Received 1 November 2022
Revised 24 December 2022
Accepted 30 December 2022

A comparison of low-cost housing units for varying climatic regions in South Africa: a knowledge management approach

Francine van Tonder
Department of Construction Economics, University of Pretoria (UP), Pretoria, South Africa;
School of Architecture and Planning, University of the Witwatersrand (WITS), Johannesburg, South Africa and
Department of Architecture and Industrial Design, Tshwane University of Technology (TUT), Tshwane, South Africa, and
P.D. Rwelamila
Graduate School of Business Leadership, University of South Africa (UNISA), Midrand, South Africa

Abstract

Purpose – One of the greatest challenges faced by the 1994 post-apartheid government in South Africa is the housing problem that has persisted for almost 30 years into democracy. Innovation in research and practice is required to address this problem. This paper aims to discuss the aforementioned objective.

Design/methodology/approach – This paper presents an argument for housing knowledge management as one part of a much larger system of housing provision and critically compares information variations on one hypothetical, low-cost housing unit adapted for varying climatic regions. It aims to enquire if there is an overlap in information.

Findings – The findings do confirm a noteworthy overlap in the information of the varying units. Therefore, knowledge management of the information would prove effective and may contribute in part to housing provision.

Research limitations/implications – The study is limited to assessing the information changes made to the contract documentation of the housing unit.

Social implications – The paper argues that knowledge management of this overlapping information could impact housing provision by providing knowledge power to those affected by the housing problem.

Originality/value – The findings are a unique perspective presented through a knowledge management lens. In addition, the said knowledge management lens provides a platform to raise additional questions. When seeking answers to these questions, it is expected that research sub-themes would be identified focussing further research studies towards finding answers.

Keywords Contract documentation, Climatic regions, Housing problem, Knowledge management, Knowledge power, Outline specifications, South Africa

Paper type Research paper

This paper emanates from a conference paper that formed part of ‘Architectural, Spatial and Infrastructure Planning, and the Fourth Industrial Revolution’ at the WBC2022 World Building Congress held in Melbourne Australia, 27-30 June. The authors would like to extend their gratitude to the reviewers for their constructive criticism and helpful advice and the National Research Foundation (NRF) for funding.

Smart and Sustainable Built Environment
Vol. 13 No. 5, 2024
pp. 1310-1329
Emerald Publishing Limited
2046-6099
DOI 10.1108/SASBE-11-2022-0237

1. Introduction

The housing problem in South Africa persists, with government provisions not meeting housing needs. This paper presents data on low-cost housing and how knowledge management would contribute to addressing the housing problem. Knowledge management could shift the government's housing focus from provision to facilitation.

The construction industry is likely to be affected by the Fourth Industrial Revolution (4IR) (Frey and Osborne, 2013) along with industries worldwide (Kim, 2019; World Economic Forum, 2016). Knowledge management of information is a precursor for automation and is associated with digitisation and the 4IR. The paper heeds the call of the World Economic Forum (2020) for tangible evidence and reliable information pertaining to the 4IR in all industries.

The research findings indicate a noteworthy overlap in the information presented in the five housing unit variations. Therefore, knowledge management as one part of the larger system of housing provision may contribute to the effectiveness of the provision of housing. Data are presented in the form of contract documentation that comprises architectural drawings and outline specifications of variations on one hypothetical low-cost housing unit for varying climatic regions.

Housing information is often inaccessible to those affected by the housing problem. An argument for knowledge management of contract documentation providing knowledge power to those affected by the housing problem forms the core of the study. This may facilitate the knowledge management cycle and provide for community involvement. The focus of this paper is thus concerned with providing knowledge power through knowledge management to those affected by the housing problem. Nevertheless, before an overlap in information and therefore an economic efficiency can be claimed to result from less information regeneration and more reuse of information, the overlap must be argued and tested.

Consequently, a comparison of the contract documentation information concerning variations of a hypothetical, low-cost housing unit across varying climatic regions was undertaken. A discussion of the data analysis findings and recommendations for further research based on salient questions concludes the paper.

2. Literature review

2.1 South African housing problem

Housing was identified as one of the greatest challenges faced by the 1994 post-apartheid South African government (Department of Housing, 1994). The government housing provision has been efficient in numbers, with 3.3 million low-cost housing units built (Marutlulle, 2021). However, the housing delivered has proven ineffective, with many people still accommodated in informal housing, informal settlements and slums (Gilbert, 2004). Approximately 5.2 million people live in 1.3 million households in informal settlements in metro areas (Dintsi *et al.*, 2020). In 2010, the housing provision backlog was 2.1 million (Phago, 2010) and in 2022 is 2.7 million (Sisulu, 2020). According to the information above, it is evident that the housing problem is mounting.

2.2 Factors contributing to the housing problem

Contributing factors include corruption and mismanagement; houses too small for occupation; substandard material choices and artisanship; poor location of housing projects; lack of involvement by stakeholders and beneficiaries of the housing projects; urbanisation; and unemployment (Manomano *et al.*, 2016).

2.3 Knowledge management and knowledge power

Knowledge management is the acquisition, creation, sharing and transfer of information (Pinho *et al.*, 2012). In this context, the goal of managing knowledge is to improve effective housing quality and delivery by providing the right information to the right people at the right time (Salzano *et al.*, 2016).

Knowledge power is power vested in accessing and controlling unique information necessary for decision-making (Burnes, 2014). Architectural knowledge is often embargoed: sometimes for profit and or generated and distributed solely by those qualified in the discipline.

2.4 Community involvement

In the absence of accurate information, those who lack knowledge power are disadvantaged (Mafukidze and Hoosen, 2009, p. 393) and this affects the success of community participation in housing provision. International legislation supporting community participation in housing provision, such as the United Nations Habitat Agenda (Huchzermeyer, 2003) had little impact and was seen to view government provision negatively (Williams, 2006). This compounded with the government provision of housing often associated with government corruption (Jeffery, 2010, p. 354).

Examples of successful community involvement may be found in the seminal work of Aule *et al.* (2020), Aigbavboa and Thwala (2011), Andani (2017), Archer (2012) and Chang *et al.* (2015). These examples are pertinent to achieving Sustainable Development Goal 11: that people must have safe, adequate and affordable housing with basic services as well as that slums must be upgraded. Knowledge power may play a part in community involvement in housing provision.

2.5 Contract documentation

Architectural information employed as an instruction to build a specific building usually includes draughted and scaled architectural drawings. Architectural drawings include construction technology, material use and size information.

A project specification frequently forms part of contract documentation. For example, a project specification for Stage 3 of the South African Council for the Architectural Profession (SACAP) Board Notice 91 (2020), Stages of Work for Architectural Projects, is called an outline specification. An outline specification comprises work sections with building systems grouped by artisanship under the applicable work section. In South Africa, the Logical Arrangement of Work Sections (LAWS) is used, which is derived from the Common Arrangements of Works Sections (CAWS) used in the United Kingdom (Allott, 1998). Architectural drawings and outline specifications are the contract documentation of an architectural proposal.

2.6 Climatic regions of South Africa

A house envelope should respond to its climatic region (Napier, 2000). Minor changes may contribute to unit variations that respond better to the environment. South Africa has nine climatic regions (Figure 1).

The nine climatic regions remain largely the same between Napier (2000, pp. 9.3.1) and Janse van Rensburg *et al.* (2019, p. 4) with minor differences. The authors have applied the regions as follows:

(1) Subtropical plateau (1) region categorised by cool to hot summers (15–27 °C), moderate winter days and cold to very cold winter night temperatures (7–12 °C). Comparatively dry and precipitation occurs mostly in summer (Napier, 2000, p. 9.4). Relative humidity is less than 30%.

(2) Desert (2) region categorised by moderate to hot summers (15–25 °C) and cold to very cold winter temperatures (less than 7–10 °C). Precipitation is low and mostly in winter

(Napier, 2000, p. 9.9). Some strong wind gusts occur inland to the north (Kruger *et al.*, 2013). Relative humidity is less than 30% inland and more than 70% at the coast.

(3) Mediterranean (3) region categorised by warm to hot summers (20–23 °C), moderate winter days and cold to very cold winter temperatures (7–10 °C). Precipitation occurs from prolonged cold and wet spells in the winter (Napier, 2000, p. 9.6). Strong wind gusts occur (Kruger *et al.*, 2013). Relative humidity is 50% inland and more than 70% at the coast.

(4) Semi-arid plateau (4) region categorised by warm to hot summers (20–27 °C) and cold to very cold winter temperatures (7–12 °C). Precipitation is low and occurs mostly in the summer (Napier, 2000, p. 9.7). In some areas, strong wind gusts occur (Kruger *et al.*, 2013). Relative humidity is less than 30% in the north and more than 50% in the south.

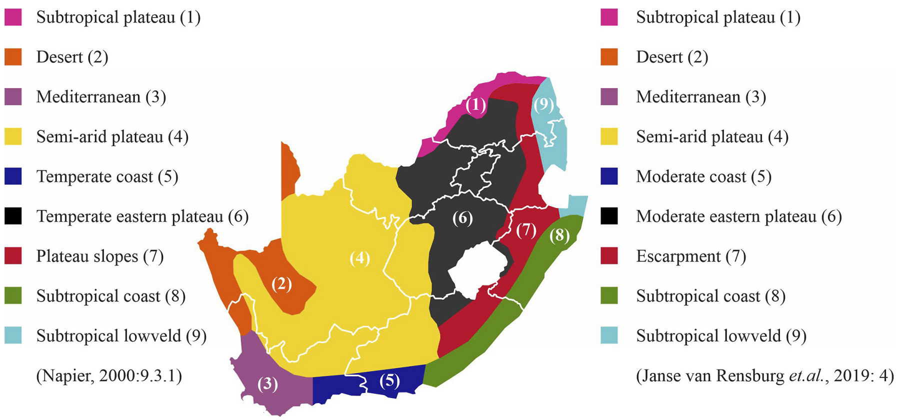
(5) Moderate coast (5) categorised by warm to hot summers (20–23 °C) and moderate winter temperatures (12–17 °C). Precipitation occurs all year round (Napier, 2000, p. 9.7). Relative humidity is 60% to more than 70%.

(6) Moderate eastern plateau (6) region categorised by warm to hot summers (20–25 °C), moderate winter days and cold to very cold winter night temperatures (10–15 °C). Precipitation occurs from thunderstorms (Napier, 2000, p. 9.8) and cloudbursts. Relative humidity is 30–50%.

(7) Escarpment (7) region categorised by warm to hot summers (20–25 °C), moderate winter days and cold to very cold winter night temperatures (7–12 °C). Precipitation occurs from high rainfalls with thunderstorms that are often prolonged (Napier, 2000, p. 9.9). Diurnal shifts in wind direction occur in this region (Garstang *et al.*, 1987) and strong wind gusts occur (Kruger *et al.*, 2013). Relative humidity is 50–60%.

(8) Subtropical coast (8) region categorised by warm to hot summers (20–25 °C) and moderate to warm winter temperatures (15–20 °C). Precipitation occurs from thunderstorms, sometimes with hail and is often prolonged (Napier, 2000, p. 9.9). Strong wind gusts occur (Kruger *et al.*, 2013). Relative humidity is more than 70%.

(9) Subtropical lowveld (9) region categorised by hot summers (25–27 °C) and moderate to warm winter temperatures (15–20 °C). Lower precipitation occurs all year round (Napier, 2000, p. 9.10). Relative humidity is more than 70%.



Source(s): Napier (2000, pp. 9.3.1), Janse van Rensburg *et al*. (2014, p. 4)

Figure 1.
A map of South Africa with province borders in white and the nine climatic regions in various colours and numbered

2.7 Tectonic

In the architectural context, tectonic refers to one of three sources of legitimacy for architecture. Tectonic refers to the art and science of construction and the artistic expression of construction through materials and construction methods (Porter, 2004). For this paper, visual tectonics refers to how a building or group of buildings reads visually and the performance of the architecture (van Tonder, 2022a). The said other two sources of legitimacy are topos (referring to the site) and typos (referring to type) (Frampton, 1995).

The envelope or tectonic of a building must consider the external weather qualities to achieve interior comfort (Napier, 2000) and energy use, mitigating the climate emergency. Considering the carbon footprint of a building, approximately 10% of annual CO_2 emissions are due to the materials and construction of the buildings and approximately 28% of annual CO_2 emissions are due to the operations of the buildings (United Nations Environment Programme, 2021, p. 40). Substandard material choices and artisanship could have far-reaching effects on the liveability and energy use of low-cost housing units. This paper proposes variations in the building envelope or technology tectonic (van Tonder, 2022a) appropriate to each climatic region.

3. Research methodology

3.1 Research approach and design

This paper aims to generate data for knowledge management assessment. To enquire whether there is a substantial overlap in contract documentation information through critically comparing variations in one hypothetical low-cost housing unit adapted for the varying climatic regions.

3.2 Low-cost housing unit adjustments

Adjustments were made to the 'typical output from housing cost model' or the 'TCM unit', as published by the Council for Scientific and Industrial Research (CSIR) (Schlotfeldt, 2000, p. F-3). The TCM unit (left of Figure 2) was adjusted to propose a single benchmark unit (UT1) (right of Figure 2).

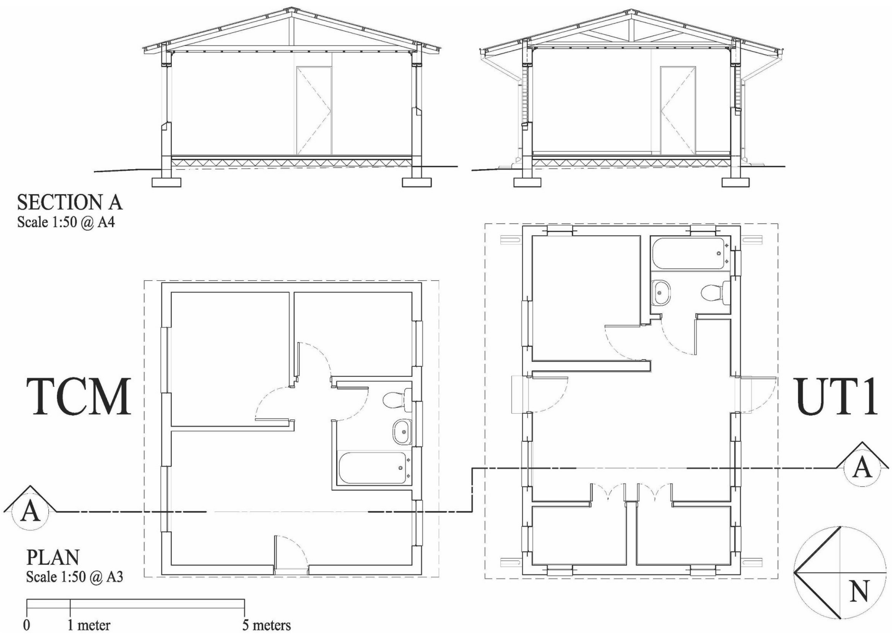


Figure 2.
TCM unit (left) and Unit 1 (UT1) (right)

UT1 benchmark unit's characteristics:

(1) Rectangular with a north-south orientation, and thus a long, thin dwelling (Alexander, 1977, p. 535)

(2) Front door and a back door for intimacy gradient, dignity and safety

(3) Two small bedrooms or bed clusters (Alexander, 1977, p. 871) that double as private online work or study spaces during the day

(4) Dual-aspect windows in each room facilitate cross ventilation (Napier, 2000, p. 5.5) and eyes on the street

(5) Parent's realm and children's realm on opposing sides of the house (Alexander, 1977, p. 384)

(6) Floor finishes, facias, barges, gutters and downpipes added

(7) Within $40 m^2$, the minimum size for a government-subsidised residential unit (Department of Human Settlements, 2009).

(8) Complies with SANS 10400 (2012).

3.3 Research limitations

This study only employs one simple, commonly used form of a low-cost housing unit: a rectangular, detached and single-storey house. Materials most used in low-cost housing are clay-brick walls, concrete systems and materials, steel windows and doors and sheet metal roofs on standard timber trusses. SANS 10400 (2012) focusses on these materials.

This study uses one visual tectonic to compare the technology tectonics for the varying climatic regions. The variations to the unit type were guided by a decision tree with minimal changes to the technology tectonic (Figure 3). The decision sequence was numbered

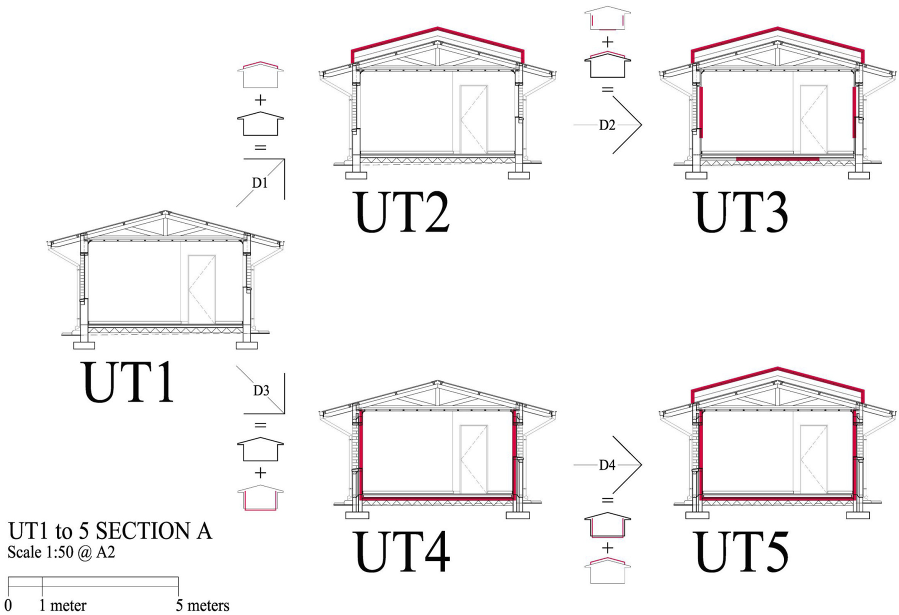


Figure 3.
The variations of decision tree from the hypothetical benchmark unit

Decisions 1 (D1) to 4 (D4). A decision tree acts as a decision support tool with nodes that demarcate variables (Kamiński *et al.*, 2017). A decision tree in which decisions in the architectural process become nodes is argued as the possible first step towards managing knowledge and eventually automating architecture (van Tonder and Brink, 2022).

Climatic response details are required, including wall type, glazing type, size and position as well as variations in roof insulation or roof material. The r-value of the walls and roofs and the u-value of the glazing are not included in this study. Nor are bioclimatic design and passive design theories, which may further contextualise and guide the discussion.

Proposals that reflect the context must be developed. Considerations include local culture and indigenous thinking, integration into wards, neighbourhoods and communities, as well as amenities, services and opportunities when reaching high density.

4. Findings and discussion

4.1 Findings

4.1.1 Variations to unit type 1. As per Figure 1, Table 1 lists the nine climatic regions of South Africa and the proposed unit type assigned to that region.

The technology tectonic associated with each of the climatic regions is proposed based on the following rationales:

(1) Subtropical plateau (1) region, a unit type (UT1) with a solid brick wall and gable-pitched roof.

(2) Desert (2) region, a unit type (UT3) with a solid brick wall with insulation lining the interior and a gable-pitched roof with a parapet. Insulation is added for cold winter temperatures. A gable parapet is added for additional structural integrity from wind, as parapets reduce peak wind pressures (Aly and da Fonseca Yousef, 202, p. 14; Krishna, 1995, p. 394).

(3) Mediterranean (3) region, a unit type (UT5) with a cavity brick wall with insulation and a gable-pitched roof with a parapet. Cavity brick wall with insulation change is for the cold winter temperatures and prolonged precipitation. The gable parapet is added for additional structural integrity from wind.

(4) Semi-arid plateau (4) region, a unit type (UT3) with a solid brick wall with insulation lining to interior and a gable-pitched roof with a parapet. Insulation is added for cold winter temperatures and the gable parapet is added for additional structural integrity from wind.

(5) Moderate coast (5) region, a unit type (UT4) with a cavity brick wall with insulation and a gable-pitched roof. Cavity brick wall with insulation change is for prolonged precipitation.

Unit type (across)	UT1	UT2	UT3	UT4	UT5
Climatic region (as Figure 1)					
Subtropical plateau (1)	+				
Desert (2)			+		
Mediterranean (3)					+
Semi-arid plateau (4)			+		
Moderate coast (5)				+	
Moderate eastern plateau (6)	+				
Escarpment (7)		+			
Subtropical coast (8)				+	
Subtropical lowveld (9)	+				

Table 1.
Climatic region and unit type assigned

(6) Moderate eastern plateau (6) region, a unit type (UT1) with a solid brick wall and a gable-pitched roof.

(7) Escarpment (7) region, a unit type (UT2) with a solid brick wall and gable-pitched roof with a parapet. A gable parapet is added for additional structural integrity from wind.

(8) Subtropical coast (8) region, a unit type (UT4) with a cavity brick wall with insulation and a gable-pitched roof. Cavity brick wall with insulation change is for prolonged precipitation.

(9) Subtropical lowveld (9) region: a unit type (UT1) with a solid brick wall and gable-pitched roof.

4.1.2 Plan and section architectural drawings. The critical comparison of the contract documentation information required the authors to draught, detail and draw up dimensions, and specify unit variations for various climatic regions. The computer-aided draughting (CAD) drawings were limited to a plan and section for each variation. The architectural drawings of the units or data generated for the paper address the substandard material choices and artisanship noted by Manomano *et al.* (2016) by presenting contract documentation of units that comply with SANS 10400 (2012).

UT1 was used as the benchmark and was draughted first. As per Table 2 and Figures 4–8 (the contract documentation of each unit type), many of the technology tectonic characteristics of UT1 could be reused for UT2 to UT5.

Changes to the plan and section architectural drawings from UT1 are highlighted with a red border on UT2 to UT5. Likewise, information changes for system references, annotations and dimensions from UT1 are highlighted in red on UT2 to UT5.

As per Figure 3: for UT2, the plan remained the same as UT1, with only the indicative line of the roof above changing to accommodate the parapet wall. On section, changes were only made to the roof from the wall plate height upwards for UT2, UT3 and UT5, with the addition of a parapet in elevation.

On plan, UT3 had substantial changes: thermal insulation was added to the interior of the external walls. On section, thermal insulation was also added under the concrete surface bed. However, the gable-pitched roof with parapet wall information was taken as is from UT2, with No additional draughting required.

For UT4 and UT5: a cavity wall construction replaced the solid wall construction on plan and on section. Only the plan for UT4 required draughting amendments. For UT5, the plan remained the same as UT4, with only the indicative line of the roof above changing to accommodate the parapet wall. For UT4 and UT5 on section, the previously draughted insulated surface bed was taken from UT5. On section, the wall structure was amended to include the cavity brick wall with insulation. However, this was only amended once for UT4 and then reused for UT5.

The overall dimensions on plan and on section remained the same for all five unit variations. This was achieved by ensuring that wall construction changes occurred inward.

House unit type (across)	UT1	UT2	UT3	UT4	UT5
Technology tectonic characteristics (down)					
Solid brick wall	+	+			
Solid brick wall with insulation			+		
Cavity brick wall with insulation				+	+
Gable pitched roof	+			+	
Gable pitched roof with parapet wall		+	+		+

Table 2. Technology tectonic characteristics (in red), the technology tectonic characteristics different from UT1 (in black)

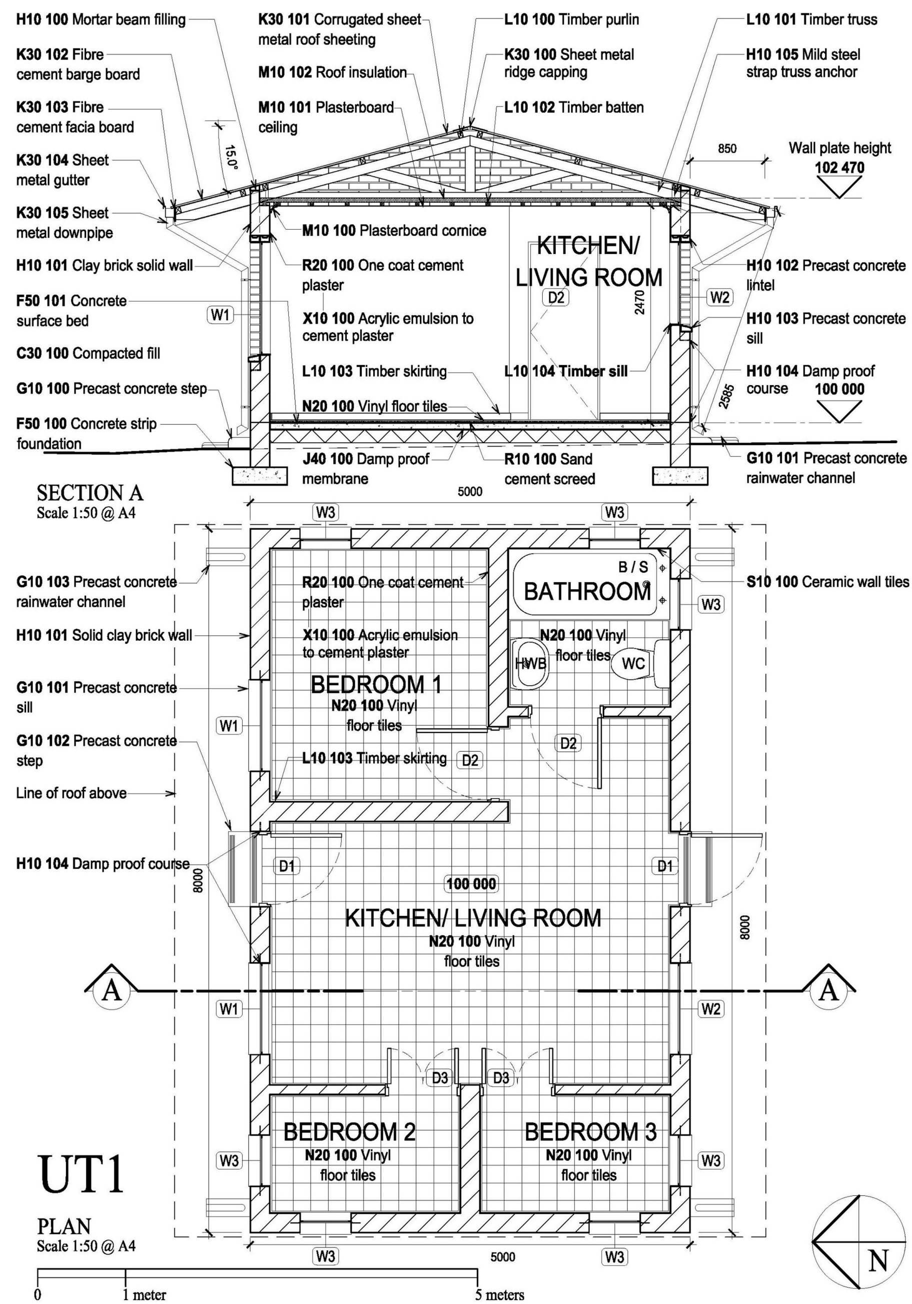


Figure 4.
Hypothetical benchmark Unit Type 1 (UT1) architectural drawings

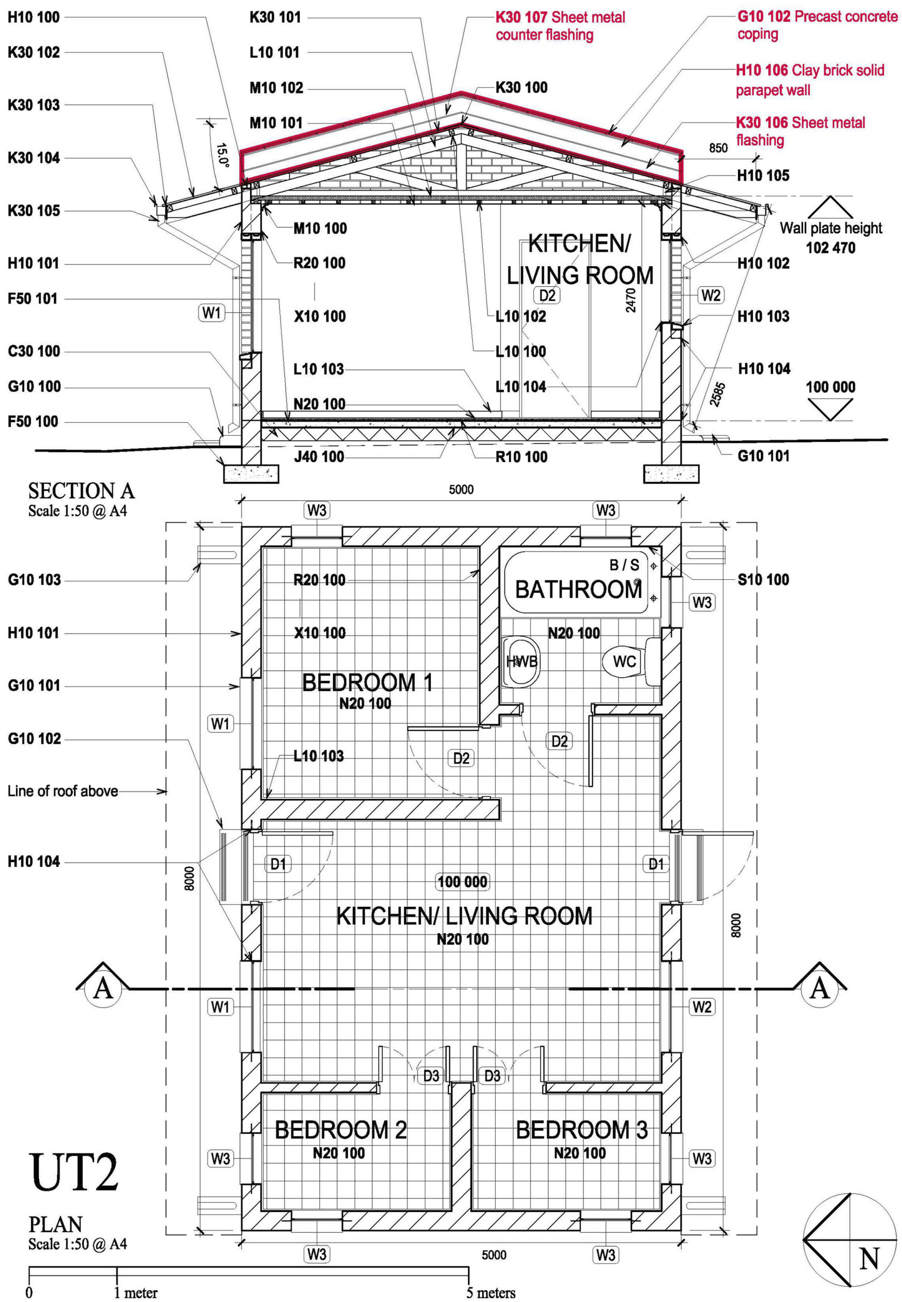


Figure 5.
Unit Type 2 (UT2) architectural drawings

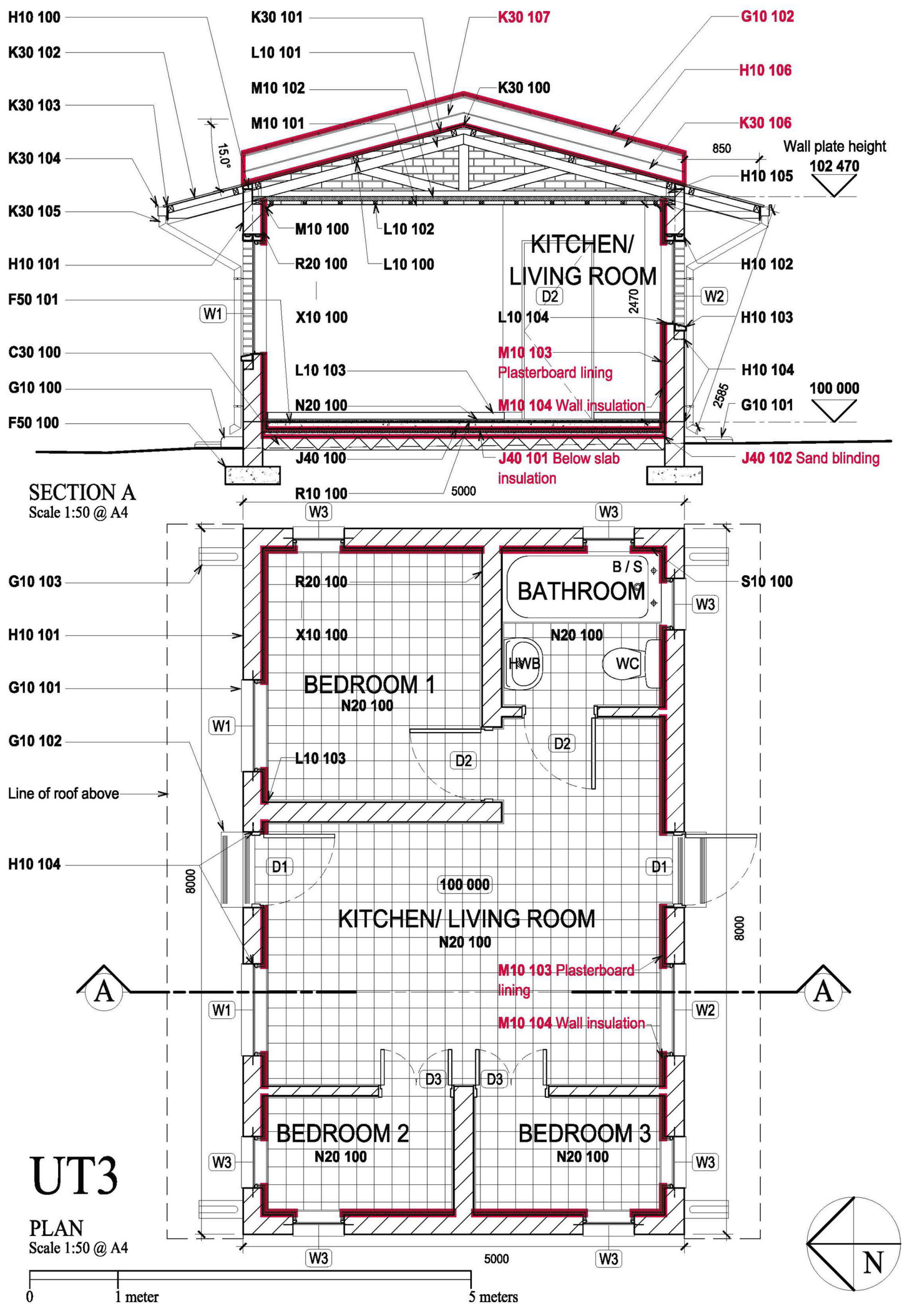


Figure 6.
Unit Type 3 (UT3) architectural drawings

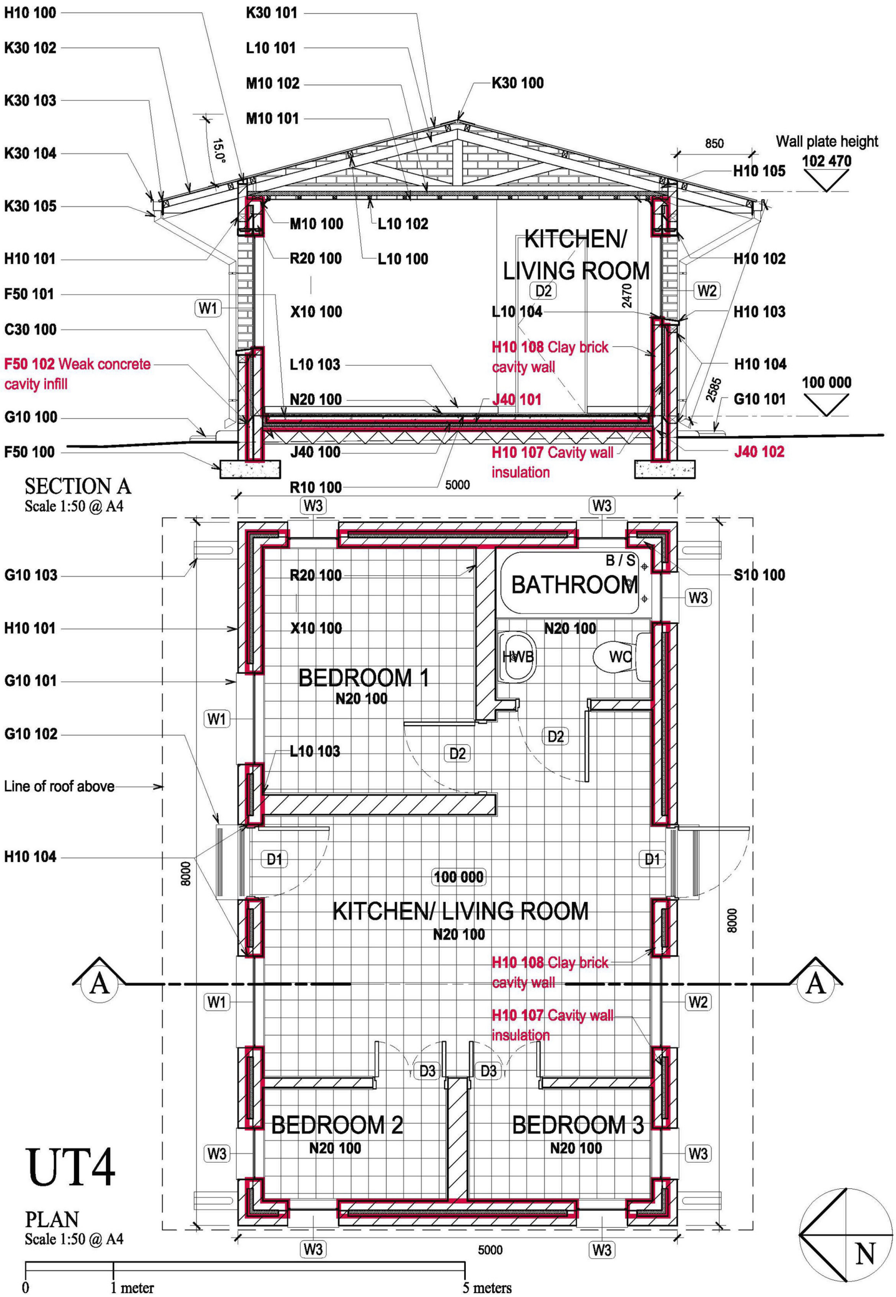


Figure 7.
Unit Type 4 (UT4) architectural drawings

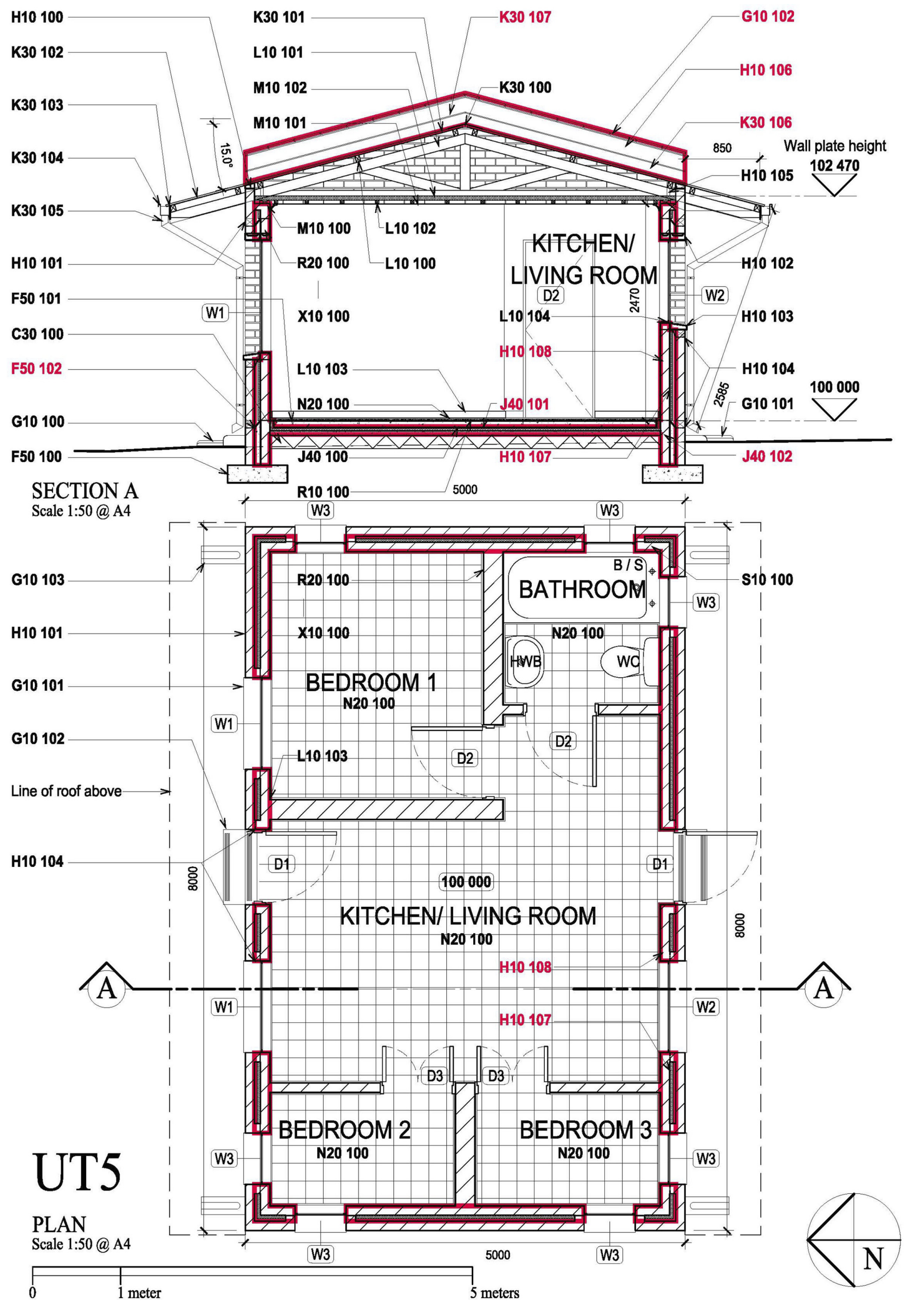


Figure 8.
Unit Type 5 (UT5) architectural drawings

Therefore, should the elevations of the units have formed part of the study, an even greater similarity in architectural drawings and annotation would be noted.

UT1 was used as the benchmark for the outline specification and was annotated first. An annotation on a contract documentation architectural drawing is typically placed as a description for each building system. An example would be *Clay brick solid wall*. The system refers to the specification document that is also added if the project has a project specification. The annotation then becomes a *systems reference and annotation* and reads, for example, *H10 101 Clay brick solid wall* with *H10 101* being the clause number in the outline specification document included in the work section *H10 Brickwork*.

The first time a systems reference and annotation was placed for this paper, it was written in full with the systems reference and annotation (for example, *H10 101 Clay brick solid wall*). Thereafter, with additional drawings, only the systems reference was placed on the drawing (for example, *H10 101*). The systems references added from UT1 in Figure 4 are highlighted in red on UT2 to UT5 in Figures 5–8.

A noteworthy overlap in information could be inferred when considering the red on the plan and section architectural drawings of each of the units in Figures 4–8.

4.1.3 Outline specification. As per the architectural drawings of the units, a noteworthy overlap in information is visible when considering the work sections of the outline specification documents of the units, as per Table 3.

In order to perform a critical comparison, it was necessary to list each building system indicated on the plan and section architectural drawings of each unit. See Table 3 for each unit's systems reference and annotation with the changes made or system references added from UT1 in red for UT2 to UT5.

Additional systems were added in red for alterations to the technology tectonic in UT2 to UT5. These 12 systems are added in red. These red systems have a combined use of 26 times for UT2 to UT5.

There are 201 (175 + 26) systems used across the five unit types. Of these, 87% are black ((175/201) × 100), indicating reuse of information and 13% are red ((26/201) × 100), indicating the need to add additional information. Therefore, the inference is made that there is an overlap in information.

Should UT1 be removed from the quantitative assessment, there would be 140 (175–35) systems in black and still 26 systems in red. There were 166 (140 + 26) systems used.

The percentages of reused systems in black and new systems in red would be as follows: 84% are black ((140/166) × 100), indicating reuse of information and 16% are red ((26/166) × 100), indicating the need to add additional information. Therefore, the inference is still made that there is an overlap in information, even after removing the benchmark UT1 from the calculation.

When considering the work section of the outline specification in Table 4, with 15 work sections in black originating from UT1 and No additional work section requirements for UT2 to UT5, then the inference could be made that there is a noteworthy overlap in information.

4.2 Discussion

This paper critically compared some of the information of one hypothetical low-cost housing unit, adapted for the varying climatic regions in South Africa. With the aim of enquiring if there is a substantial overlap in information.

Figures 3–8 indicate the reuse of information in the architectural drawings. The architectural drawings and outline specifications together are the contract documentation of an architectural proposal. Table 1 showed the unit reuse across the climatic regions, Table 2 the technology tectonic reuse, Table 3 the outline specification system information reuse and Table 4 the outline specification work section information reuse.

Knowledge management enhances effectiveness because the reproduction of architectural information is time-consuming and costly. Therefore, the reuse of information results in an

Systems reference and annotation	UT1	UT2	UT3	UT4	UT5
C30 100 Compacted fill	+	+	+	+	+
F50 100 Concrete strip foundation	+	+	+	+	+
F50 101 Concrete surface bed	+	+	+	+	+
F50 102 Weak concrete cavity infill				+	+
G10 100 Precast concrete step	+	+	+	+	+
G10 101 Precast concrete rainwater channel	+	+	+	+	+
G10 102 Precast concrete coping		+	+		+
H10 100 Mortar beam filling	+	+	+	+	+
H10 101 Clay brick solid wall	+	+	+	+	+
H10 102 Precast concrete lintel	+	+	+	+	+
H10 103 Precast concrete sill	+	+	+	+	+
H10 104 Damp proof course	+	+	+	+	+
H10 105 Mild steel strap truss anchor	+	+	+	+	+
H10 106 Solid clay brick parapet wall		+	+		+
H10 107 Cavity wall insulation				+	+
H10 108 Clay brick cavity wall				+	+
J40 100 Damp proof membrane	+	+	+	+	+
J40 101 Below slab insulation			+	+	+
J40 102 Sand blinding			+	+	+
K30 100 Sheet metal ridge capping	+	+	+	+	+
K30 101 Corrugated sheet metal roof sheeting	+	+	+	+	+
K30 102 Fibre cement barge board	+	+	+	+	+
K30 103 Fibre cement facia board	+	+	+	+	+
K30 104 Sheet metal gutter	+	+	+	+	+
K30 105 Sheet metal downpipe	+	+	+	+	+
K30 106 Sheet metal flashing		+	+		+
K30 107 Sheet metal counter flashing		+	+		+
L10 100 Timber purlin	+	+	+	+	+
L10 101 Timber truss	+	+	+	+	+
L10 102 Timber batten	+	+	+	+	+
L10 103 Timber skirting	+	+	+	+	+
L10 104 Timber sill	+	+	+	+	+
L22 100 External timber door steel frame	+	+	+	+	+
L22 101 Internal timber door steel frame	+	+	+	+	+
M10 100 Plasterboard cornice	+	+	+	+	+
M10 101 Plasterboard ceiling	+	+	+	+	+
M10 102 Roof insulation	+	+	+	+	+
M10 103 Plasterboard lining			+		
M10 104 Wall insulation			+		
N20 100 Vinyl floor tiles	+	+	+	+	+
Q21 100 Steel top hung window	+	+	+	+	+
Q21 101 Steel top hung and fixed window	+	+	+	+	+
R10 100 Sand cement screed	+	+	+	+	+
R20 100 One coat cement plaster	+	+	+	+	+
S10 100 Ceramic wall tiles	+	+	+	+	+
X10 100 Acrylic emulsion to cement plaster	+	+	+	+	+

Table 3.
System reference and annotation table

exponential growth in the value of the information when the information is reused (van Tonder, 2022b).

The noteworthy overlap in information in the contract documentation and outline specifications of the five units presented indicates that knowledge management is possible and may have a far-reaching impact. Therefore, this paper argues that knowledge management of the contract documentation information of architectural proposals for housing units can contributes to the effectiveness of housing provision. Further effectiveness would be achieved if the knowledge management provided those affected by the housing

Work sections	UT1	UT2	UT3	UT4	UT5
C30 Site clearance/excavation/filling	+	+	+	+	+
F50 In situ concrete construction	+	+	+	+	+
G10 Precast concrete	+	+	+	+	+
H10 Brickwork	+	+	+	+	+
J40 Damp-proofing	+	+	+	+	+
K30 Metal-profiled sheet covering	+	+	+	+	+
L10 Carpentry/timber framing/first fixing	+	+	+	+	+
L22 Timber doors	+	+	+	+	+
M10 Plasterboard ceilings/lining	+	+	+	+	+
N20 Vinyl flooring	+	+	+	+	+
Q21 Steel windows	+	+	+	+	+
R10 Cement-based screeds	+	+	+	+	+
R20 Plaster coatings	+	+	+	+	+
S10 Tiling	+	+	+	+	+
X10 Painting finishing	+	+	+	+	+

Table 4. Work sections table with work section found in the outline specification of UT1 in black and No additional work sections required for UT2 to UT5

problem with knowledge power by providing the right information to the right people at the right time and in the right place.

However, it is noted that knowledge management as a system that includes the steps of *acquisition, creation, sharing* and *transfer* of information will only be effective if the knowledge *acquired and created* is also *shared and transferred*. Further research on the problem that is the system of housing provision in South Africa must be done.

5. Recommendations for further research

This paper presents data on knowledge management, which is one part of a much larger housing provision system. Knowledge management can contribute to addressing short fallings in the system of housing provision. However, limited academic research is available on knowledge management for the low-cost housing sector in South Africa. This lacuna in research must be addressed.

The subsequent questions are, Where to start? What information and knowledge should be acquired, created, shared and transferred to address the housing problem? To what detail can climatic response detail variations be included? How will the environment affect the knowledge management of technology tectonics? Can knowledge management include bioclimatic design, passive design, biophilia, biomimicry and ultimately systems disruptions towards greater climate emergency resilience and responses? Should this information also include visual tectonics that will respond more appropriately to the environment in which the unit is placed? How to better reflect and accommodate local culture and indigenous thinking? How would various unit sizes affect knowledge management, and will knowledge management be as effective as in the five unit types presented in this paper? How far can the use of knowledge management for low-cost housing information disseminate? Could knowledge management for low-cost housing aid the required shift from a linear economy to a circular economy, and what would that look like? How would the knowledge management of the adaptation, densification and revitalisation of low-cost housing for resilient communities work? Is it possible for knowledge management to perform the architectural design process required for housing design? Can the knowledge management of units be conceptualised to form wards and neighbourhoods towards achieving higher density? Can knowledge management provide the knowledge power for laypersons or communities to build their own homes in a manner that will mitigate the climate emergency?

These questions potentially strengthen the theme of this paper by inviting further research projects.

6. Conclusion

The data presented in this paper are a small contribution to addressing the large and complex housing problem. This paper critically compared some information from one hypothetical low-cost housing benchmark unit adapted for varying climatic regions.

This paper found there is a substantial overlap in information. The reuse of information in knowledge management is important because the reproduction of architectural information is time-consuming and costly and reuse enhances performance effectiveness. The noteworthy information overlap in the contract documentation and outline specifications of the five units indicates that knowledge management is possible and could have a far-reaching impact when shared.

This paper concludes that knowledge management could contribute to addressing shortcomings in the housing provision system. Knowledge management is a system that includes the steps of acquisition, creation, sharing and transfer of information. Knowledge management would only be effective if the knowledge *acquired and created* is also *shared and transferred*. Therefore, in the architectural context, knowledge management is the contract documentation acquired, architectural proposals created and sharing and transfer of the content to those affected by the housing problem. Knowledge management is knowledge power that provides the right information to the right people at the right time and in the right place. Thus, knowledge management through knowledge reuse could contribute to the effectiveness of housing provision.

References

Aigbavboa, C. and Thwala, W.D. (2011), "Community participation for housing development", *Proceedings of the 6th Built Environment Conference on Community Participation for Housing Development (31 July–2 August)*, Johannesburg, pp. 418-428, available at: https://core.ac.uk/download/pdf/20259517.pdf (accessed 19 December 2022).

Alexander, C. (1977), *A Pattern Language: Towns, Buildings, Construction*, Oxford University Press, Oxford, ISBN: 13 978-0-19-501919-3.

Allott, T. (1998), *Common Arrangement of Work Sections for Building Works*, Construction Project Information Committee, 2nd ed., Armstrong Print, Newcastle upon Tyne, ISBN: 0 951 2662 5 X.

Aly, A.M. and da Fonseca Yousef, N. (2021), "High Reynolds number aerodynamic testing of a roof with parapet", *Engineering Structures*, Vol. 234, p. 112006, available at: https://doi.org/10.1016/j.engstruct.2021.112006 (accessed 18 December 2022).

Andani, A. (2017), "Alternative approaches to community participation beyond formal structures: evidence from Langa within the municipality of Cape Town", *Commonwealth Journal of Local Governance*, Vol. 20 No. 12, pp. 83-97, available at: https://doi.org/10.5130/cjlg.v0i20.6084 (accessed 19 December 2022).

Archer, D. (2012), "Baan Mankong participatory slum upgrading in Bangkok, Thailand: community perceptions of outcomes and security of tenure", *Habitat International*, Vol. 36 No. 1, pp. 178-184, available at: https://doi.org/10.1016/j.habitatint.2011.08.006 (accessed 19 December 2022).

Aule, T.T., Jusan, M.M. and Ayoosu, M.I. (2020), "Outcomes of community participation in housing development: an update review", *Journal of Scientific and Engineering Research*, Vol. 6 No. 6, pp. 208-218, doi: 10.32628/IJSRSET196642.

Burnes, B. (2014), *Change Management*, 6th ed., Edinburgh Gate, Pearson Education Limited, London, ISBN: 978-0-273-77896-7.

Chang, F.H., Helfrich, C.A., Coster, W.J. and Rogers, E.S. (2015), "Factors associated with community participation among individuals who have experienced homelessness", *International Journal of Environmental Research and Public Health*, Vol. 12 No. 9, pp. 11364-11378, doi: 10.3390/ijerph120911364.

Department of Housing, Republic of South Africa (1994), *White Paper on Housing, A New Housing Policy and Strategy for South Africa*, Government Gazette, 345(16178) notice 1376 of 1994, 23 December, available at: https://www.gov.za/sites/default/files/gcis_document/201409/161780.pdf (accessed 18 December 2022).

Department of Human Settlements, Republic of South Africa (2009), "The national housing code, Part 3, technical and general guidelines", available at: http://www.dhs.gov.za/sites/default/files/documents/national_housing_2009/2_Technical_General_Guidelines/1%20Vol%202%20Part%203%20Technical%20and%20General%20Guidelines.pdf (accessed 18 December 2022).

Dintsi, S., Mbanga, S. and Smallwood, J. (2020), "Covid-19 pandemic and the challenges of informal settlements in South Africa and beyond: theoretical insights and practical interventions", *Journal of Public Administration*, Vol. 55 No. 3, pp. 283-293, available at: https://doi.org/10.10520/ejc-jpad-v55-n3-a4 (accessed 18 December 2022).

Frampton, K. (1995), *Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture*, MIT Press, Cambridge, MA, ISBN 9780262561495.

Frey, C.B. and Osborne, M.A. (2013), *The Future of Employment: How Susceptible Are Jobs to Computerisation?*, Oxford Martin School, Oxford, doi: 10.1016/j.techfore.2016.08.019.

Garstang, M., Kelbe, B.E., Emmitt, G.D. and London, W.B. (1987), "Generation of convective storms over the escarpment of northeastern South Africa", *Monthly Weather Review*, Vol. 115 No. 2, pp. 429-443, 2, available at:. https://doi.org/10.1175/1520-0493(1987)115<0429:GOCSOT>2.0.CO (accessed 18 December 2022).

Gilbert, A. (2004), "Helping the poor through housing subsidies: lessons from Chile, Colombia and South Africa", *Habitat International*, Vol. 28 No. 1, pp. 13-40, available at: https://doi.org/10.1016/S0197-3975(02)00070-X (accessed 18 December 2022).

Huchzermeyer, M. (2003), "Addressing segregation through housing policy and finance", in Harrison, P., Huchzermeyer, M. and Mayekiso, M. (Eds), *Confronting Fragmentation: Housing and Urban Development in a Democratising Society*, University of Cape Town Press, Cape Town, pp. 211-227, ISBN 1 91 971 3735.

Janse van Rensburg, D.T., Cornish, L.A. and Van der Merwe, J. (2019), "Corrosion map of South Africa's macro atmosphere", *South African Journal of Science*, Vol. 115 Nos 7-8, pp. 1-8, available at: https://doi.org/10.17159/sajs.2019/4901 (accessed 18 December 2022).

Jeffery, A. (2010), *Chasing the Rainbow: South Africa's Move from Mandela to Zuma*, South African Institute of Race Relations Publishers, Cape Town, ISBN 1869825829, 978186982582.

Kamiński, B., Jakubczyk, M. and Szufel, P. (2017), "A framework for sensitivity analysis of decision trees", *Central European Journal of Operations Research*, Vol. 26 No. 1, pp. 135-159, doi: 10.1007/s10100-017-0479-6.

Kim, S.Y. (2019), "The fourth industrial revolution: trends and impacts on the world of work", *Handbook of Vocational Education and Training: Developments in the Changing World of Work*, Springer Nature Switzerland, pp. 1-19, doi: 10.1007/978-3-319-49789-1_115-1.

Krishna, P. (1995), "Wind loads on low rise buildings – a review", *Journal of Wind Engineering and Industrial Aerodynamics*, Vol. 54, pp. 383-396, available at: https://doi.org/10.1016/0167-6105(94)00055-I (accessed 18 December 2022).

Kruger, A.C., Retief, J.V. and Goliger, A.M. (2013), "Strong winds in South Africa: part 2 Mapping of updated statistics", *Journal of the South African Institution of Civil Engineering*, Vol. 55 No. 2, pp. 46-58, available at: https://hdl.handle.net/10520/EJC145418 (accessed 18 December 2022).

Mafukidze, J.K. and Hoosen, F. (2009), “Housing shortages in South Africa: a discussion of the after-effects of community participation in housing provision in Diepkloof”, *Urban Forum*, Vol. 20 No. 4, pp. 379-396, doi: 10.1007/s12132-009-9068-7.

Manomano, T., Tanga, P.T. and Tanyi, P. (2016), “Housing problems and programs in South Africa: a literature review”, *Journal of Sociology and Social Anthropology*, Vol. 7 No. 2, pp. 111-117, available at: https://doi.org/10.1080/09766634.2016.11885707 (accessed 18 December 2022).

Marutlulle, N.K. (2021), “A critical analysis of housing inadequacy in South Africa and its ramifications”, *Africa’s Public Service Delivery and Performance Review*, Vol. 9 No. 1, p. 16, available at: https://doi.org/10.4102/apsdpr.v9i1.372 (accessed 18 December 2022).

Napier, A. (2000), Enviro-friendly methods in small building design for South Africa, published by the author, ISBN 0-620-2572-3.

Phago, K. (2010), “The development of housing policy in South Africa”, *Politeia*, Vol. 29 No. 3, pp. 88-106, available at: https://hdl.handle.net/10520/EJC88255 (accessed 18 December 2022).

Pinho, I., Rego, A. and e Cunha, M.P. (2012), “Improving knowledge management processes: a hybrid positive approach”, *Journal of Knowledge Management*, Vol. 16 No. 2, pp. 215-242, 1367-3270, available at: https://doi.org/10.1108/13673271211218834 (accessed 18 December 2022).

Porter, T. (2004), *An Illustrated Guide to Architectural Terms, Archispeak*, Spon Press, New York, NY, ISBN: 0-415-30011-8.

Salzano, K.A., Maurer, C.A., Wyvratt, J.M., Stewart, T., Peck, J., Rygiel, B. and Petree, T. (2016), “A knowledge management framework and approach for clinical development”, *Therapeutic Innovation and Regulatory Science*, Vol. 50 No. 5, pp. 536-545, doi: 10.1177/2168479016664773.

Schlotfeldt, C. (2000), “Housing is not about houses, the Boutek experience”, Council for Scientific and Industrial Research (CSIR), Division of Building and Construction Technology, Pretoria, ISBN: 9780798856904.

Sisulu, L. (2020), “Human settlements Dept Budget Vote 2020/21Speech, 21 July”, The National Assembly on the occasion of the Debate on the Human Settlements Budget Vote (33) in the National Assembly, available at: https://www.gov.za/speeches/minister-lindiwe-sisulu-human-settlements-dept-budget-vote-202021-21-jul-2020-0000 (accessed 18 December 2022).

South African Council for the Architectural Profession (SACAP) (2020), “Final guideline professional fees issued in terms of section 34 (2) *of the architectural profession act*, 2000 act 44 of 2000”, South Africa Government Gazette vol 662 No 43591 dated 7 August 2020, Board Notice 91 OF 2020. ISSN 1682-5843, available at: https://www.sacapsa.com/documents/uploads/Gazettee-Final-Guideline-Professional-Fees.pdf (accessed 18 December 2022).

South African National Standards (SANS) (2012), “SANS 10400”, available at: http://sans10400.co.za/wp-content/uploads/2012/12/SANS10400A.pdf (accessed 18 December 2022).

United Nations Environment Programme (2021), “2021 global status report for buildings and construction: towards a zero emission, efficient and resilient buildings and construction sector”, Nairobi, available at: https://globalabc.org/sites/default/files/2021-10/GABC_Buildings-GSR-2021_BOOK.pdf (accessed 12 December 2022).

Van Tonder, F. (2022a), “An Architectural Design Process for Housing in South Africa”, World Building Congress 2022, in *IOP Conference Series: Earth and Environmental Science*, Vol. 1101, No 5 Planning, Partnership, and Law, p. 052006, published: 2022-12-07, IOP Publishing, doi: 10.1088/1755-1315/1101/5/052006.

Van Tonder, F. (2022b), “A knowledge management comparison of nine house typologies for varying climatic regions in South Africa”, World Building Congress 2022, *IOP Conference Series: Earth and Environmental Science*, Vol. 1101, No 3 Knowledge and Learning, p. 032029, published: 2022-12-07, IOP Publishing, doi: 10.1088/1755-1315/1101/3/032029.

Van Tonder, F. and Brink, P. (2022), "A conceptual decision tree for the automation of architecture applied to Housing", ECIAIR, *European Conference on the Impact of Artificial Intelligence and Robotics*, Vol. 4 No 1, pp. 108-117, available at: https://doi.org/10.34190/eciair.4.1.875 (accessed 12 December 2022).

Williams, J.J. (2006), "Community participation: lessons from post-apartheid South Africa", *Policy Studies*, Vol. 27 No. 3, pp. 197-217, available at: https://doi.org/10.1080/01442870600885982 (accessed 18 December 2022).

World Economic Forum (2016), "The future of jobs: employment, skills and workforce strategy for the fourth industrial revolution", available at: http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf (accessed 24 September 2021).

World Economic Forum (2020), "The future of jobs report 2020", available at: http://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf (accessed 24 September 2021).

Corresponding author
Francine van Tonder can be contacted at: francinevantonder@gmail.com