas where people might still have these skills, he can employ more of these methods.

All practitioners employ emerging building technologies in their design and construction processes. These include hand-based and local technologies and allow for skilled participation in the construction process. This has allowed practitioners to explore more circular design and construction processes, first by utilising these technologies and second by formulating more iterative processes. Only a few practitioners have employed unskilled participation in the form of local communities in their projects, and very few have employed Indigenous building technologies in their projects. This is an unforeseen outcome since most practitioners value using natural, locally found materials and local skills. The existing technologies allow more practitioners to employ Indigenous building technologies. It could also help the emergence of these technologies as a circular solution in the design and construction processes of modern South African architecture. This further strengthens the need for these topics to be brought up for more circular design processes.

## 4.5. DISCUSSION ON ALL DATASETS

### 4.5.1. EMPLOYMENT OF CIRCULAR DESIGN

This section discusses how South African practitioners have employed participatory design and low-tech building technologies. It also discusses the value of these methods and how they could lead to circular design and construction processes.

UNSKILLED PARTICIPATORY DESIGN: Smuts employs unskilled participation through community-based projects, where the community's needs and existing skills are assessed and used in the design and construction process. This creates a circular design and construction process since the structure will go through iterations at every point the community has been involved (Fig 9). Earthworld Architects also employs unskilled participants in hand-assembling CNC-cut plywood components and allows niche skills to be taught.

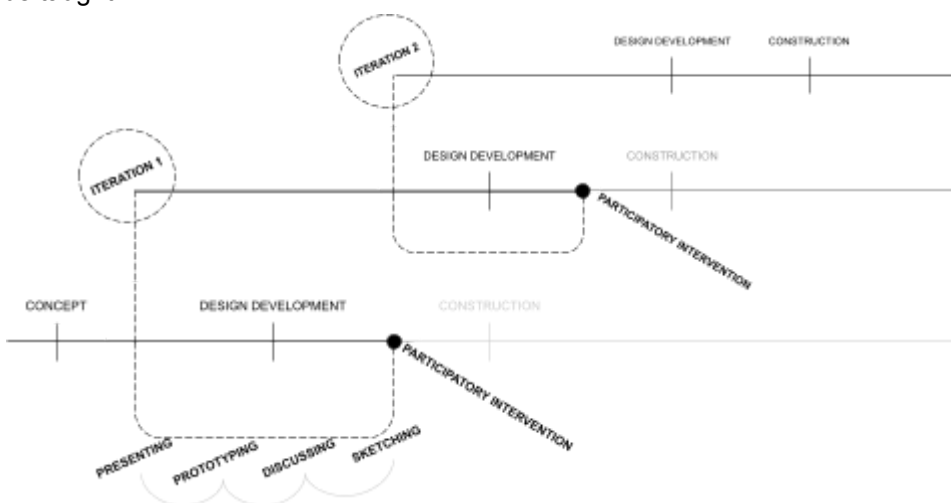


Figure 9: Improved design process, adapted from Nitsche (2018:1620)

**SKILLED PARTICIPATORY DESIGN:** Smuts and Otten often employ local craftspeople or skilled labourers to participate in their design. The results are usually circular in their construction since each participant is urged to create a result in their style. Rich also employs skilled local participants in his designs to create an outcome related to the local environment.

**HAND-BASED BUILDING TECHNOLOGIES:** Earthworld Architects employs hand-based technologies to hand-assemble CNC-cut plywood components. This creates a circular design and construction process as the objects go through iterations. This is done because components must be prototyped before the final installation (Fig 14). This also allows the architect to become part of the entire design and construction process.

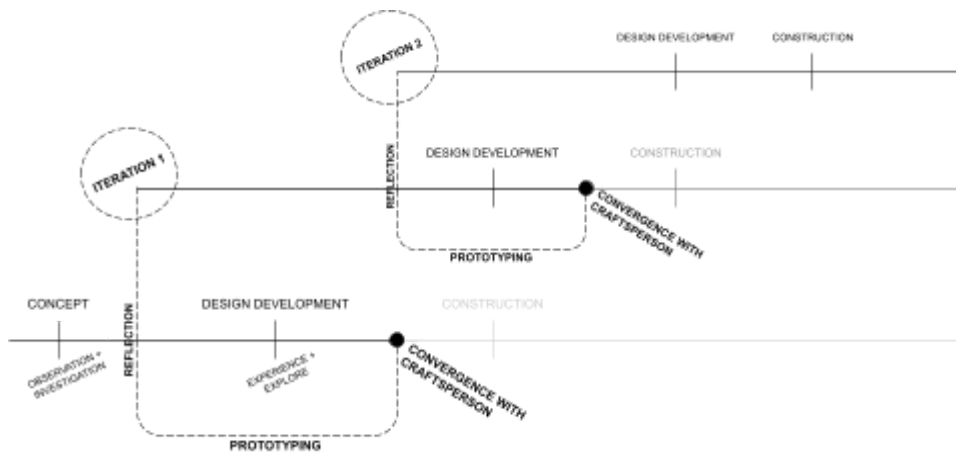


Figure 14: Improved design process, influenced by Nitsche (2018:1620)

**HAND-BASED AND LOCAL BUILDING TECHNOLOGIES:** Since Smuts incorporates local communities in her designs, she often employs hand-based and local building technologies. This is done through labour-intensive construction methods and building with local natural or found materials. In her projects, Otten usually incorporates local technologies through locally ‘found’ objects. Rich often utilises readily available materials locally and implements them using hand-based methods. Booyens frequently employs hand-based local technologies in his designs, as he usually works in rural areas. Thus, he uses the surrounding materials and skills to create sustainable outcomes. Booyens's experimentation with these methods becomes more circular, as it is an iterative process until a successful result is found.

**INDIGENOUS BUILDING TECHNOLOGIES:** The Environmental Education Center (nr. 64) employed indigenous methods in their project through the use of Cob and natural plaster made of cow dung and lime. Rich abstractly draws inspiration from indigenous building technologies in his designs, often through geometry. Each of the practitioners has an opportunity to employ this more in their projects, as they already value hand-based local technologies and participation in their design processes.

#### 4.5.2. RELATIONSHIPS OF ALL DATASETS

This section compiles and analyses the data gathered from the catalogue’s case studies, interviews, and practitioner project analyses according to their relationships. Each data set has also been transformed into a five-point average graph to be overlaid. It also explores how the applied methods could contribute to developing circular design and construction processes.

#### EMERGING BUILDING TECHNOLOGY CATALOGUE

The following datasets belong to the catalogue and have been transformed from a nine to a five-point radar chart (Chart 10).

Project/Precedent number	68	64	60	42	30	22	21	15	2
Unskilled Participation	X	X	X			X	X	X	X
Skilled Participation	X	X		X	X	X	X	X	
Hand-based technologies / Craft	X	X	X	X	X	X	X	X	X
Local technologies	X	X				X	X	X	X
Indigenous Building Technologies	X	X				X	X		X

Table 13: Total themes analysis of case studies (Author, 2024)

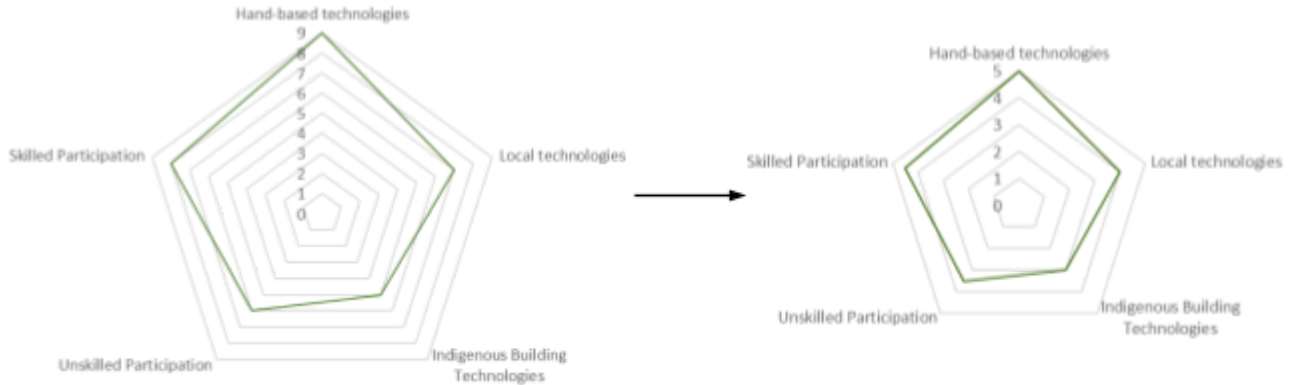


Chart 10: Total themes analysis of case studies five-point chart (Author, 2024)

## PRACTITIONER INTERVIEWS

The second dataset comprises the interviewed practitioners (Chart 3).

Practitioners	Smut	Otte	Eart	Rich	Booy
Unskilled Participation	X	X	X	X	X
Skilled Participation	X	X	X	X	
Hand-based technologies / Craft	X	X	X	X	X
Local technologies	X	X	X	X	X
Indigenous Building Technologies	X			X	

Table 20: Total themes (Author, 2024)

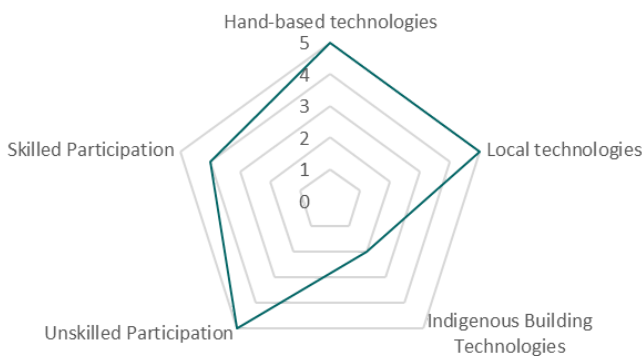


Chart 3: Total themes (Author, 2024)

## PRACTITIONER PROJECTS

The final datasets comprised the practitioner's projects analysed, and averages in the projects had to be found (Chart 11).

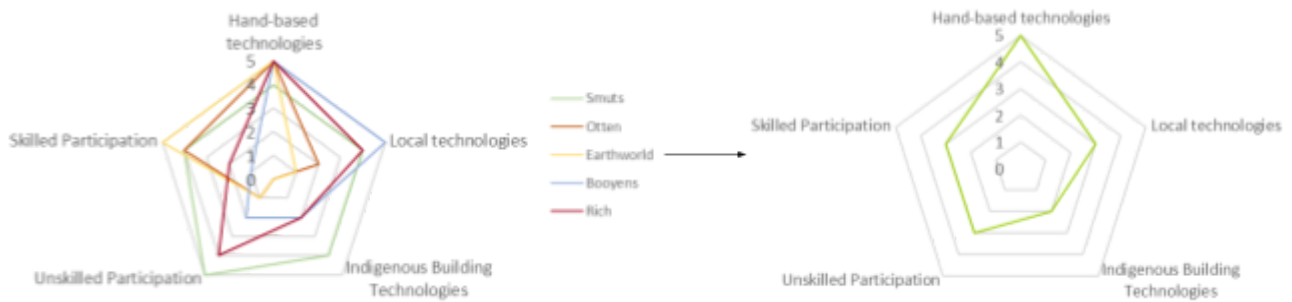


Chart 11: Total themes of all practitioners average (Author, 2024)

## PRACTITIONER PROJECTS

All datasets were compiled into one radar chart to be compared (Chart 12).

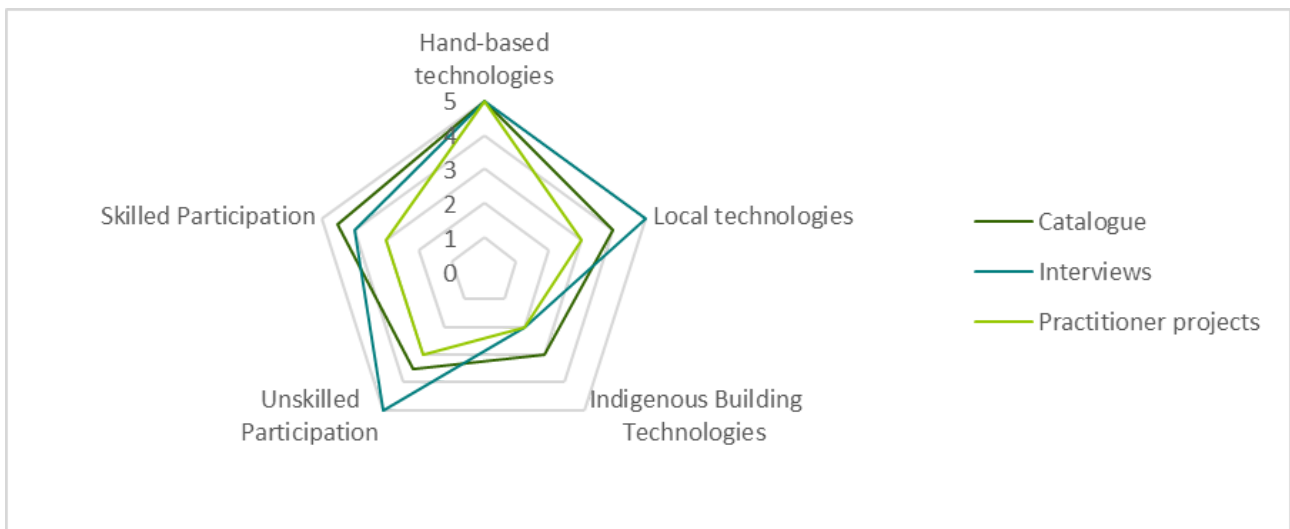


Chart 12: All datasets (Author, 2024)

In all instances, hand-based building technologies have been applied. The interviews indicate a wide range of adoption of local technologies. However, when the projects of each practitioner were analysed, this did not appear to be the case. The case of employing unskilled participation is the same. This would indicate that practitioners value local technologies and unskilled participation (who usually form part of the local communities) but fail to implement them in their designs. Although this is true, there is still a higher-than-average uptake of local technologies and unskilled participation. Skilled participation is utilised less than unskilled, except for in the catalogue.

This indicates that many South African practitioners employ local craftspeople and hand-based labourers. Since all of the practitioners and projects chosen employ hand-based building technologies, it serves the opportunity for a wider uptake of skilled or unskilled participation. Participatory design, if local community members or skilled labourers, allows for the employment of hand-based technology, which is the primary method all chosen practitioners value. Thus, the uptake of participatory processes could lead to the employment of circular design and construction processes. It can also lead to more circular processes through iterations created in the design and construction processes. This is because the involvement of communities and craftspeople will inherently lead to design iterations, which could lead throughout the entire process.

Indigenous building technologies have shown to be least utilised by South African practitioners. The interviewed practitioners applied it below the average amount in their projects, and other practitioners from

the catalogue implemented it only slightly more. This is an unusual finding since South African practitioners have the amenities to apply these methods in their designs. It has also been clear that an above-average number of practitioners employ local technologies and skilled practitioners who might have inherited indigenous skills. Employing indigenous building technologies can improve the uptake of skilled participants in this field in architectural projects. The uptake of skilled Indigenous practitioners could thus lead to more circular processes and sustainable project outcomes.

## 5. CONCLUSION

The study emphasises circular design processes and how participatory design can facilitate their adoption. It critiques the linear and conventional nature of modern design processes, highlighting how industrialisation has fragmented the role of architects. The circular design allows architects to engage more deeply with the construction process, enhancing sustainability and adaptability. The report advocates for a return to hand-based, community-oriented, and culturally relevant construction methods to restore architects' comprehensive involvement in the building process.

The study aimed to bridge gaps in the industry and encourage more practitioners to adopt or innovate similar technologies, advocating for economically, ecologically, and socially sustainable design practices. The study investigates the impact of industrialisation on the role of architects, proposing a shift towards incorporating low-tech building technologies through participatory design processes. It critiques the shift from the architect as a master builder to a more fragmented role due to advanced industrial techniques. The research aims to re-establish architects as integral to the entire building process by emphasising sustainable, community-based, and culturally resonant construction methods.

The study uses several methods to analyse data. First, five themes were derived from the literature to assess various projects and practitioners in South Africa. These themes are Unskilled and skilled participatory design and hand-based, local, and indigenous building technologies. Participatory design promotes skills transfer and job creation, particularly in lower-income and rural areas, fostering community upliftment. It also allows for hand-based technologies through labour-intensive and craft-based approaches. Adopting local building technologies allows for more sustainable processes as local skills and materials can be utilised. Integrating indigenous building technologies into modern practices can lead to more culturally and socially relevant architecture. A pre-set catalogue of case studies, interviews with South African practitioners, and precedent studies of the interviewed individuals were analysed according to these themes.

The analysed data indicated that the chosen projects employed hand-based technologies and that most employed skilled participants. This is due to practitioners and projects from the catalogue, who closely align with the study's focus, being chosen. Since all of the practitioners and projects chosen employ hand-based building technologies, it serves the opportunity for a wider uptake of skilled or unskilled participation. Participatory processes could lead to more circular design and construction processes. A wide range of practitioners value local technologies but do not employ it as much in their designs. There is an opportunity for a wider uptake for this as most practitioners already apply hand-based methods and probably employ skilled participants from the local area. Unskilled participation has had a similar outcome. The least adoption applies to indigenous technologies. Yet, all contribute to circular design and construction processes in South Africa. The literature also highlights a lack of adoption of indigenous building technologies in the South African context. Despite having the resources, South African practitioners rarely employ indigenous building technologies, which could enhance skilled participation and lead to more sustainable and circular architectural projects.

Participatory design processes lead to the employment of low-tech building technologies through the application of iterations in the design and construction process driven by the participants. The participants could consist of unskilled community members or skilled craftspeople and labourers. By involving local craftsmen and labourers, local techniques and other technologies could drive the design and make it more socially, economically and ecologically sustainable. Participation of the practitioner in the entire design and construction process can also lead to circular and sustainable methods. This is due to the iterations created when a practitioner prototyping their designs. This can also entail a constant back-and-forth between a craftsperson and a practitioner, where changes in the design would constantly be made as knowledge is transferred.

The studied South African practitioners have applied participatory and low-tech design strategies to adopt more circular design and construction processes and to become more socially, economically, and ecologically sustainable. Smuts has employed all the themes in most of her designs, especially unskilled participation, as she is renowned for her community-based projects. Her design and construction process is the most circular since participation allows constant iterations. She also employs hand-based methods in all these designs since she aims to make the process as labour-intensive as possible. She often utilises existing local materials and skills for her designs and thus develops socially, economically and ecologically sustainable outcomes. Otten values the role of craft in architecture and thus often employs hand-based technologies. This has resulted in her employing local craftspeople in some of her designs, creating an iterative process as the craftspersons were given the opportunity to self-instruct their work. Earthworld architects use computational design, such as CNC-cut plywood components, for easy hand-assembly by unskilled labour, which differs from low-tech approaches. This approach is circular in its own way, as the prototyping process is iterative. Rich often employs hand-based and local building technologies. This has allowed him to create a process involving skilled and unskilled participants. Booyens is experienced in many hand-based technologies. Since he is renowned for working in rural areas, he often incorporates local materials and skills into his designs. This has allowed him to experiment with local methods and even indigenous building technologies.

Adopting circular design and construction processes is still not widely utilised in South Africa. The research has allowed exploring these processes through participation and adoption low-tech technologies. It has set criteria for future studies to build upon. How practitioners can successfully apply indigenous building technologies to modern architectural practice is still unknown. Further research can build upon these methods. They can also interview more practitioners who utilise participatory design and low-tech building technologies. Practitioners outside South Africa can also be interviewed on the successful application of indigenous building technologies. The research contributes to a deeper understanding of how practitioners can situate themselves in circular design and construction processes and resemble a 'modern master builder'. It does this by assessing current building practices and identifying opportunities to make it more circular.

Word count excluding tables: 15 257

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#### **APPENDIX LINKS:**

The complete catalogue can be accessed by following the link below:

[📄 2023 RFS 701 Final Catalogue](#)


The interview Excel sheet can be accessed by following the link below:

[📄 2024\\_All Transcribed Interviews](#)



Entry Number	Architect	Project	Images & Diagrams	Year of Completion (or Ongoing)	Location (or Ongoing)	General Project Description	Emerging building technology			Development status	Value			Value			
							Building method (B)	Construction technique (CT)	Structural system (S)		Material production	High-tech	Low-tech		Development status	Environmental	Social
30	Burkard Architects	Plaza Atlanta Campus		2014	Atlanta, Georgia, Atlanta, GA, USA 33.773333 N, 84.391667 W	Headquartered in the Future Axiom, the Plaza Atlanta Campus is a 1.2 million sq ft office building with a central atrium, a 10-story tower, and a 10-story parking garage. The building is designed to be a sustainable, high-tech office building with a central atrium, a 10-story tower, and a 10-story parking garage.	Physical concrete (P)	Concrete (C)	Structural system (S)	Developing	Environmental	Social	Economic	Resilience	Health	Community	Value
42	Mori Okada Architects	House Saitama		2017	Osaka, Japan 34.693333 N, 135.750000 E	Headquartered in the Future Axiom, the House Saitama is a 1.2 million sq ft office building with a central atrium, a 10-story tower, and a 10-story parking garage. The building is designed to be a sustainable, high-tech office building with a central atrium, a 10-story tower, and a 10-story parking garage.	Physical concrete (P)	Concrete (C)	Structural system (S)	Completed	Environmental	Social	Economic	Resilience	Health	Community	Value
60	University of Technology Design/Studio	Project Alpha		2014	London, UK 51.507351 N, 0.127758 W	Headquartered in the Future Axiom, the Project Alpha is a 1.2 million sq ft office building with a central atrium, a 10-story tower, and a 10-story parking garage. The building is designed to be a sustainable, high-tech office building with a central atrium, a 10-story tower, and a 10-story parking garage.	Physical concrete (P)	Concrete (C)	Structural system (S)	Completed	Environmental	Social	Economic	Resilience	Health	Community	Value
64	University of Technology Design/Architects	University of Technology Cultural Project		2013	London, UK 51.507351 N, 0.127758 W	Headquartered in the Future Axiom, the University of Technology Cultural Project is a 1.2 million sq ft office building with a central atrium, a 10-story tower, and a 10-story parking garage. The building is designed to be a sustainable, high-tech office building with a central atrium, a 10-story tower, and a 10-story parking garage.	Physical concrete (P)	Concrete (C)	Structural system (S)	Completed	Environmental	Social	Economic	Resilience	Health	Community	Value

Entry Number	Architect	Project	Images & Diagrams	Year of Completion (2000-2025)	Location (GPS Coordinates)	General Project Description	Emerging building technology (with information on material construction and technique doesn't have to be widely used in this project but will help define a material's emergence)			Mats of production		Developmental status		Value				Value
							Building material (M)	Structural system (S)	Construction technique (C)	Low-tech (traditional or hand-based)	High-tech (industrialized)	Developing	Developed	Environmental	Economic	Socially Responsible	Versatile	
							<p><b>Emerging building technology</b></p> <p>(with information on material construction and technique doesn't have to be widely used in this project but will help define a material's emergence)</p> <p><b>Building material (M)</b></p> <p>Reinforced Earth, a construction technique that uses a mixture of earth, sand, gravel and stabilizers with a formwork to create solid walls.</p> <p><b>Structural system (S)</b></p> <p></p> <p><b>Construction technique (C)</b></p> <p></p>	<p><b>Low-tech (traditional or hand-based)</b></p> <p>Hand-based construction technique that uses a mixture of reinforced earth, formwork and manual compaction of soil.</p> <p><b>High-tech (industrialized)</b></p> <p></p>	<p><b>Developing</b></p> <p>The concept of using earth material for construction was introduced by many generations in SA.</p> <p><b>Developed</b></p> <p></p>	<p><b>Environmental</b></p> <p>Environmentally friendly, uses local materials, low carbon footprint compared to conventional materials, it utilizes locally available soil, reducing the extraction of non-renewable resources. (Reinforced Earth Construction, 1, 10, 11)</p> <p><b>Economic</b></p> <p>Cost-effective construction as it utilizes inexpensive local soil materials. Low to no maintenance required. (Reinforced Earth Construction, 1, 10, 11)</p> <p><b>Socially Responsible</b></p> <p>There is no structure in place, which makes social approval from consuming and more expensive. (Reinforced Earth Construction, 1, 10, 11)</p> <p><b>Versatile</b></p> <p></p> <p><b>Continually Responsive</b></p> <p></p>	<p><b>Environmental</b></p> <p>✓</p>	<p><b>Economic</b></p> <p>✓</p>	<p><b>Socially Responsible</b></p> <p>✓</p>	<p><b>Versatile</b></p> <p></p>	<p><b>Continually Responsive</b></p> <p></p>	<p><b>Value</b></p> <p>Reinforced earth in labor intensive and can be done by local unskilled laborers. It is a low carbon footprint in the construction process. The use of local soil and indigenous knowledge. (Reinforced Earth Construction, 1, 10, 11)</p>		

68	Design Research Ltd, RMIT Academic Library	Open Access Centre		2010	Western Cape, Pinelands (Latitude: 33°57'15.00S Longitude: 18°35'45.00E)	Education, the Primary School, Secondary School, and the Open Access Centre. A large project done through a design develop build workshop.	<p><b>Building material (M)</b></p> <p>Aluminum, steel, concrete and stone for the main structure of the open access centre, sand and stone.</p> <p><b>Structural system (S)</b></p> <p></p> <p><b>Construction technique (C)</b></p> <p></p>	<p><b>Low-tech (traditional or hand-based)</b></p> <p>Earth taken from the roof and compacted back with the use of a manual lock press, this is done on site.</p> <p><b>High-tech (industrialized)</b></p> <p></p>	<p><b>Developing</b></p> <p>The use of lockable (1) South Africa has been known for its pre-colonial era. Most brick construction techniques were employed to ensure long-term durability and developed nature of the building technology its still not commonly used when the compact building practice.</p> <p><b>Developed</b></p> <p></p>	<p><b>Environmental</b></p> <p>✓</p>	<p><b>Economic</b></p> <p>✓</p>	<p><b>Socially Responsible</b></p> <p>✓</p>	<p><b>Versatile</b></p> <p>✓</p>	<p><b>Continually Responsive</b></p> <p>✓</p>	<p><b>Value</b></p> <p>Socially well considered, innovative with the use of indigenous knowledge, its contrast to the labor intensive which can allow for job creation, utilizing and community engagement.</p> <p>Environmentally correct earth has a lower carbon footprint compared to conventional materials. It utilizes locally available soil, reducing the extraction of non-renewable resources.</p> <p>Environmentally sound earth construction can be cost-effective, utilizing responsive local or site materials. It supports local economies through job creation and the utilization of local materials. The durability and low maintenance of the structure result in long term cost savings.</p> <p>Social: relatively low- intensive allows for community involvement, job creation, skill development and innovation. (Open Access Centre, website)</p> <p>Environmentally: not machine heavy reduces waste and reuse material.</p>
						<p><b>Emerging building technology</b></p> <p>(with information on material construction and technique doesn't have to be widely used in this project but will help define a material's emergence)</p> <p><b>Building material (M)</b></p> <p>Hand-based construction technique that uses a mixture of reinforced earth, formwork and manual compaction of soil.</p> <p><b>Structural system (S)</b></p> <p></p> <p><b>Construction technique (C)</b></p> <p></p>	<p><b>Low-tech (traditional or hand-based)</b></p> <p>Hand-based construction technique that uses a mixture of reinforced earth, formwork and manual compaction of soil.</p> <p><b>High-tech (industrialized)</b></p> <p></p>	<p><b>Developing</b></p> <p>The use of lockable (1) South Africa has been known for its pre-colonial era. Most brick construction techniques were employed to ensure long-term durability and developed nature of the building technology its still not commonly used when the compact building practice.</p> <p><b>Developed</b></p> <p></p>	<p><b>Environmental</b></p> <p>✓</p>	<p><b>Economic</b></p> <p>✓</p>	<p><b>Socially Responsible</b></p> <p>✓</p>	<p><b>Versatile</b></p> <p>✓</p>	<p><b>Continually Responsive</b></p> <p>✓</p>	<p><b>Value</b></p> <p>Social: commonly used in the current building practice is typically contained to project managers, contractors and subcontractors.</p>	

