buildings

MDPI

Article

A Critical Success Factor Framework for Implementing Sustainable Innovative and Affordable Housing: A Systematic Review and Bibliometric Analysis

Alireza Moghayedi [1,*], Bankole Awuzie [2], Temitope Omotayo [3], Karen Le Jeune [1], Mark Massyn [1], Christiana Okobi Ekpo [1], Manfred Braune [1] and Paimaan Byron [4]

[1] Department of Construction Economics and Management, University of Cape Town, Rondebosch, Cape Town 7700, South Africa; Karen.lejeune@uct.ac.za (K.L.J.); Mark.massyn@uct.ac.za (M.M.); Christiana.ekpo@alumni.uct.ac.za (C.O.E.); manfredbraune@uct.ac.za (M.B.)

[2] Centre for Sustainable Smart Cities, Central University of Technology, Bloemfontein 9301, South Africa; bawuzie@cut.ac.za

[3] School of Built Environment, Engineering and Computing, Leeds Beckett University, Leeds LS2 8AG, UK; t.s.omotayo@leedsbeckett.ac.uk

[4] Department of Public Works and Infrastructure, National Government of South Africa, Pretoria 0001, South Africa; Paimaan.byron@dpw.gov.za

* Correspondence: alireza.moghayedi@alumni.uct.ac.za

check for updates

Citation: Moghayedi, A.; Awuzie, B.; Omotayo, T.; Le Jeune, K.; Massyn, M.; Ekpo, C.O.; Braune, M.; Byron, P. A Critical Success Factor Framework for Implementing Sustainable Innovative and Affordable Housing: A Systematic Review and Bibliometric Analysis. *Buildings* **2021**, *11*, 317. https://doi.org/10.3390/buildings11080317

Academic Editors: Chyi Lin Lee, Samad M. E. Sepasgozar and Lan Ding

Received: 27 June 2021
Accepted: 17 July 2021
Published: 23 July 2021

Abstract: The actualization of affordable housing remains a challenge. This challenge is exacerbated by the increasing societal demand for the incorporation of sustainability principles into such housing types to improve levels of occupant health and well-being whilst avouching the desired levels of affordability. Innovative technologies and practices have been described as beneficial to the effectuation of sustainable affordable housing. However, knowledge concerning the deployment of innovative technologies and practices in sustainable affordable housing (sustainable, innovative, affordable housing—SIAH) delivery remains nascent. Consequently, there is a lack of a common ontology among stakeholders concerning how to realize SIAH. This study aims to contribute toward the development of this body of knowledge through the establishment of the critical success factors (CSFs) for effective SIAH implementation. To achieve this objective, a systematic review and bibliometric analysis focusing on a juxtaposition of sustainable, innovative and affordable housing concepts was carried out based on the relevant literature. This led to the identification and clustering of CSFs for these housing concepts at individual levels and as a collective (SIAH). The findings of the study consisted of the establishment of four distinct yet interrelated facets through which SIAH can be achieved holistically, namely, housing design, house element, housing production method and housing technology. A total of 127 CSFs were found to be aligned to these facets, subsequently clustered, and conclusively used for the development of a SIAH CSF framework. The most frequently occurring CSFs with predominant interconnections were the utilization of energy-efficient systems/fittings, tenure security, a comfortable and healthy indoor environment, affordable housing price in relation to income and using water-efficient systems/fittings CSFs, and establishing the emergent SIAH CSF framework. The framework in this study is useful in the documentation of SIAH features for construction projects and further studies into SIAH CSFs.

Keywords: bibliometric analysis; critical success factor; innovative; sustainable affordable housing; systematic review

1. Introduction

The right to adequate housing has been described as an inalienable and fundamental human right by the United Nations. It features prominently—weaving like a common thread through the sustainable development goals (SDGs)—the globally accepted development blueprint to achieving sustainability, featuring especially in SDG 11. Efforts are being made to ensure that dwellings are delivered to appease various income brackets whilst supporting improved levels of social inclusivity and cohesion, economic access, and productivity with the least debilitating impact on the environment. Central to this drive to provide affordable and sustainable housing for most of the populace, particular emphasis has been placed on the denizens belonging to the low and middle income strata in both the developed and developing world. In developing countries, research has shown that over a billion people are likely to be living in slums, shanty towns and sub-standard housing at present [1]. Similarly, affordable housing challenges are said to exist in lower income brackets in most developed countries as well [2,3]. Consequently, because the housing supply has not been able to adequately meet the demand around the globe, there is widespread advocacy for more housing to meet this ever-increasing need, as the world's urban population is speculated to rise exponentially from 4.3 billion (2020) to 6.7 billion in 2050 [4].

However, there has been a significant decline in the provision of adequate sustainable affordable housing over the years. This has negatively impacted the quality of life of urban dwellers, with particular emphasis on the low and middle class segments of society [5]. In the global south, this challenge has been exacerbated by the projected rates of urbanization and the limited knowledge base available concerning probable context-dependent solutions. Consequently, the interventionist role of the construction industry to stem this disturbing tide has been adumbrated in various reports by stakeholders. For instance, Makinde [6] suggests that the construction industry should expedite actions that promote a balance between affordable housing supply and demand.

Furthermore, Makinde [6] opines that the challenge does not stop with an increased supply of affordable housing but by carrying out developments in a way that guarantees quality assurance of housing, thus cementing the pivotal role of the construction industry in facilitating the development of sustainable, affordable housing. However, the opportunities for development in this housing market class has been improving yearly, due to growing demand, but such demand has been met with struggling supply [7]. The supply of sustainable affordable housing has been hindered by the lack of interest by potential investors in most climes, as such housing types are largely considered to be social commodities with little or no profit capabilities. As a result, sustainable affordable housing development has been left for the public sector, non-governmental organizations, and low-profit entities to provide, with little or no interest from the private sector. The available evidence highlights an underwhelming performance of these entities in the attempt to deliver sustainable affordable housing, especially within the developing world context.

Extensive studies around the globe provide significant evidence of the deterioration of housing affordability. This has led to an increased focus on the affordability of housing at the expense of other considerations, such as sustainability and innovation. Unfortunately, the conservative nature and institutional quagmires inhibit the ability of the construction industry to pick the gauntlet in enabling the supply of sustainable affordable housing. The sector has been unable to effectively adopt and utilize innovative technologies to reduce the inefficiencies associated with the use of traditional design and construction methods in the delivery of sustainable affordable housing [8]. The use of traditional design and construction methods has been identified as a major contributor to the low levels of sustainability and poor cost-effectiveness of sustainable affordable housing units [8,9].

With the increasing need to enhance the sustainability of affordable housing through integrating technological innovation into the process of the design, construction, and operation of these types of housing, there is a need to systematically review and summarize the most influential and critical success factors associated with developing sustainable and affordable housing and the possible technological innovations at play in this market. As its central aim, this study seeks to contribute toward the development of this knowledge base, through the establishment of the critical success factors for the implementation of sustainable, innovative, affordable housing (SIAH).

In furtherance to this, the objectives of this study are to (1) define the SIAH as a new term in the body of construction knowledge; (2) systematically identify the critical success factors (CSFs) for developing SIAH; and (3) cluster the SIAH CSFs and conceptualize the comprehensive SIAH CSFs framework to inform the academic and industry communities for future studies. The SIAH CSF framework seeks to embrace the CSFs associated with the various facets of SIAH implementation, namely, housing design, house element, the housing assembly method, and housing technology as well as the interconnections between them. Besides contributing to the development of the SIAH knowledge base, the taxonomy of CSFs in a format of a conceptual framework provides a foundation for the management of SIAH projects to ensure the effective integration of innovative technologies during various phases of sustainable affordable housing delivery. Therefore, the novelty of this research rests not only in the inaugural introduction of the SIAH as a new term in the body of knowledge, but also in the accentuation and clustering of all critical success factors involved in developing SIAH.

The rest of the paper is structured as follows: Section 2 consists of a literature review of sustainable innovative affordable housing terms and concepts and the construction of the SIAH definition, along with the preliminary identification of CSFs associated with the concept; Section 3 presents the methods used for data collection and analysis; Section 4 offers the findings and the discussion thereof and highlights the conceptualization of the SIAH CSF framework; and Section 5 offers the conclusion.

2. Literature Review

2.1. Sustainable Affordable Housing Review

There have always been contrasting views on what is meant by "affordable housing" because the term "affordable" is highly subjective and varies according to contexts and individual opinion. On a general note, affordability describes anything that is able to bear cost with no dire consequences but due to its subjectivity and the context of a major asset class, namely housing, a clear definition of affordable housing is difficult to establish. Subsequently, various measures have been employed to define "affordability" from an objective perspective, and "income" is a major factor. Carswell [10] suggests that, as no consensus exists for measuring housing affordability explicitly, it can be determined from analyzing housing expenditure-to-income ratios. This includes rental cost as well as the total cost of utilities (gas, oil, electricity, other fuel, water, and refuse collection) [11]. Anacker [12] agrees that housing affordability and affordable housing challenges may adversely affect a household's budget. These challenges may result in decreased opportunities and a lower overall quality of life [13]. Overall, "affordable housing" has conventional terms, such as social, public and community housing, to imply subsidized housing provision by the state to low-income earners. [11]. The proponents of the expenditure–income rationale, such authors as Jones and Stead [14] and Carswel [10], propose that affordable housing be defined as housing that does not exceed more than 30 percent of the occupants' income. Due to the opponents of this definition, many other measures have been developed and utilized in further attempts to widen the understanding of affordable housing.

Anacker [12] reports that housing affordability is determined by both demand- and supply-side factors. Anacker [12] asserts that supply-side drivers of housing affordability need to take into consideration the infrastructure cost transfer via developer levies, together with the complexities and costs of releasing developable land. Anacker [12] agrees that land acquisition, design, approval processes and construction are very significant factors that can influence development. In the same vein, population growth, real income, and the cost and availability of finance for housing are identified as the main demand-side drivers of housing affordability [15]. Bangura and Lee [16] postulate that the slow growth rate in the housing supply response to demand with no corresponding increase in household income has resulted in higher house prices.

This has led to an increased focus on the affordability of these types of dwellings with minimal recourse to other considerations, such as sustainability. Gan and Zuo [1] thus argue that, even though sustainable affordable housing remains a priority for most governments and policy makers, the circumscribed supply of sustainable affordable housing continues to pose a significant challenge to successive governments globally. House prices around the world appear to be rising with no commensurate increase in income growth [17], a situation that continues to attract the attention of researchers, policy makers, developers, and investors.

The built environment has also been acknowledged to influence the urban climate [18], and since the 1990s, the impact of buildings on the environment has increasingly gained recognition [19]. This is due to modern cities (buildings inclusive) that consume natural resources, and generate heat and pollution in significant and wasteful amounts [18]. Energy demand has risen rapidly, causing innumerable universal economic and environmental challenges, such as global warming [20]. Buildings account for about 40% of primary energy consumption and one-third of greenhouse gas (GHG) emissions, making the built environment one of the most energy-intensive sectors and the top GHG emitters [20]. It has been acknowledged, therefore, that a shift in thinking is required to reduce the impact of construction on the environment. A critical rethink of how sustainability enhancement ideas might be required right from the conception stage or design phase of the building project, is vital. Incontrovertibly, the entire life cycle of a building should be considered when evaluating its sustainability [19]. It is, thus, essential to design sustainable urban spaces that improve energy independence and urban resilience; hence, smart green technologies should be promoted in buildings [21]. Despite the extensive global studies devoted toward housing affordability, few, if any, have sought to address housing affordability and sustainability through innovation.

Hence, affordable housing, when scrutinized through the lens of sustainability and innovation, requires the creation of durable housing for this income class who experience losses and abandonment because of substandard housing and construction, especially in the developing world. Thus, Chan and Adabre [3] suggest that "not all that is affordable is sustainable" and that bridging the gap between sustainable housing and affordable housing has become critical. Mulliner et al. [22] state that, in addition to economic measures, there are non-economic criteria associated with evaluating the success of sustainable affordable housing projects. Sustainable housing implies that the buildings are constructed using sustainable methods, materials, promote green practices that enhance a more sustainable lifestyle.

Accordingly, a paradigmatic shift in the nature of these dwellings toward the increased consideration of sustainability principles during the planning, design, delivery and operations phases has been noted in recent times. This quintessential shift is attributed to the commonly held perspective that the incorporation of these principles is beneficial to the health and well-being of the occupants and for the community, culminating in the rise of the sustainable affordable housing construct. In addition, with the increasing awareness of the impact of anthropogenic activities associated with the construction of such houses on the environment, it has become imperative that affordable houses are built in such a manner that they do not negatively impact the environment [23]. Scholars have acknowledged that the efficient delivery of sustainable affordable housing remains integral to societal socio-economic advancement and opine that it should be prioritized [24].

In the contemporary world, affordable housing should aspire to more than just creating habitable spaces by offering solutions that incorporate sustainable and innovative features. This will help to reduce construction and maintenance costs, introduce innovative technologies that enhance residents' empowerment and connect them to outside resources, and proffer greater human scale reference and connection to the community and neighborhood. However, innovative activities associated with affordable housing have not been adequately empirically considered [25]. Innovation ideally implies "the successful exploitation of new ideas", applicable to both technological, social and/or behavioral change [26]. Innovative housing in this context is the practical implementation of housing ideas that result in the introduction of new housing that is not only be affordable, but sustainable or improved. Innovation that aids sustainability is very important for research and policy since sustainable development requires retaining cohesive, diverse but inclusive communities as well as the separation of economic activity from environmental impact [27]. Apparently, over the last 30–40 years, a significant sustainable housing movement has evolved, championing new ideas, practices, and experiments, but many of their supported innovations have not been widely propagated [28].

Innovation broadly engages the environmental, social, and economic parameters of sustainability, culminating in the analysis of commercial and technological activities in the market economy [29]. Accordingly, Cucca and Friesenecker [30] suggest that building healthy, comfortable, and ecologically sustainable residential areas is very important. In terms of construction, sustainable (housing) development requires a shift toward high-quality buildings. This requires the application of sustainable building and design techniques for energy conservation and generation and building standards, a reduction in the use of non-renewable materials, and the facilitation of the recycling of resources [30]. The wherefores are because construction has impacts through carbon emissions, climate change, waste generation, change of land use, and loss of biodiversity [31]. In terms of ensuring accessibility to housing, sustainability also promotes the right supply of affordable housing to guarantee social justice and cohesion [32] and addresses adequate planning of social infrastructure. This is questioned by Cucca and Friesenecker [30] who opine that, currently, housing regeneration or construction applying sustainability criteria plays an uncertain role in the promotion of more ecological and just cities.

The development of sustainable construction ultimately aims to improve the quality of life, achievable through increased construction, improved quality of construction projects and the level of innovation potential [33]. This is based on scientific knowledge, technological tools, human resources, entrepreneurial resources, and investment necessary to produce new building materials, products and building systems that require a higher level of human capital [34]. The innovative potential of housing is conceived under the influence of such factors as the use of new materials, technologies, methods of organizing production and stimulating labor, and resource provision. Human capital is forged by the natural abilities of a person, their health, motivation to work, creative potential, knowledge, skills, and professional experience acquired because of investment. All these components together contribute to the growth of labor productivity and offer a return to the owner of such capital.

To resolve the aforementioned challenges, scholars have advocated for the extensive use of innovative building technologies in the design and construction of affordable housing to bring about a reduction in production costs [9]. Instances of technologies include the integration of cyber–physical technologies into the development phases and processes to create sustainably smart homes [23]. Others include the use of alternative, cost-effective building materials during the construction phases and modern construction methods, such as modular (off-site) construction processes. Among several others, it is believed that the utilization of such innovative technologies and practices will result in the reduction of supply costs, thereby boosting the sustainability and affordability of such dwellings [7,23].

2.2. Defining Sustainable Innovative Affordable Housing (SIAH): A Review of Related Literature

The provision of sustainable affordable housing remains central to the attainment of the aspiration elucidated by United Nation sustainability development goals [35]. However, the inability of relevant stakeholders to engender the effective delivery of sustainable affordable housing to cater to the urban poor and low-income earners has continued to negate the attainment of this aspiration. Whilst the incidence of urban housing shortages has lingered for decades, the rapidly urbanizing world has made the prioritization of tackling this malaise imperative in contemporary society. As a result of the lack of an effective approach to countering urban housing shortages, especially for low-income households, a burgeoning of slums in urban areas within the developing country context has been observed. Judging by the number of publications emanating from studies seeking to resolve the impact of housing shortages in the developing country context, the proliferation of these slums has also attracted the interest of various scholars. Based on the conclusions reached in most of these studies, it does appear that the supply of sustainable affordable housing remains a panacea for tackling this challenge confronting poor urban dwellers. Accordingly, successive governments have mandated and supported the delivery of such houses in recent times. Unfortunately, the delivery of such houses has been fraught by many challenges.

Significant among these challenges is the lack of a commonly accepted definition of the term "affordable housing", "sustainable housing" and "sustainable affordable housing". Evidence in the literature indicates that although contextual peculiarities impact the definitions of these terms [36], affordability remains central to the extant definitions [37]. The issue of what constitutes affordability within the housing context is still contentious, as scholars have argued that it could be assessed using several measures. Some of the measures include household expenditure, repayment affordability, location affordability, and affordable livability, among others [37].

Recently, the need to incorporate and prioritize other measures, including those mentioned previously, has come to the fore through the advocacy for the integration of sustainability considerations in affordable housing. Prior to this time, efforts for delivering affordable housing, particularly in developing countries, were focused on the cost of production and affordability without including sustainability considerations [1]. By incorporating the sustainability measures drawn from the economic (cost-efficiency, peaceful habitation, and resale value), environmental (water, waste and energy efficiency), and social (safety, security and universal design) dimensions [38] into affordable housing development, such dwellings not only contribute toward an improved quality of life and health for occupants with little or no negative impact on the environment, but also engender the potential for cost savings for the occupants for the duration of the affordable housing lifecycle whilst remaining affordable [39]. Gan et al. [1] describe sustainable, affordable housing as the design and delivery of affordable housing in a way that enables it to meet the needs of low- and medium-income earners presently without compromising the ability of the future generations of these income groups to meet their own housing needs. Similarly, Jamaludin et al. [40] admit that sustainable, affordable housing can be described as dwellings that, although procured at minimal cost, are cognizant of the need for the safety and well-being of the occupant, amongst other facets of sustainability.

Several critical success criteria for sustainable affordable housing have been identified and reported in the extant literature. Chan and Adabre [3] identify a plethora of success criteria for sustainable affordable housing, including house prices and rental costs in relation to household incomes, the interest rates and availability of mortgages, rental accommodation availability, the availability of affordable home ownership schemes, safety, stakeholder satisfaction, commuting costs, access to gainful employment opportunities, access to quality healthcare, access to retail and shopping outlets, access to child care and leisure facilities, access to open green public spaces, quality of housing, and energy efficiency levels in houses as well as the availability of waste management facilities. Chan and Adabre [3] go a step further to classify these critical success criteria into three distinct yet interconnected categories attributable to the following: product success, project success and project management success. The product success criteria consist of indicators for measuring the utility of the dwelling, whereas the project success criteria category is concerned with the ability of the sustainable affordable housing scheme to achieve the project outcomes, significant of which is the incorporation of sustainability considerations into the project and the allocation of these houses to eligible households within a short period of time. The project management success criteria rely largely on the performance indicators associated with the iron triangle, such as the cost, the time and quality performance, and the satisfaction of the construction stakeholders, etc. Additionally, Saidu and Yeom [9] outline the following success criteria for sustainable affordable housing, which ordinarily culminate in improved occupant satisfaction: security and welfare, accessibility, adaptability, utility, building technology application, community participation and affordability of housing.

The seamless delivery of sustainable affordable housing (SAH) and the potential of these dwellings to achieve these critical success criteria has been circumvented by a variety of factors. Chan and Adabre [3] observe that the emphasis on assessing affordable housing based on price or rent has contributed to widening the gap between affordable and sustainable housing concepts. Shahparvari and Fong [41] maintain that sustainable affordable housing delivery has been hindered by a lack of understanding of sustainability, a lack of technological innovation knowledge, inadequate design, the adoption of inappropriate construction methods and materials and a lack of innovative practices. Moghayedi and Windapo [42] corroborate this viewpoint, stating that the subsequent selection of poor designs, construction methods, materials, and technologies played a significant role in undermining the development of SAH. In a similar study, Adabre et al. [39] identify 26 potential barriers affecting the SAH development from the extant literature. These barriers range from the inadequacy of the affordable housing policy/guidelines, the high cost of sustainable building materials and technologies, to the shortage of skilled labor, among others. According to the authors, these barriers can be categorized into five underlying components: green retrofit-related barriers, land market-related barriers, incentive-related barriers, housing market-related barriers, and infrastructural-related barriers. Although it is evident that these issues are common to other types of housing, it can easily be discerned that these barriers have the potential to undermine the critical success criteria belonging to the three categories mentioned previously, especially the product success criteria and project management success criteria.

Innovative technologies and practices have been identified as having the potential to tackle these barriers and effectuate the successful delivery of SAH [8]. However, limited studies have sought to explore this potential further. Martinez et al. [43] report, through a case study of a contractor in Ecuador, that the utility of lean construction practices and information technology platforms assists in resolving the operational challenges brought about by the policy and regulatory constraints within the affordable housing project context whilst engendering process innovation.

In separate studies, Syamsuri et al. [44] and Aris et al. [45] highlight the expedience of the industrialized building system (IBS) and prefabrication technology in facilitating sustainable affordable housing construction in Indonesia and Malaysia, respectively. Nanyam et al. [46] suggest that the deployment of manufacturing techniques, such as Lean, 5S, Six Sigma, Last Planner, and green construction concepts, enhanced the efficiency of off-site construction for affordable housing delivery in India. Colistra [47] investigates the suitability of prefabricated construction methodologies in enabling a plug-and-play technology infrastructure to support ageing-in-place and telehealth technology deployment within sustainable affordable housing contexts in smart cities. Additionally, Osunsanmi et al. [48] advocate for the fusion of extant housing delivery strategies with fourth industrial revolution-related technologies to boost the delivery of sustainable housing in South Africa. Some of these technologies mentioned in their study include Building Information Modeling (BIM), Internet of Things (IoT), 3D printing, virtual reality, and cloud computing platforms, among others. Panteli et al. [49], for example, prove that integrating BIM into processes related to the design, construction and operation of buildings improves the sustainability of buildings. BIM, as one of the main streams of the industry 4.0 era, supports the entire philosophy behind sustainable building by delivering quantifiable results and significant contributions to the three pillars of sustainability.

Similarly, Aghimien et al. [50] make the case for the adoption of 3D printing in housing delivery. According to the authors, the benefits of deploying 3D printing technology in housing delivery include decreased construction timeframes, increased sustainability and durability of houses, improved productivity, increased quality delivery because of automated workmanship, and a reduction in material costs and wastage. Bennett et al. [8] investigate the role of digital technologies in overcoming the challenges posed by extant finance models, design processes and construction practices associated with affordable housing delivery in Los Angeles. They establish the beneficial use of digital technologies in facilitating process innovation in the predesign, design and construction phases of the affordable housing delivery process through providing the easy translation of complex sets of information, among others. Further, whilst highlighting the benefits associated with smart homes, Tetteh and Amponsah [51] recommend the adaptation of affordable housing designs in sub-Saharan Africa to incorporate the attributes of smart homes. Ge et al. [52] identify 11 essential green building technologies, which can be implemented in affordable housing contexts to improve building performance whilst maintaining stipulated affordability and comfort levels. These technologies include plant noise reduction technology, an intelligent lighting control system, water-tight pipes and the high structural strength in materials and construction of building elements.

Focusing on material-based innovation advantageous to SAH delivery contexts, Cherian et al. [53] demonstrate the capability of glass-fiber reinforced gypsum (GFRG) panels in providing rapid and affordable mass housing delivery. The advantages of GFRG buildings include the low cost of structural components, less energy consumption, less building weight, and quick construction. Similarly, Bredenoord [54] advocates for the adoption of locally sourced sustainable building materials during the delivery of low-cost housing projects in the Global South. His study appraises the challenges facing the utilization of bamboo, earth-block technologies, building blocks from recycled materials and improved concrete panels. According to Bredenoord [54], the local communities should be educated on the usefulness of these readily available materials for housebuilding.

This study seeks to identify the CSFs for the optimal integration of these innovative technologies and practices across various phases of the SAH lifecycle. The integration of innovative technologies in SAH has culminated in the evolution of the sustainable, innovative, affordable housing (SIAH) concept. Accordingly, SIAH is defined as the incorporation of innovative methods, materials, technologies and practices in the development of sustainable and affordable housing with the express purpose to enhance and optimize the potential of these houses to not only provide for the economic, social and environmental needs of low- and medium-income earners, but to also satisfy the technical aspects, and minimize the negative impact on the environment without compromising the affordability of houses across their lifecycle.

It is noted that, although the CSFs for the optimal implementation of SAH delivery are identified in the study of Adabre and Chan [55], there has been no known attempt at identifying the CSFs for SIAH. As such, this study seeks to extract CSFs for affordable housing, SAH, and innovative housing from the relevant literature in a bid to establish SIAH CSFs. It is expected that the identification of these CSFs will mark a notable contribution to the emerging field of study concerning SIAH. Furthermore, these CSFs will be used in the development of a comprehensive SIAH CSF framework by studying the contents and properties of the CSFs taxonomy.

3. Research Methods

There are three methods for reviewing and analyzing a large number of documents: meta-analysis, systematic review, and bibliometric analysis [e]. Due to the verifiability and reproducibility of the results emanating from a combination of the systematic literature review and bibliometric analysis, the mixture of these two methods was utilized in this study for identifying, analyzing, and mapping the structure of the critical success factors of sustainable, innovative, affordable housing.

The systematic literature review was used to gather the CSFs from bodies of knowledge within construction and across disciplines, streamlined through synthesis and clustered to identify CSFs, using a content analysis. The main strength of a systematic narrative review is the relatively fine-grained content analysis constructing explanatory theoretical models [56].

Subsequently, a bibliometric analysis was applied to validate and map the clustered CSFs that resulted from the systematic literature review. Bibliometric analyses use mathematical and statistical analysis methods for measuring the research impact in a quantitative way (seen as the objective) and compare the research impact more readily than the other methods, which are seen as subjective [57]. The quantitative approach of the bibliometric analysis method allowed for obtaining comprehensive, reliable, and influential CSFs for SIAH. Therefore, a combination of systematic review and bibliometric analysis allows for determining, analyzing, and properly clustering the various aspects of scientific production using conceptual (content analysis, thematic maps, co-occurrences networks), intellectual (references and co-citations), and social (publication territory maps) structure of the SIAH CSFs. One alternative to the systematic literature review and bibliometric analysis is the use of the survey research strategy. However, there is a need to conduct an extensive literature review on the existing SIAH CSFs to create a review article that offers a clear direction for research instrument design on this topic. Another alternative is scientometric analysis, which is very similar to bibliometric analysis. Scientometric analysis considers informetric and webometric mapping, which is also conducted through a bibliometric analysis [57,58].

The mapping of SIAH CSFs helped recognize the extant gaps in the knowledge and the development of the SIAH CSFs framework through the classification of CSFs. In addition, bibliometric and content analyses were used to identify the SIAH CSFs, their frequency and interconnections between the CSFs in creating the bibliographical SIAH CSFs network to verify the content analysis and structure of the SIAH CSFs framework.

The study's research workflow was carried out in five steps: development of the research protocol for the study; document search and filtering, using a systematic literature review; content analysis identifying and clustering CSFs; bibliometric data analysis and visualization using bibliographical analysis; interpretation of the results; and the development of the SIAH CSFs framework. The bibliometric review and attendant processes described in the protocol were carried out between December 2020 and January 2021.

In the first step, the research protocol for the study was developed. For this, two main questions of the study were defined. (1) What are the critical success factors influencing the design, construction, and operation of sustainable, innovative, affordable housing? (2) How do we cluster and conceptualize these CSFs into the relevant categories and subcategories that enable the development of a sustainable, innovative, affordable housing critical success factors' framework for further research?

The research protocol adopted for this study is presented in Figure 1 below.

The terms (keywords) and a reliable database for searching documents were identified in the second step. Web of Science and Scopus as the two comprehensive scientific databases containing the majority of the peer-review documents were selected. As terms or keywords are designed to convey the main topics of studies and, as such, represent them, the relevant documents were identified by searching for specific words. After an initial examination, it was determined that the terms utilized to reflect the theme of this study should be the following: "affordable", "sustainable", "innovative" and "house". Subsequently, the union sets of "house *" AND "sustainable *" AND "affordable *" OR "innovative *" were used for searching for documents on the selected databases. The selected keywords provided a streamlined approach to extracting the relevant publications on SIAH. A broader range of keywords outside the scope of this article would have created unwanted articles. The document search was developed, gathering the document titles, abstracts and author keywords, using defined terms and union sets of terms. A database search enhances the possibility of building the whole portfolio of documents, using the defined database results, once the articles that emerge have been analyzed. Thus, co-occurring terms can be identified and analyzed to reflect the most popular research issues in each field. In both databases, the document search was limited to peer-reviewed documents published in English because of these documents' quality assurance process. There was no restriction on the time intervals for the publication, as all peer-reviewed documents published until the end of 2020 were extracted from the relevant databases. After the initial database search, the outcomes from the two databases (Scopus, 85 documents, and Web of Science, 51) were combined, and 21 common documents were identified and subsequently excluded.

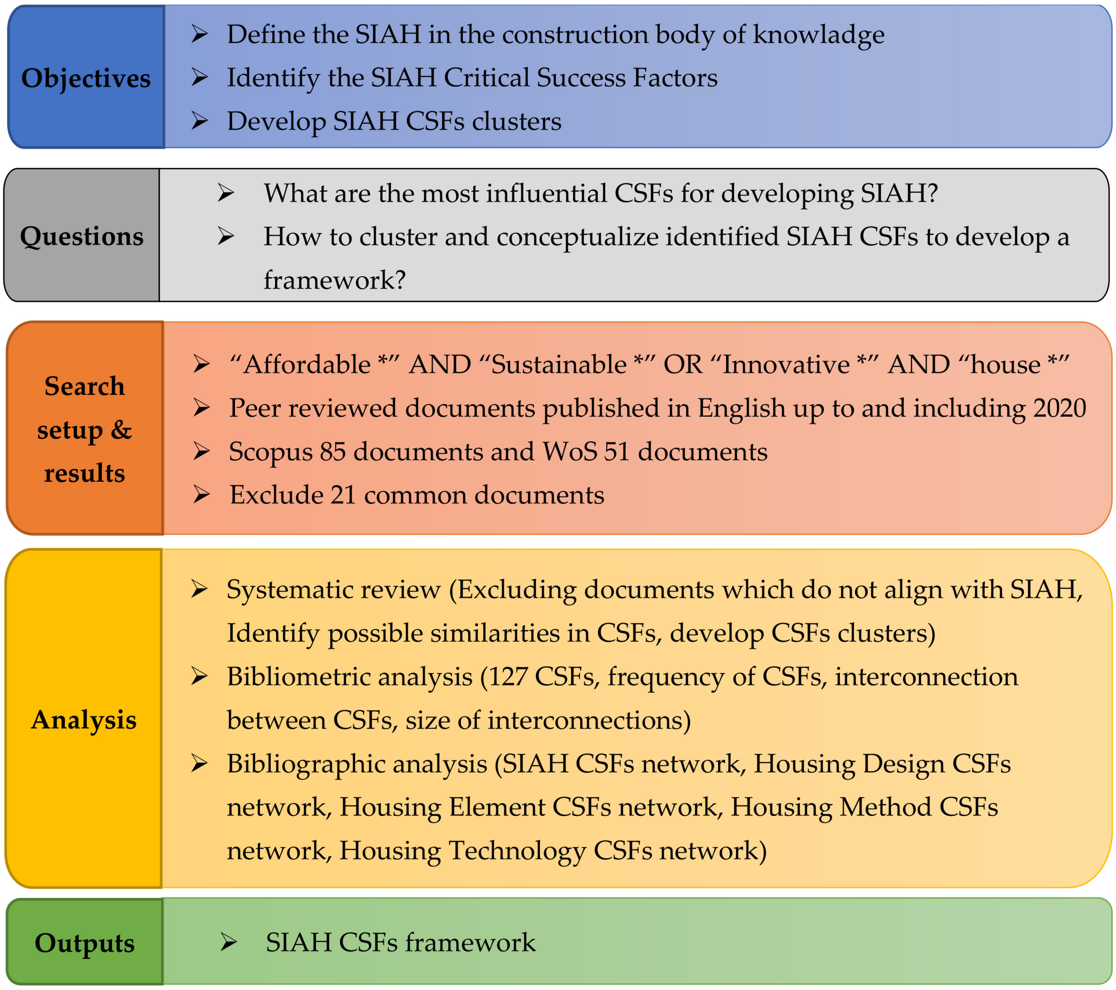

Figure 1. Research protocol for the study.

In the third step, the titles, keywords and abstract of the 115 documents from the two databases were merged and examined, using content analysis for determining their alignment to the research objective (identification of SIAH CSFs). Based on the evaluation of the 115 documents' titles, keywords and abstract, 45 documents were excluded, as it was deemed that they did not align with the research objective, leaving a final list of 70 documents. The relevant indicators, criteria and CSFs were extracted and analyzed to establish SIAH CSFs from these selected 70 documents. The content analysis was conducted manually to identify and eliminate possible similarities in CSFs used by different researchers. Usually, researchers use slightly different indicators/factors to indicate the same or a similar concept. The final list comprised 127 SIAH CSFs and were clustered into four categories (housing design, house element, assembly method and housing technology). Moreover, each categorized was split into four sub-categories (economic, environmental, social, technical).

In the fourth step, the frequency of the 127 identified CSFs and co-CSFs appearing in the same document were calculated, and subsequently, the node table and interconnection matrix was developed. In this way, 5289 co-CSFs were extracted. The developed node table and edge matrix were imported to the Gephi software to establish and visualize the SIAH CSFs networks. Gephi is an open-source network analysis and visualization software package that is widely use by researchers for bibliometric and bibliographic analyses [58]. Similar software, such as Cytoscape and Citespace, will produce the same outcomes as Gephi, using the nodes and edges matrix.

In the fifth step, the findings that emerged from the bibliometric analysis, bibliographic analysis and content analysis of the data were interpreted, and finally, the SIAH CSFs framework was developed.

4. Result and Discussion

4.1. Publication Trend in Time

The temporal distribution and trend of publications associated with SIAH CSFs is illustrated in Figure 2. Although the publication period was not restricted in this study, only 7% of the sample documents (5 documents) were published before 2010, which indicates the novelty of the sustainable, affordable housing research field. The increasing trend of publication was somewhat stable over the whole period of study. Moreover, almost half of the selected documents (47%) were published in the last three years.

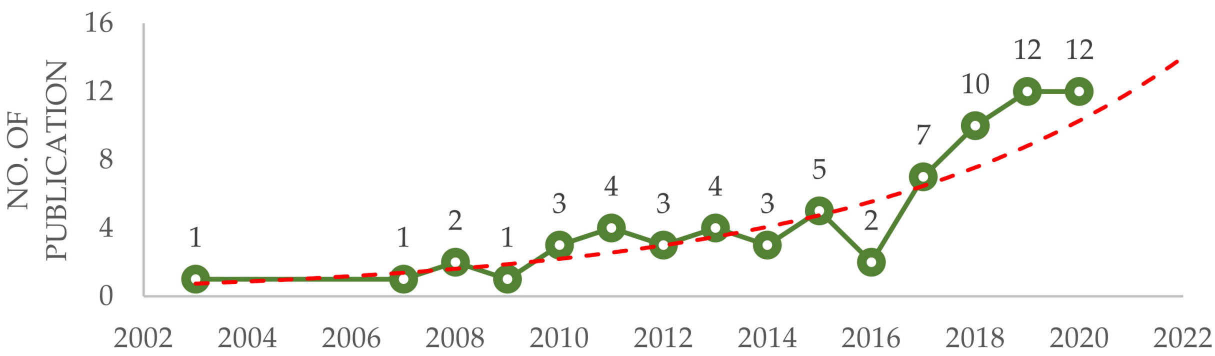

Figure 2. Temporal distribution and trend of SIAH CSFs.

From the output of Figure 2, the exponential increase in publications could be attributed to the increased international and local attention on reducing the impact of housing on the environment, and improving the residents' quality of life as well as embracing the 4th industrial revolution (IR) era, which has encouraged scholars to engage more significantly with research on sustainable, innovative affordable housing [54,58,59].

4.2. Publication Territory

The number of document publications in a country indicates the extent to which research in the field of SIAH is being undertaken. It acts to identify which countries are more progressive on this specific topic. Thus, it is meaningful to analyze the contributions of countries to sustainable, affordable housing research; Figure 3 illustrates the number of selected documents distributed by the countries of origin.

Figure 3. Publication territory in SIAH CSFs.

The top three contributors to SIAH CSFs research are the United Kingdom (U.K.) (11), Malaysia (9) and Nigeria (6), responsible for more than 46% of all publications. Furthermore, Figure 3 shows that 57% of the selected documents are affiliated with global south countries, another term to denote developing countries. Malaysia (9), Nigeria (6) and China (5) are the only countries in the global south that have frequently contributed in SIAH CSFs. To a great extent, this indicates that the other developing countries, particularly East Asian and Sub-Saharan African countries, are realizing the importance of developing sustainable, affordable housing.

4.3. Analysis and Taxonomy of the Critical Success Factors for SIAH

The systematic literature review and thematic content analysis of 70 peer review literature sources from two major scientific databases identified 127 critical success factors associated with sustainable innovative affordable housing. The thematic content analysis was conducted manually to eliminate CSFs used to identify possible similarities in concepts that were signposted by different CSFs. The frequency of identified CSFs was determined, and subsequently, a node table was constructed to document the quantification of the recurrence of CSFs in the 70 documents.

According to Isalou et al. [60], the performance of affordable housing projects can be evaluated in three scales, namely, housing conditions, neighborhood, and location. Since the focus of this paper is on housing, the sub-conditions of design, construction and operation of affordable housing types is relevant. Overlaying the issues of affordability, sustainability, and the degree of innovation of houses, the study adopted four housing facets from Akadiri et al. [61] to establish the taxonomy of SIAH CSFs, namely the following: the design of a house, pertinent elements of a house, assembly methods used in the design and construction of a house, and innovative technologies used for operating a house. The highlighted words denote the primary cluster themes applied to the identified CSFs. Each cluster was subsequently further sub-categorized into the three components of sustainability (economic, social, environment) with the technical aspect added as a fourth sub-category.

The frequency of occurrence of the CSFs, arranged according the primary and secondary cluster themes, is summarized in Table 1.

Table 1. Clustered SIAH CSFs.

Category	Subcategory	Critical Success Factor	Label	Freq.	Source
Design	Economic	Local value creation by design	DEC1	10	[39,62–70]
		Housing price in relation to income	DEC2	26	[1,3,9,39,40,60,62,65,67,68,71–84]
		Economy of scale mass production	DEC3	3	[65,68,75]
		Duration of design and construction	DEC4	2	[39,85]
		Lifecycle cost of house (design, material, construction, operation, maintenance, demolition/recycling)	DEC5	19	[1,3,39,59,66,67,71,76,80,82,83,85–90]
		Cost of house (Design, construction and material cost)	DEC6	18	[1,3,9,39,59,66,67,71,76,80,82–84,86–88]
		Cost of operating	DEC7	11	[1,9,39,59,67,71,76,87–89]
		Cost of maintenance	DEC8	12	[1,9,39,59,67,71,76,85,87,88]
		Cost of demolition/recycling	DEC9	9	[9,39,59,67,76,85,87,88,91]
	Environment	Integrating renewable energy (solar geyser, PV, etc.)	DEN1	24	[9,39,63,64,67,78,80,83,89,91–104]
		Lean design (minimizing waste)	DEN2	12	[39,61,64,67,71,73,78,81,89,97,100,104]
		Integrating water recycling (rainwater harvesting, greywater, blackwater)	DEN3	14	[63,64,67,71,80,88,90,91,96–98,103–105]
		Design with local nature	DEN4	6	[62,66,70,71,88,90]
		Using energy efficient systems/fittings	DEN5	34	[1,3,9,22,39,61,63,64,66,67,69–73,75,79,81,83,85,87,89,90,92,94,95,97,100,102,104,106,107]
		Using water efficient systems/fittings	DEN6	25	[1,22,39,63,64,66,67,69–71,73,75,84,85,87,89,90,95,97,100,101,103,104]
		Disaster resistance design	DEN7	7	[1,64,65,69,70,105,108,109]
		Integrating green building aspects	DEN8	5	[3,64,70,71,104]
		Using passive thermal	DEN9	13	[62,70,72,80,83,89–91,93,99,105,107]
		Using natural lighting	DEN10	22	[3,62,63,70–72,81,83,89,91–93,97,99,101,105,107,110–112]
		Using natural ventilation	DEN11	16	[62,72,80,81,83,89–92,99,101,102,107,109,110]
	Social	Minimizing social segregation	DS1	6	[65,67,70,90,92,102,106]
		Social acceptability of design	DS2	7	[1,67,68,71,84,91,97]
		Provide end-users' needs and satisfaction	DS3	18	[9,39,63–65,67,71,72,80,82,83,87,88,90,101,104]
		Aesthetic	DS4	13	[9,64,66,67,71,72,84,90,110,111]
		Privacy of house	DS5	10	[62,66,71,72,90,97,101,107,110,113]
		Comfortable and healthy indoor environment (air, thermal, acoustics, humidity, etc.)	DS6	27	[1,9,62–64,66,67,69,71,72,81–84,87,89,90,92,95–97,100,102,104,114]
		Compatible with local culture and lifestyle	DS7	14	[9,63–67,70–72,88,92,104,113]
		Tenure security	DS8	30	[1,3,9,39,61–64,66,67,70–75,77–79,81–83,89,92,105,108,110–113]
		Sense of Community	DS9	15	[9,63–67,71,83,87,90,92,102,104]
		Equality design (disabled, female, child, elderly)	DS10	9	[9,63,64,77,87,90,104,105,113]

Table 1. *Cont.*

Category	Subcategory	Critical Success Factor	Label	Freq.	Source
	Technical	Maintainability of design	DT1	12	[39,63,64,71,72,74,78,82,104,105,108]
		Flexibility of design	DT2	6	[67,71,76,83,103,114]
		Simplicity of design	DT3	3	[68,76,83]
		Compatibility of design with new construction methods (modularization, prefabrication, 3D printing)	DT4	3	[68,95,97,115]
		Design for disassembly	DT5	3	[67,90,97,110]
		Plumbing system/fittings	DT6	10	[62,64,66,72,75,81,90,95,110]
		Structural integrity	DT7	4	[62,90,98,110]
		Fire system (escape)	DT8	3	[72,98,107,110]
		Drainage system	DT9	6	[62,71,72,96,97,110]
		Sanitation system/fittings	DT10	10	[62,64,66,72,75,81,90,95,110]
		Electrical system/fittings	DT11	7	[66,71,72,75,94,109,110]
		Heating and cooling system	DT12	13	[66,67,70,78,82,83,94,97,102,103,105]
		Insulation (thermal, water, noise, humidity)	DT13	19	[22,62,66,67,70–73,80,82,89,90,99,101,102,105–107,110]
		Building typology and orientation	DT14	22	[9,62,63,66,68,70,72,75,80,82–84,88,95,99,103,110,111,116,117]
		Economical design (floor area/plot area)	DT15	22	[1,39,63,70,72,75–78,80,83,87,90,92,95,97,99,101,104,110,112]
		Living area size (net floor area)	DT16	19	[63,66,68,70,75,78,81,82,90,95,99,101,107,110–112,116]
		Functionality of layout	DT17	14	[3,39,62,67,70,71,75,76,81,90,91,101,105,116]
		Adequate living spaces within small size unit	DT18	12	[1,39,64,70,82,90,91,101,110,114]
		Entrance design	DT19	6	[62,70,71,80,110,112]
		Bedrooms numbers, size	DT20	15	[62,66,70,71,76,80–82,101,107,110–112,116]
		Bathroom numbers, size/layout	DT21	15	[62,70,71,73,76,78,80–82,101,107,110,111,116]
		Kitchen size/layout	DT22	7	[62,70,71,107,110,112]
		Amenities (kitchen cupboard, bathroom cabinets, bedroom wardrobe, etc.)	DT23	11	[62,67,70–72,75,82,112,114]
		Open space (yard, garden, balcony, green area)	DT24	23	[1,61,65,66,70–72,76,81,82,89,90,92,93,95,99,102–104,109,116]
		Storage	DT25	4	[95,107,109]
		Parking/Garage	DT26	8	[59,70,80,83,105,109,110,112]
		Vertical circulation	DT27	5	[70,110,114]
		Horizontal circulation	DT28	3	[70,72,110,116]
		link between indoor-outdoor spaces	DT29	4	[66,70,72,90]
		Able to install additional systems (telecommunications, TV)	DT30	4	[62,66,70,95]
		Facade	DT31	4	[64,95,107,109,112,117]
	Economic	Local value creation by construction/assembly elements	EEC1	7	[62–65,67–69]
		Economy of scale mass production of element	EEC2	4	[59,64,65,75]
		Lifecycle cost element (materials, transport, construction/assembly, maintenance, demolition/recycle)	EEC3	15	[22,39,40,59,66,67,70,71,73,83–85,87,108]
		Material cost	EEC4	6	[3,9,85,88,117]
		Transport cost	EEC5	2	[1,9,115]
		Construction/assembly cost	EEC6	8	[1,3,9,39,76,80,82]
		Maintenance cost	EEC7	2	[9,63]
		Demolition/recycling cost	EEC8	1	[9,92]

Table 1. *Cont.*

Category	Subcategory	Critical Success Factor	Label	Freq.	Source
	Environment	Using local materials	EEN1	12	[9,62,64,66,67,88,91–93,95,97,101]
		Recycling and deconstruction ability (circular economy)	EEN2	11	[9,63,66,68,87,88,90–93]
		Compatible with local nature	EEN3	7	[9,62,64,66,88,90,91]
		Effectively utilizing resources (virgin and recycled)	EEN4	18	[1,9,63,64,66,67,71,77,85,87,88,90–93,97,104,117]
		Water efficient	EEN5	8	[1,9,71,75,90,100,104]
		Minimize biodiversity loss	EEN6	8	[1,9,67,71,77,88,91,102]
		Waste efficient (lean)	EEN7	12	[9,63,71,72,75,78,90,97,100,103,104,117]
		Nontoxic	EEN8	8	[9,63,71,77,88,90,100,103]
		Using green Material	EEN9	7	[9,64,81,88,91,97,104]
		Lifecycle Energy	EEN10	10	[9,64,67,90,91,93–95,106,117]
		Lifecycle GHG	EEN11	10	[1,9,66,88,90–94,97,117]
	Social	Local job creation by construction/assembly element	ES1	10	[1,9,39,64,65,70,72,77,87,92]
		End user acceptance of element	ES2	6	[1,71,84,91,97]
		Cultural and heritage conservation	ES3	8	[1,9,64,65,67,90,92,104]
	Technical	Durability	ET1	14	[1,9,62,67,69,72,77,83,90,97,110,111,115]
		Compatibility with other building components/systems	ET2	3	[9,71,75,115]
		Standards/building codes	ET3	9	[1,9,39,63,70,71,86,118]
		Adaptability/flexibility	ET4	11	[1,9,39,63,67–69,76,83,91,107,114]
		Resilience	ET5	5	[1,9,69,70,86]
		Skill required for construction/assembly element	ET6	5	[9,71,75,77,86]
		Equipment and machinery required for construction/assembly element	ET7	4	[62,75,90,95]
		Prefabrication/modularization degree	ET8	6	[69,70,90,91,95,115]
		Thermal conductivity	ET9	9	[9,39,62,63,66,71,90,91,99]
		Water tightness	ET10	5	[9,39,63,71,110]
		Air tightness	ET11	7	[9,39,66,71,99,110]
		Acoustic	ET12	4	[3,9,66,71]
		Construction duration	ET13	7	[3,9,39,63,68,71,83]
Method	Economic	Local value creation by method	MEC1	8	[62,63,65,67–71]
		Impact on the construction cost (labor, equipment, plant)	MEC2	6	[9,69,71,77]
		Economy of scale of mass production of method	MEC3	2	[68,94,118]
	Environment	Minimizing pollution and GHG emission	MEN1	11	[1,63,67,71,78,82,88,90,94,101,102,115]
		Water efficient method	MEN2	10	[63,71,90,91,97,100,103,104,115]
		Energy efficient method	MEN3	17	[63,64,70–72,75,79,83,90–92,95,97,100,104,115]
		Minimizing waste by method	MEN4	15	[1,9,61,62,64,67,70,72,78,88,92,97,100,103,115]
	Social	Community participation	MS1	11	[40,64,65,71,77,81,87,90,92,103]
		Social acceptability of method	MS2	6	[1,40,68,84,91,92]
		Local job creation	MS3	11	[9,64,65,68,70–72,77,87,92]

Table 1. *Cont.*

Category	Subcategory	Critical Success Factor	Label	Freq.	Source
	Technical	Interface to basic services	MT1	5	[39,68,75,110,114]
		Reliability and durability	MT2	12	[39,62,67–69,72,83,90,107,110,115,118]
		Standards/manuals	MT3	8	[1,39,71,72,86,88,115,119]
		Impact on construction duration	MT4	6	[3,9,40,69,72,83]
		Skill required for construction method	MT5	4	[40,71,86,115]
		Equipment and machinery required	MT6	4	[71,75,76,115]
		Adaptability and flexibility with other methods	MT7	7	[63,68,69,71,76,83,91,114]
		Quality of workmanship	MT8	14	[39,61,62,64,66,70,71,77,79,81,107,115]
Technology	Economic	Initial cost of technology	TEC1	5	[9,71,83]
		Operational cost of technology	TEC2	2	[68,71]
		Maintenance cost of technology	TEC3	3	[68,71,87]
		Impact of technology on operation or maintenance cost of house	TEC4	4	[1,9,71,87]
	Environment	Minimizing waste by technology	TEN1	7	[1,66,71,89–91]
		Minimizing water and energy by technology	TEN2	14	[1,63,64,66,70,83,90,91,94–97,99,101,102,106]
		Improve air quality by technology	TEN3	4	[1,64–66]
	Social	Social acceptance of technology	TS1	4	[1,64,70,71]
		Improve lifestyle by technology	TS2	7	[39,62,65,70,71,87,114]
	Technical	Availability of technology	TT1	3	[39,40,68,114]
		Durability and Reliability of technology	TT2	3	[40,68,114]
		Skill requirement for using technology	TT3	2	[40,71,97]
		Decentralized infrastructure (energy, water) autonomous	TT4	6	[88,94,97–99,102]

The developed node table and edge matrix were imported to the Gephi software to establish and visualize a SIAH CSFs network, as presented in Figure 4. The presence of the four primary SIAH clusters are illustrated as design (green), element (red), method (pink) and technology (blue), respectively.

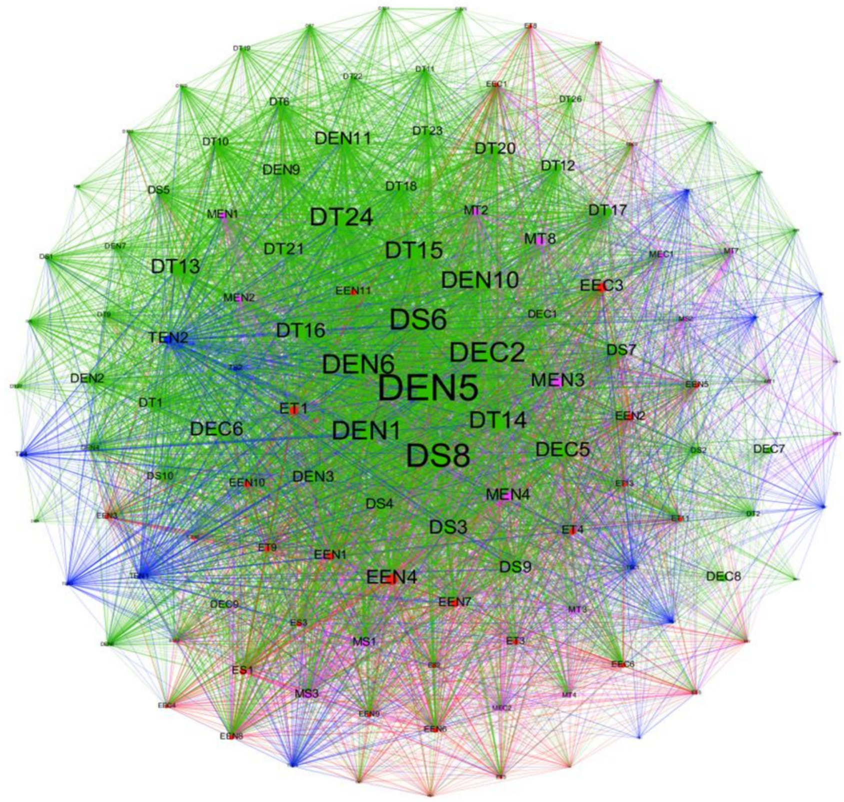

Figure 4. Clustered SIAH CSFs network.

Advanced statistical analysis of the four clusters of SIAH CSFs were applied to evaluate and validate the taxonomy and conglomeration of each category; the results are presented in Table 2.

Table 2. Connected components and average clustering coefficient.

Category	Connected Components	Average Clustering Coefficient
Design	1.0	0.714
Element	1.0	0.747
Method	1.0	0.802
Technology	1.0	0.840

The connected components of four SIAH categories are 1.0, which proves that all CSFs in each cluster are interconnected. Moreover, the average clustering coefficient for all four of the primary clusters is greater than 0.7, which validates that the CSFs in each cluster have strong interconnections [57]. The connected components and average clustering coefficient of the four SIAH facets validate the process of thematical content analysis.

In CSFs network, each node represents a primary or secondary CSF cluster, and its size reflects the number of recurrences of the CSF in the sample of documents. An overview of the size of CSF nodes shows the most predominant indicators and their distinct importance in developing sustainable innovative affordable housing.

There are some high-frequency central CSFs in the first focus, including DEN5 (using energy-efficient systems/fittings) with the highest citation occurrence (51% in sample documents) followed by DS8 (tenure security) cited in 43% of the literature surveyed; on the third tier, DS6 (comfortable and healthy indoor environment), DEC2 (housing price in relation to income) and DEN6 (using water efficient systems/fittings) are cited by 39%, 37% and 36% of scholars, respectively.

It should be noted that technology CSFs was cited more recently (since 2010), due to the innovative nature of this category in developing SIAH.

The links in Figure 4 denote the interconnections among CSFs, and the thickness of each link denotes the interconnection strength (number of interconnections) between two CSFs. DEN5 (using energy-efficient systems/fittings) and DS6 (comfortable and healthy indoor environment); DEN6 (using water-efficient systems/fittings) and DEN5 (using energy-efficient systems/fittings); and DEC2 (housing price in relation to income) and DS8 (tenure security) are the pairs of CSFs with the strongest interconnections. The number of CSFs identified under the design cluster are notable as is the relevant frequency of these CSFs occurring in the literature sample; together with the strong interconnection between the design cluster's secondary CSFs clusters, compared to the other three CSFs categories, it proves the important role that design CSFs play in developing sustainable, innovative, affordable housing units.

4.4. Sustainable Innovative Affordable Housing Facets

4.4.1. Housing Design

Housing design refers to the architectural and engineering applications and specifications in the design of housing units. A well-designed house is secured, well protected [9], offers a high level of functionality and social interaction on a small footprint [77], realizes residents' needs, and provides comfortability based on their activities, lifestyle, and microclimate [39,63]. Moreover, the architectural and engineering housing specifications, such as materials and utility services, must be efficient and selected to last [39,76].

Housing design is closely related to a variety of economic, environmental, and social problems [76]. Therefore, sustainable, affordable house needs to be designed to maximize residents' well-being and minimize the negative impact on the local economy, society and environment.

Due to the significant impact of the design on the sustainability and affordability of housing units and on residents' health and well-being, all selected sampled documents contributed to housing design facet of the CSFs. This is the largest facet of SIAH, as it contains 61 CSFs (48%) in total, which are the following:

- A total of 8 CSFs involve economic sustainability (DEC 1–8 red) (local value creation by design; housing price in relation to income; economy of scale mass production; duration of design and construction; lifecycle cost of house; cost of house; cost of operation; cost of maintenance; cost of demolition/recycling).
- A total of 12 CSFs incorporate environmentally sustainable concepts (DEN 1–12 green) (integrating renewable energy; lean design; integrating water recycling; design with local nature; using energy-efficient systems/fittings; using water-efficient systems/fittings; disaster resistance design; integrating green building aspects; using passive thermal; using natural lighting; using natural ventilation).
- A total of 13 CSFs cover social sustainability matters (DS 1–13 pink) (social acceptability of design; provide end-users' needs and satisfaction; aesthetic; privacy of house; comfortable and healthy indoor environment; compatible with local culture and lifestyle; tenure security; sense of Community; equality design).
- A total of 31 CSFs deal with technical issues (DT 1–31 purple) (maintainability of design; flexibility of design; simplicity of design; compatibility of design with new construction methods; design for disassembly; plumbing system/fittings; structural integrity; fire system; drainage system; sanitation system/fittings; electrical system/fittings; heating and cooling system; insulation; building typology and orientation; economical design; living area size; functionality of layout; adequate living spaces within small size unit; entrance design; bedrooms numbers/size; bathroom

numbers, size/layout; kitchen size/layout; amenities; open space; storage; parking/garage; vertical circulation; horizontal circulation; link between indoor–outdoor spaces; ability to install additional systems; façade), all as shown in the design cluster CSFs network in Figure 5.

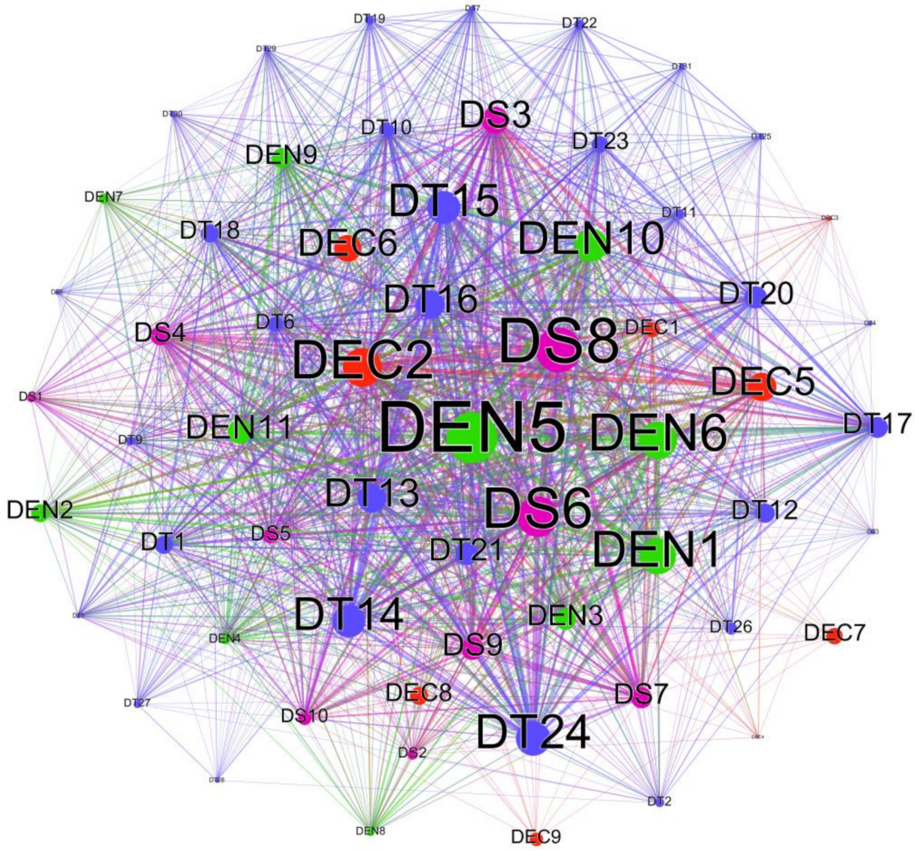

Figure 5. Design CSFs network.

As illustrated in Figure 5, the most frequently cited SIAH CSFs belong to the housing design facet, of which the following the five most cited CSFs are coded as DEN5 (using energy-efficient systems/fittings), DS8 (tenure security), DS6 (comfortable and healthy indoor environment, air, thermal, acoustics, humidity, etc.), DEC2 (housing price in relation to income) and DEN6 (using water-efficient systems/fittings).

Gan et al. [1] identify the integration of energy- and water-efficient systems/fittings as the most important components of SIAH because these systems/fittings not only increase the occupants' comfort and provide for a healthier indoor environment, but also make the housing units more affordable through a reduction in the operational cost of the house. This, according to Saidu and Yeom [9] and Gan et al. [63], also serves to increase the safety factor of the house and promote tenure security, which are essential social factors.

The CSFs in the design cluster network are characterized by the most inter-category (among the design CSFs) linkages (65%) and intra-categories linkages (57%) with the CSFs belonging to other SIAH categories. This supports the proposition that design-related CSFs are the main drivers for sustainable, innovative, affordable housing units, an observation that is aligned with the findings of Tibesigwa et al. [108], Elkady et al. [116] and Von Seidlein et al. [85].

Among the 1269 inter-category links in the design category, the association between DEN5 (using energy-efficient Systems/fittings) and DS6 (comfortable and healthy indoor environment, air, thermal, acoustics, humidity, etc.); DEN5 (using energy-efficient systems/fittings); and DEN6 (using water-efficient systems/fittings) are the most robust links between any pair of CSFs. These associations further prove the importance of integrating efficient systems/fittings to improve housing units' affordability and sustainability.

4.4.2. House Element

House element refers to the physical components of the housing unit. The American Society for Testing and Materials [120] classify the house elements into structural and non-structural elements. Structural elements refer to the skeleton of the house that carries its weight. The structural elements include the foundation and footings, curtain walls (exterior) and load-bearing walls (interior), beams and columns, floors, and the roof. The use of green roofs and urban greenery, for instance, can decrease the mean radiant temperature by about 10°C during the summer season, improving indoor thermal comfort conditions and resulting in savings of up to 12% in space cooling energy consumption [21]. Faroughi et al. [18] suggest that among the variables examined in their study, the type and size of buildings, orientation of building, texture concentration, and surface color, among other things, are the most important factors affecting energy consumption. The non-structural elements, on the other hand, refer to everything inside, outside or on top of the house other than the structural elements. The non-structural elements include architectural components (doors, windows, cabinets, suspended ceilings and light fixtures, internal walls), and utility and mechanical equipment/systems (heating, ventilation, air conditioning, water/sewer, electric ductwork, pipes, motors, pumps, and tanks). The non-structured elements are typically permanently attached to the house and supported by the structure of the building. House elements consume a large amount of housing project budget and resources; therefore, the final cost and quality of these elements significantly impact the affordability and sustainability of housing units [42].

The house element facet mainly focuses on key items, such as the resources used in the elements, cost of the element, duration of construction, quality, and performance of elements. This category contains 35 CSFs (28%) in total, which are the following:

- A total of 8 CSFs involve economic sustainability (EEC 1–8 red) (local value creation by construction/assembly elements; economy of scale mass production of element; lifecycle cost element; material cost; transport cost; construction/assembly cost; maintenance cost; demolition/recycling cost).
- A total of 11 CSFs incorporate environmentally sustainable concepts (EEN 1–11 green) (using local materials; recycling and deconstruction ability; compatibility with local nature; effectively utilizing resources; water efficiency; minimizing biodiversity loss; waste efficiency; nontoxicity; using green material; lifecycle energy usage; lifecycle GHG).
- A total of 3 CSFs cover social sustainability matters (ES 1–3 pink) (local job creation by construction/assembly element; end user acceptance of element; cultural and heritage conservation).
- A total of 8 CSFs deal with technical issues (ET 1–8 purple) (durability; compatibility with other building components/systems; standards/building codes; adaptability/flexibility; resilience; skill required for construction/assembly element; equipment and machinery required for construction/assembly element; prefabrication/ modularization degree; thermal conductivity; water tightness; air tightness; acoustic; construction duration) as shown in the element cluster CSFs network in Figure 6.

Of the sampled literature, 80% was cited as relevant to the house element CSFs, which clearly indicates the importance of this facet. EEN4 (effectively utilizing resources, virgin and recycled), EEC3 (lifecycle cost of the house element included materials, transport, construction/assembly, maintenance, demolition/recycle), ET1 (durability), EEN1 (using local materials), and EEN7 (waste efficient element, lean) are the five most cited CSFs associated with the house element cluster.

According to Shama and Motlak [67] and Hamid et al. [88], the effective use of virgin and recycled resources and local materials in the development and construction of housing elements, and the utilization of waste efficient elements, significantly improve the sustainability and affordability of a house. Moreover, Saidu and Yeom [9] and Gan et al. [58] suggest that the affordability and economic sustainability of housing units is significantly improved if the durability and lifecycle cost of elements are considered by the designers and developers alongside the material and construction cost of elements.

The network for the element cluster of CSFs as illustrated in Figure 6 highlights the strong inter-category links between various CSFs. This category represents 26% of the entire inter-categories links (among the CSFs elements) and 31% of the intra-categories links to other CSFs categories across the SIAH network, proving the importance of the house elements' CSFs on the affordability and sustainability of houses.

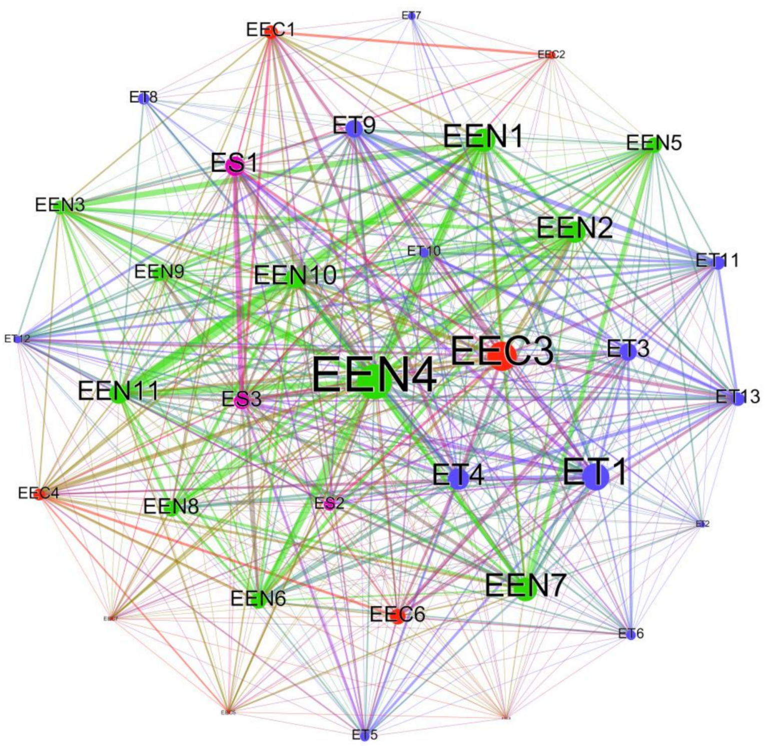

Figure 6. House element CSFs network.

The strong association between EEN10 (lifecycle energy) and EEN11 (lifecycle GHG) and EEN4 (effectively utilizing virgin and recycled resources) and EEN1 (using local materials) is evident in the thick lines connecting these nodes in Figure 6. This is because of the environmental and economic issues plaguing the existing house elements, such as the high cost of elements, negative impact on the environment and irresponsible consumption of resources [9,39]. The characteristics of the element cluster CSFs have received increased interest from scholars in the recent years and are highly connected with other CSFs SIAH categories.

4.4.3. Housing Production Method

Housing production methods refer to the process and techniques utilized in the construction, assembly and erection of structural and non-structural elements of housing units [120]. The methods used to produce houses exhaust most of the housing development time and, due to inefficient, conventional methods used in the production stage of housing development, a significant amount of resources is consumed and a large amount of wastage and pollutions is produced, all of which dramatically increase the time and cost of housing units and consequently reduce the affordability and sustainability of housing units quite noticeably [45].

The housing methods facet mainly consists of CSFs related to the requirements, efficiency and output of the production methods used for the construction or assembly of housing units, such as technical standards, water and energy efficiency, and impact on the housing construction objectives (cost, time, quality). The housing method cluster only contains 17% (18) CSFs:

- A total of 3 CSFs involve economic sustainability (MEC 1–3 red) (local value creation by method; impact on the construction cost; economy of scale of mass production of method).
- A total of 4 CSFs incorporate environmentally sustainable concepts (MEN 1–4 green) (minimizing pollution and GHG emission; water-efficient method; energy-efficient method; minimizing waste by method).
- A total of 3 CSFs cover social sustainability matters (MS 1–3 pink) (community participation; social acceptability of method; local job creation).
- A total of 8 CSFs deal with technical issues (MT 1–8 purple) (interface to basic services; reliability and durability; standards/manuals; impact on construction duration; skill required for construction method; equipment and machinery required; adaptability and flexibility with other methods; quality of workmanship), as shown in the method cluster's CSFs network in Figure 7.

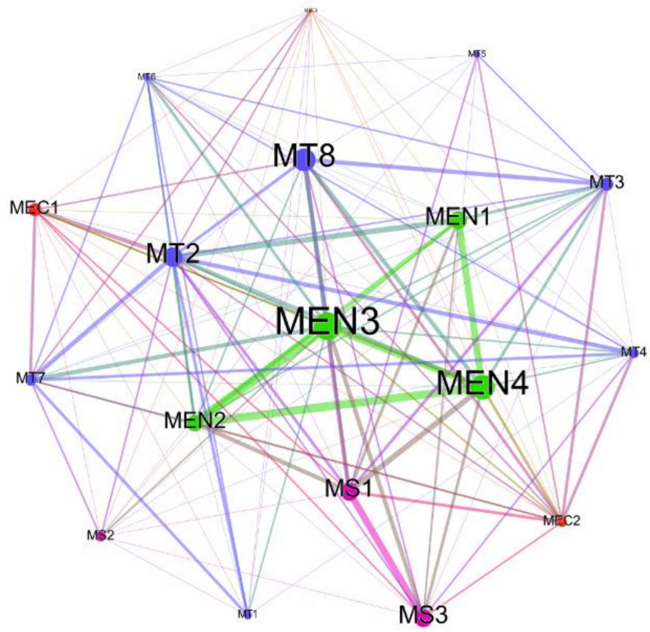

Figure 7. Method CSFs network.

Due to the high technicality of the production stage of housing development, most of the method CSFs are classified under the technical sub-category, as highlighted in purple in Figure 7. MEN3 (energy-efficient method), MEN4 (minimizing waste by method), MT8 (quality of workmanship), MT2 (reliability and durability), and MEN1 (minimizing pollution and GHG emission) are the most frequently cited CSFs in this cluster.

Moghayedi and Windapo [42] find that the housing production methods used in the construction stage of housing units mostly involve substandard conventional methods that negatively impact the environment because of the limited knowledge and experience of the local designers and developers. This finding is illustrated by the strong inter-category links between the sub-categorized environment CSFs as illustrated in Figure 7.

The CSFs in housing production method network have relatively fewer linkages with the CSFs of the other categories of SIAH (19%), clearly illustrating that the scholars have paid less attention to the CSFs associated with the housing production methods CSFs in the development of SIAH, echoing the findings of Hashemi et al. [115] that the lack of attention to the construction process of housing development is regarded as one of the main issues negating the achievement of sustainable, affordable housing in the global south.

4.4.4. Housing Technology

Housing technology refers to the influence of technical procedures and innovative tools utilized in the operation of a house [9,84]. Many researchers have reported on the positive impact of innovative technologies on the operation and maintenance of affordable housing units, as these minimize the cost of operation and increase the housing services and functionality by reducing water and energy consumption and improving air quality.

The housing technology is the most recent facet of SIAH CSFs to be considered by scholars. Lately, the trend of considering innovative technologies in the operation of affordable housing has increased as demonstrated by the occurrence of 66% citations regarding technology CSFs in the last three years. It is likely that this exponential interest shown by researchers is driven by the rise in global energy prices and reduction in water resources due to climate change in the past decade, thus fueling increased consideration of the integration of environmental and social sustainability in affordable housing projects [95].

Innovative housing technology is touted as the most important factor for improving the affordability and sustainability of housing units in the operational stage of housing development and is influenced by various CSFs, such as the initial cost of technology, social acceptance of technology, and improved lifestyle [84,88].

The housing technology facet of the CSFs comprises 13 CSFs (10%), which are as follows:

- A total of 4 CSFs involve economic sustainability (TEC 1–4 red) (initial cost of technology; operational cost of technology; maintenance cost of technology; impact of technology on operation or maintenance cost of house).
- A total of 3 CSFs incorporate environmentally sustainable concepts (TEN 1–3 green) (minimizing waste by technology; minimizing water and energy by technology; improve air quality by technology).
- A total of 2 CSFs cover social sustainability matters (TS 1–2 pink) (social acceptance of technology; improve lifestyle by technology).
- A total of 4 CSFs deal with technical issues (TT 1–4 purple) (availability of technology; durability and reliability of technology; skill requirement for using technology; decentralized infrastructure autonomous), as illustrated in the technology cluster CSFs network in Figure 8.

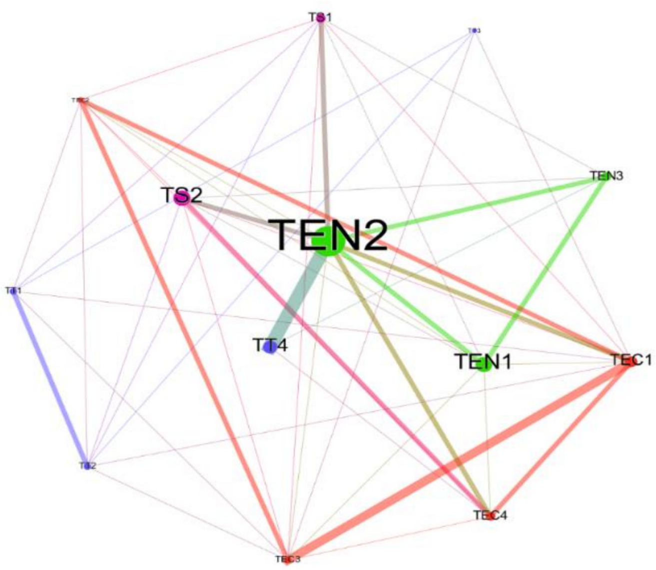

Figure 8. Technology CSFs network.

As the smallest SIAH CSF cluster, the housing technologies contains only 2% of the inter-category links (among the CSFs technology) and 12% of the intra-category links to other CSFs across the SIAH network.

As illustrated in Figure 8, the strongest inter-category links occur between TEN2 (minimizing water and energy by technology) and TT4 (decentralized and autonomous infrastructure). This aligns with the findings that decentralized and autonomous housing infrastructures are imbued with the capacity to reduce the water and energy consumption of housing units [89,95], and are thus described as innovative technologies.

Among these CSFs, TEN2 (minimizing water and energy by technology), TEN1 (minimizing waste by technology), TS2 (improve lifestyle by technology), TT4 (decentralized and autonomous infrastructure) and TEC1 (initial cost of technology) were the top five technology CSFs with the highest frequency and links as shown in Figure 8.

According to various studies, the optimization of water and energy consumption efficiencies and a reduction in waste generation directly impacts the lifestyle of residents [63,71]. Furthermore, studies have shown that that the deployment of independent and self-reliant water and energy infrastructures for housing are proven to be more affordable and sustainable in the long term [89,90]. For instance, to attain a near zero energy building design, Khakian et al. [20] conducted a study of a building equipped with photovoltaic modules. The building design was then evaluated economically to appraise the building viability. The results showed that about 29% energy savings can be achieved, compared to conventional buildings. However, other scholars have argued that before utilizing any technology in affordable housing contexts, the cost of technology (initial, operation and maintenance) should be carefully considered [39,72].

4.5. Conceptualizing an SIAH CSFs Framework

The SIAH CSFs framework summarizes and clusters the 127 CSFs, according to the four primary housing facets (design, element, method, and technology) and four secondary sub-categories (economic, environment, social and technical) of SIAH and their interconnections to the characteristics of SIAH, namely, sustainability, innovation and affordability as shown in Figure 9. The SIAH CSFs framework is beneficial for determining the weight and influence of each CSF as well as establishing the categorization of each characteristic of a SIA-house, using analytical methods.

The SIAH CSFs framework is the (often implicit) set of standards or indicators that underline and control, to some extent, the expression of sustainable affordable housing development. The developed SIAH CSFs framework provides a basis for hypotheses to be developed, tested and refined whilst identifying the impact of each CSFs on the affordability and sustainability of housing units in future studies.

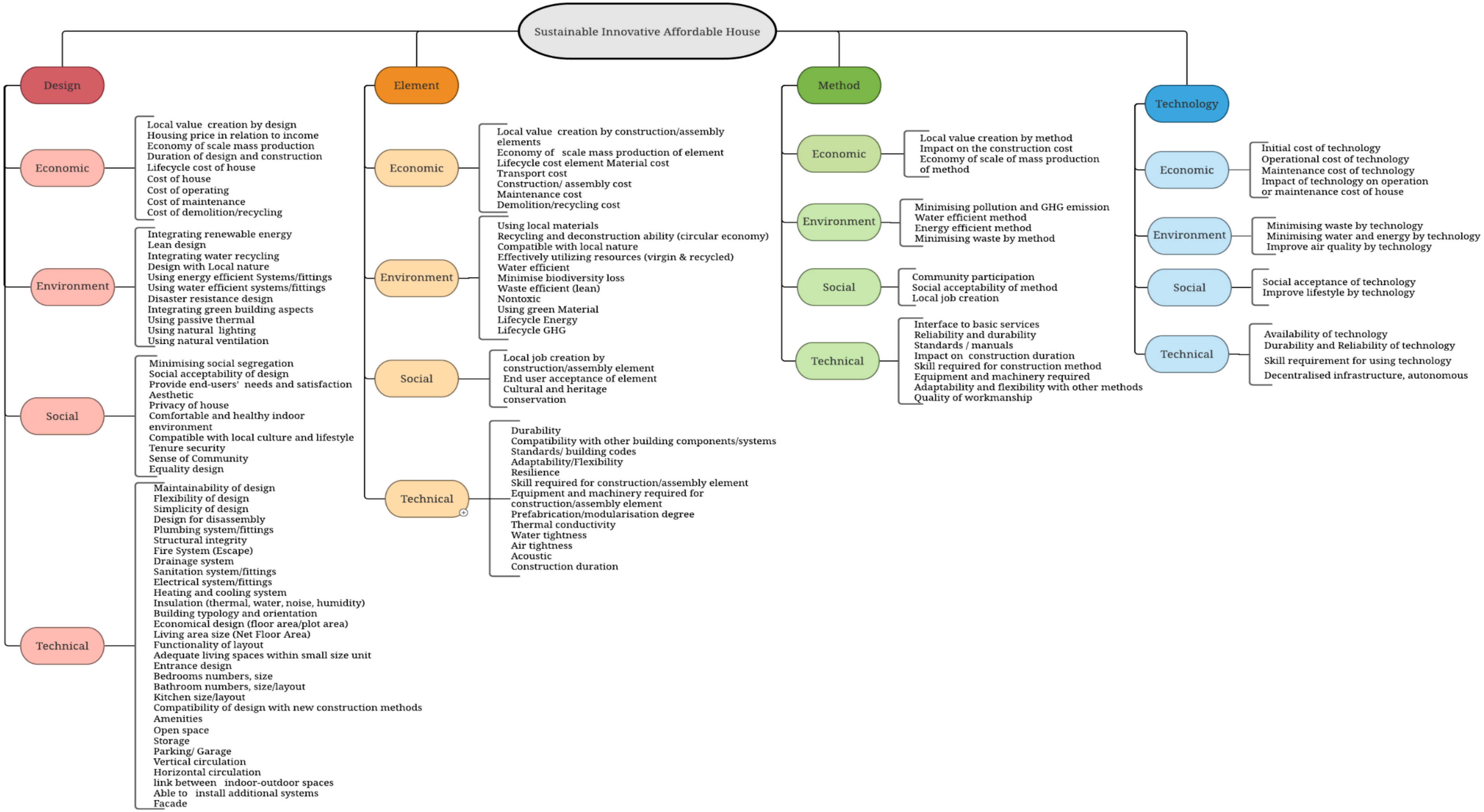

Figure 9. SIAH CSFs framework.

5. Conclusions and Limitations of the Study

Sustainable innovative affordable housing (SIAH) is a relatively new and evolving field that has received growing interest from scholars, practitioners, and policy makers over the last few years, due to the social, environment and economic benefits associated with such initiatives. As an emerging knowledge domain, there is a need to define sustainable, innovative, and affordable housing (SIAH) in the body of construction knowledge for the first time and subsequently establish and cluster the critical success factors (CSFs) for developing SIAH. The study defined SIAH as the incorporation of innovative methods, practices, materials, and technologies in the development of sustainable and affordable housing.

This was the contribution that this study set out to make, leveraging the utility of systematic literature review and bibliometric analysis as data collection and analysis techniques. Peer-reviewed publications focusing on the four fields of affordable housing, sustainable housing, sustainable affordable housing, and innovative housing were sourced from Web of Science and Scopus databases and analyzed, according to the study's objectives. CSFs were identified from these sources, combined, and clustered. This study reveals the extensive range of CSFs for SIAH and the interconnections between the CSFs.

It emerged from the SIAH CSFs framework that housing design, house elements, housing production methods and housing technology are the primary facets with which to analyze the data, given that they contain the highest number of features and represent the most significant SIAH CSFs that have been actively investigated by scholars. Each primary SIAH CSFs cluster network revealed predominant CSFs, such as the need for housing design to take into consideration the use of energy-efficient systems/fittings, tenure security, a comfortable and healthy indoor environment, and housing price in relation to income. The CSFs associated with house elements calls for the consideration of effective resource utilization, lifecycle cost of element and durability. The housing production methods deployed need to be energy efficient, minimize waste and promote quality workmanship. Minimizing water and energy consumption through the use of technology, minimizing waste production, and improving the lifestyle of housing occupants were the most frequent CSFs raised when considering the technology facet.

The comprehensive clustered CSFs framework of sustainable affordable housing developed in this study is predicated on the three sustainability dimensions and the technical aspects of SAH. It highlights the CSFs that must be used in engendering SIAH successfully to provide not only affordable houses that are economically, socially, and environmentally sustainable, but also innovative and smart, when compared to conventional versions of SAH. The conceptualized SIAH CSFs framework serves as a precursor to the development of a dynamic assessment model for evaluating the impact of the integration of innovative technologies and practices on the actualization of the critical success criteria of SAH. Furthermore, it provides both academics and practitioners with a common language to recognize and make sense of what makes a house sustainable, innovative, and affordable. Therefore, the SIAH CSFs framework developed in this study can be employed as the basis of not only developing SIAH, but also evaluating the sustainability, affordability, and innovation of low-income houses.

Although the study of SIAH has been receiving growing attention over the years, there are still many gaps in this field of research. The specific results of this study provide insight into the lacunae in the literature and research opportunities, particularly within the housing technology facet. Future research could use the SIAH CSFs framework to determine the weight and importance of each CSF in developing SIAH. Researchers may want to consider the evaluation of the impact of developing SIAH on the social, environmental, and economic aspects of entire housing projects.

Only documents published in peer-reviewed journals and conference papers domiciled within scientific databases were used for the analyses conducted in this study. Accordingly, some relevant non-peer-reviewed documents may have been excluded. While this may be considered a limitation, it does not in any way affect the credibility of the study's findings and the emergent framework.

Author Contributions: Conceptualization: A.M., B.A. and T.O.; methodology: A.M. and T.O.; validation: B.A. and M.M.; formal analysis: A.M.; investigation: M.B. and P.B.; resources: A.M.; data curation: A.M.; writing—original draft preparation: A.M., B.A. and C.O.E.; writing—review and editing, A.M., K.L.J. and T.O.; project administration: K.L.J.; funding acquisition, A.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was financially supported by the Royal Academy of Engineering, U.K. under the Transforming Systems through Partnership (grant No. TSP 1352).

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of University of Cape Town and approved by the Institutional Ethics Committee of the Faculty of Engineering and Built Environment, University of Cape Town (Application Ref: 17118040 and 5 August 2020).

Acknowledgments: The authors express their gratitude to the National Home Builders Registration Council (NHBRC) of South Africa panel members, who provided their expertise for this research.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Gan, X.; Zuo, J.; Wu, P.; Wang, J.; Chang, R.; Wen, T. How Affordable Housing Becomes More Sustainable? A Stakeholder Study. *J. Clean. Prod.* **2017**, *162*. [CrossRef]
2. Bangura, M.; Lee, C.L. The Determinants of Homeownership Affordability in Greater Sydney: Evidence from a Submarket Analysis. *Hous. Stud.* **2021**. [CrossRef]
3. Chan, A.P.C.; Adabre, M.A. Bridging the Gap between Sustainable Housing and Affordable Housing: The Required Critical Success Criteria (CSC). *Build. Environ.* **2019**, *151*. [CrossRef]
4. Leridon, H. World Population Outlook: Explosion or Implosion? *Popul. Soc.* **2020**, *573*, 1–4. [CrossRef]
5. Kuddus, M.A.; Tynan, E.; McBryde, E. Urbanization: A Problem for the Rich and the Poor? *Public Health Rev.* **2020**, *41*. [CrossRef]
6. Makinde, O.O. Housing Delivery System, Need and Demand. *Environ. Dev. Sustain.* **2014**, *16*. [CrossRef]
7. Massyn, M.W.; McGaffin, R.; Viruly, F.; Hopkins, N. The Challenge of Developing Higher Density, Affordable Housing in the Inner City of Cape Town. *Int. J. Hous. Mark. Anal.* **2015**, *8*. [CrossRef]
8. Bennett, A.; Cuff, D.; Wendel, G. Backyard Housing Boom: New Markets for Affordable Housing and the Role of Digital Technology. *Technol. Archit. Des.* **2019**, *3*. [CrossRef]
9. Saidu, A.I.; Yeom, C. Success Criteria Evaluation for a Sustainable and Affordable Housing Model: A Case for Improving Household Welfare in Nigeria Cities. *Sustainability* **2020**, *12*, 656. [CrossRef]
10. Carswell, A.T. *The Encyclopedia of Housing*; SAGE Publications: Thousand Oaks, CA, USA, 2012. [CrossRef]
11. Yeganeh, A.; Agee, P.R.; Gao, X.; McCoy, A.P. Feasibility of Zero-Energy Affordable Housing. *Energy Build.* **2021**, *241*. [CrossRef]
12. Anacker, K.B. Introduction: Housing Affordability and Affordable Housing. *Int. J. Hous. Policy* **2019**. [CrossRef]
13. Balcilar, M.; Katzke, N.; Gupta, R. Date-Stamping US Housing Market Explosivity. *Economics* **2018**, *12*. [CrossRef]
14. Jones, A.; Stead, L. Can People on Low Incomes Access Affordable Housing Loans in Urban Africa and Asia? Examples of Innovative Housing Finance Models from Reall's Global Network. *Environ. Urban.* **2020**, *32*. [CrossRef]
15. Worthington, A.; Higgs, H. Macro Drivers of Australian Housing Affordability, 1985–2010: An Autoregressive Distributed Lag Approach. *Stud. Econ. Financ.* **2013**, *30*. [CrossRef]
16. Bangura, M.; Lee, C.L. House Price Diffusion of Housing Submarkets in Greater Sydney. *Hous. Stud.* **2020**, *35*. [CrossRef]
17. Bangura, M.; Lee, C.L. The Differential Geography of Housing Affordability in Sydney: A Disaggregated Approach. *Aust. Geogr.* **2019**, *50*. [CrossRef]
18. Faroughi, M.; Karimimoshaver, M.; Aram, F.; Solgi, E.; Mosavi, A.; Nabipour, N.; Chau, K.W. Computational Modeling of Land Surface Temperature Using Remote Sensing Data to Investigate the Spatial Arrangement of Buildings and Energy Consumption Relationship. *Eng. Appl. Comput. Fluid Mech.* **2020**, *14*. [CrossRef]
19. Sfakianaki, E.; Moutsatsou, K. A Decision Support Tool for the Adaptive Reuse or Demolition and Reconstruction of Existing Buildings. *Int. J. Environ. Sustain. Dev.* **2015**, *14*. [CrossRef]
20. Khakian, R.; Karimimoshaver, M.; Aram, F.; Benis, S.Z.; Mosavi, A.; Varkonyi-Koczy, A.R. Modeling Nearly Zero Energy Buildings for Sustainable Development in Rural Areas. *Energies* **2020**, *13*, 2593. [CrossRef]
21. Mutani, G.; Todeschi, V. Roof-Integrated Green Technologies, Energy Saving and Outdoor Thermal Comfort: Insights from a Case Study in Urban Environment. *Int. J. Sustain. Dev. Plan.* **2021**, *16*. [CrossRef]
22. Mulliner, E.; Malys, N.; Maliene, V. Comparative Analysis of MCDM Methods for the Assessment of Sustainable Housing Affordability. *Omega* **2016**, *59*. [CrossRef]
23. Charoenkit, S.; Kumar, S. Environmental Sustainability Assessment Tools for Low Carbon and Climate Resilient Low Income Housing Settlements. *Renew. Sustain. Energy Rev.* **2014**. [CrossRef]
24. Ibem, E.; Azuh, D.E. Framework for Evaluating the Sustainability of Public Housing Programmes in Developing Countries. *J. Sustain. Dev. Environ. Prot.* **2011**, *1*, 24–39.

25. King, R.; Orloff, M.; Virsilas, T.; Pande, T. Confronting the Urban Housing Crisis in the Global South: Adequate, Secure, and Affordable. World Resources Report. 2017. Available online: https://smartnet.niua.org/sites/default/files/resources/towards-more-equal-city-confronting-urban-housing-crisis-global-south.pdf (accessed on 22 July 2021).
26. Taylor, S.P. What Is Innovation? A Study of the Definitions, Academic Models and Applicability of Innovation to an Example of Social Housing in England. *Open J. Soc. Sci.* **2017**, *5*. [CrossRef]
27. Baker, S.; Mehmood, A. Social Innovation and the Governance of Sustainable Places. *Local Environ.* **2015**, *20*. [CrossRef]
28. Seyfang, G. Community Action for Sustainable Housing: Building a Low-Carbon Future. *Energy Policy* **2010**, *38*. [CrossRef]
29. Przychodzen, W.; Przychodzen, J.; Lerner, D.A. Critical Factors for Transforming Creativity into Sustainability. *J. Clean. Prod.* **2016**, *135*. [CrossRef]
30. Cucca, R.; Friesenecker, M. Potential and Limitations of Innovative Housing Solutions in Planning for Degrowth: The Case of Vienna. *Local Environ.* **2021**. [CrossRef]
31. Alwan, Z.; Jones, P.; Holgate, P. Strategic Sustainable Development in the UK Construction Industry, through the Framework for Strategic Sustainable Development, Using Building Information Modelling. *J. Clean. Prod.* **2017**, *140*. [CrossRef]
32. Haase, D.; Kabisch, S.; Haase, A.; Andersson, E.; Banzhaf, E.; Baró, F.; Brenck, M.; Fischer, L.K.; Frantzeskaki, N.; Kabisch, N.; et al. Greening Cities—To Be Socially Inclusive? About the Alleged Paradox of Society and Ecology in Cities. *Habitat Int.* **2017**, *64*. [CrossRef]
33. Nikulsheeva, V.F.; Khokhlova, G.I.; Kretova, N.V.; Borisova, A.S. Human Capital as a Factor of Development of Innovative Activity of Construction Industry Enterprises. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *751*. [CrossRef]
34. Tayurskaya, O.V.; Okladnikova, D.R.; Bibarsov, K.R. Challenges and Growth Scenarios for Small Businesses in Manufacturing. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *753*. [CrossRef]
35. Koch, F.; Krellenberg, K. How to Contextualize SDG 11? Looking at Indicators for Sustainable Urban Development in Germany. *ISPRS Int. J. Geo-Inf.* **2018**, *7*, 464. [CrossRef]
36. Friedman, R.; Rosen, G. The Challenge of Conceptualizing Affordable Housing: Definitions and Their Underlying Agendas in Israel. *Hous. Stud.* **2019**, *34*. [CrossRef]
37. Gopalan, K.; Venkataraman, M. Affordable Housing: Policy and Practice in India. *IIMB Manag. Rev.* **2015**, *27*. [CrossRef]
38. Susilawati, C.; Miller, W.W.F. Sustainable and Affordable Housing: A Myth or Reality. In Proceedings of the 19th International CIB World Building Congress, Queensland University of Technology, Brisbane, Queensland, Australia, 5–9 May 2013; pp. 1–12.
39. Adabre, M.A.; Chan, A.P.C.; Edwards, D.J.; Adinyira, E. Assessing Critical Risk Factors (CRFs) to Sustainable Housing: The Perspective of a Sub-Saharan African Country. *J. Build. Eng.* **2021**, *41*. [CrossRef]
40. Syed Jamaludin, S.Z.H.; Mahayuddin, S.A.; Hamid, S.H.A. Challenges of Integrating Affordable and Sustainable Housing in Malaysia. *IOP Conf. Ser. Earth Environ. Sci.* **2018**, *140*. [CrossRef]
41. Shahparvari, M.; Fong, D. The Review of Rework Causes and Costs in Housing Construction Supply Chain. In Proceedings of the IGLC 2018—26th Annual Conference of the International Group for Lean Construction: Evolving Lean Construction towards Mature Production Management across Cultures and Frontiers, Chennai, India, 16–22 July 2018; Volume 2. [CrossRef]
42. Moghayedi, A.; Windapo, A. Key Performance Criteria Influencing the Selection of Construction Methods Used for the Fabrication of Building Components in the Middle East. *Sustain. Constr. Build. Mater.* **2019**. [CrossRef]
43. Martinez, E.; Reid, C.K.; Tommelein, I.D. Lean Construction for Affordable Housing: A Case Study in Latin America. *Constr. Innov.* **2019**, *19*. [CrossRef]
44. Syamsuri, E.U.; Tahir, M.M.; Basyaruddin, B.A.; Sulaiman, A.; Ngian, S.P.; Bakri, A. Conceptual Design Using Industrialized Building System for Affordable Housing Construction in Indonesia. *Adv. Sci. Lett.* **2018**, *24*. [CrossRef]
45. Mohamed Aris, N.A.; Fathi, M.S.; Harun, A.N.; Mohamed, Z. Towards A Sustainable Supply of Affordable Housing with Prefabrication Technology: An Overview. *J. Adv. Res. Bus. Manag. Stud.* **2019**, *1*, 1–13.
46. Nanyam, V.P.S.N.; Sawhney, A.; Gupta, P.A. Evaluating Offsite Technologies for Affordable Housing. *Procedia Eng.* **2017**, *196*. [CrossRef]
47. Colistra, J. Innovations in Housing for Smart Cities. *J. Archit. Eng.* **2019**, *25*. [CrossRef]
48. Osunsanmi, T.O.; Aigbavboa, C.; Oke, A. Construction 4.0: The Future of the Construction Industry in South Africa. *Int. J. Civ. Environ. Eng.* **2018**, *12*, 206–212.
49. Panteli, C.; Kylili, A.; Fokaides, P.A. Building Information Modelling Applications in Smart Buildings: From Design to Commissioning and beyond A Critical Review. *J. Clean. Prod.* **2020**, *265*. [CrossRef]
50. Aghimien, D.; Aigbavboa, C.; Aghimien, L.; Thwala, W.D.; Ndlovu, L. Making a Case for 3D Printing for Housing Delivery in South Africa. *Int. J. Hous. Mark. Anal.* **2020**, *13*. [CrossRef]
51. Tetteh, N.; Amponsah, O. Sustainable Adoption of Smart Homes from the Sub-Saharan African Perspective. *Sustain. Cities Soc.* **2020**. [CrossRef]
52. Ge, J.; Zhao, Y.; Luo, X.; Lin, M. Study on the Suitability of Green Building Technology for Affordable Housing: A Case Study on Zhejiang Province, China. *J. Clean. Prod.* **2020**, *275*. [CrossRef]
53. Cherian, P.; Paul, S.; Krishna, S.R.G.; Menon, D.; Meher Prasad, A. Mass Housing Using GFRG Panels: A Sustainable, Rapid and Affordable Solution. *J. Inst. Eng. Ser. A* **2017**, *98*. [CrossRef]

54. Bredenoord, J. Sustainable Building Materials for Low-Cost Housing and the Challenges Facing Their Technological Developments: Examples and Lessons Regarding Bamboo, Earth-Block Technologies, Building Blocks of Recycled Materials, and Improved Concrete Panels. *J. Archit. Eng. Technol.* **2017**, *6*. [CrossRef]
55. Adabre, M.A.; Chan, A.P.C. Critical Success Factors (CSFs) for Sustainable Affordable Housing. *Build. Environ.* **2019**, *156*. [CrossRef]
56. Liang, D.; De Jong, M.; Schraven, D.; Wang, L. Mapping Key Features and Dimensions of the Inclusive City: A Systematic Bibliometric Analysis and Literature Study. *Int. J. Sustain. Dev. World Ecol.* **2021**. [CrossRef]
57. Moghayedi, A.; Le Jeune, K.; Massyn, M.; Ekpo, C. Establishing the Key Elements of Incorporation and Outcomes of 4th Industrial Revolution in Built Environment Education: A Mixed Bibliographic and Bibliometric Analysis. *J. Constr. Proj. Manag. Innov.* **2020**, *10*. [CrossRef]
58. Oshodi, O.S.; Awuzie, B.O.; Akotia, J.; Ademiloye, A.S.; Ngowi, A. A Bibliometric Analysis of Recycled Concrete Research (1978–2019). *Built Environ. Proj. Asset Manag.* **2020**, *10*. [CrossRef]
59. Windapo, A.; Omopariola, E.D.; Olugboyega, O.; Moghayedi, A. Use and Performance of Conventional and Sustainable Building Technologies in Low-Income Housing. *Sustain. Cities Soc.* **2021**, *65*. [CrossRef]
60. Isalou, A.A.; Litman, T.; Shahmoradi, B. Testing the Housing and Transportation Affordability Index in a Developing World Context: A Sustainability Comparison of Central and Suburban Districts in Qom, Iran. *Transp. Policy* **2014**, *33*. [CrossRef]
61. Akadiri, P.O.; Chinyio, E.A.; Olomolaiye, P.O. Design of a Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector. *Buildings* **2012**, *2*, 126. [CrossRef]
62. Mulliner, E.; Maliene, V. Criteria for Sustainable Housing Affordability. In Proceedings of the 8th International Conference on Environmental Engineering, ICEE 2011, Vilnius, Lithuania, 19–20 May 2011.
63. Gan, X.; Zuo, J.; Wen, T.; She, Y. Exploring the Adequacy of Massive Constructed Public Housing in China. *Sustainability* **2019**, *11*, 1949. [CrossRef]
64. Turcotte, D.A.; Geiser, K. A Framework to Guide Sustainable Housing Development. *Hous. Soc.* **2010**, *37*. [CrossRef]
65. Golubchikov, O.; Badyina, A. *Sustainable Housing for Sustainable Cities: A Policy Framework for Developing Countries*; UN-HABITAT: Nairobi, Kenya, 2012.
66. Karji, A.; Woldesenbet, A.; Khanzadi, M.; Tafazzoli, M. Assessment of Social Sustainability Indicators in Mass Housing Construction: A Case Study of Mehr Housing Project. *Sustain. Cities Soc.* **2019**, *50*. [CrossRef]
67. Shama, Z.S.; Motlak, J.B. Indicators for Sustainable Housing. *IOP Conf. Ser. Mater. Sci. Eng.* **2019**, 518. [CrossRef]
68. Kamali, M.; Hewage, K.; Milani, A.S. Life Cycle Sustainability Performance Assessment Framework for Residential Modular Buildings: Aggregated Sustainability Indices. *Build. Environ.* **2018**, *138*. [CrossRef]
69. Wallbaum, H.; Ostermeyer, Y.; Salzer, C.; Escamilla, E.Z. Indicator Based Sustainability Assessment Tool for Affordable Housing Construction Technologies. *Ecol. Indic.* **2012**, *18*. [CrossRef]
70. Rockwood, D.; Da Silva, J.T.; Olsen, S.; Robertson, I.; Tran, T. Design and Prototyping of a FRCC Modular and Climate Responsive Affordable Housing System for Underserved People in the Pacific Island Nations. *J. Build. Eng.* **2015**, *4*. [CrossRef]
71. Ezennia, I.S.; Hoskara, S.O. Exploring the Severity of Factors Influencing Sustainable Affordable Housing Choice: Evidence from Abuja, Nigeria. *Sustainability* **2019**, *11*, 5792. [CrossRef]
72. Prochorskaite, A.; Couch, C.; Malys, N.; Maliene, V. Housing Stakeholder Preferences for the "Soft" Features of Sustainable and Healthy Housing Design in the UK. *Int. J. Environ. Res. Public Health* **2016**, *13*, 111. [CrossRef]
73. Davoodi, T.; Dağli, U.U. Exploring the Determinants of Residential Satisfaction in Historic Urban Quarters: Towards Sustainability of the Walled City Famagusta, North Cyprus. *Sustainability* **2019**, *11*, 6261. [CrossRef]
74. Celhay, P.A.; Gil, D. The Function and Credibility of Urban Slums: Evidence on Informal Settlements and Affordable Housing in Chile. *Cities* **2020**, *99*. [CrossRef]
75. Mulliner, E.; Maliene, V. An Analysis of Professional Perceptions of Criteria Contributing to Sustainable Housing Affordability. *Sustainability* **2015**, *7*, 248. [CrossRef]
76. Masram, H.; Misnan, S.H.; Yassin, A.M. Implementation of Affordable Housing Programmes in Johor, Malaysia for Sustainable Housing. *IOP Conf. Ser. Earth Environ. Sci.* **2020**, *447*. [CrossRef]
77. Ahmad, T.; Thaheem, M.J. Economic Sustainability Assessment of Residential Buildings: A Dedicated Assessment Framework and Implications for BIM. *Sustain. Cities Soc.* **2018**, *38*. [CrossRef]
78. Oyebanji, A.O.; Liyanage, C.; Akintoye, A. Critical Success Factors (CSFs) for Achieving Sustainable Social Housing (SSH). *Int. J. Sustain. Built Environ.* **2017**, *6*. [CrossRef]
79. Zhao, X. Early Warning of Urban Residential Development Considering Sustainability Factors. *Int. J. Smart Home* **2016**, *10*. [CrossRef]
80. Mulliner, E.; Smallbone, K.; Maliene, V. An Assessment of Sustainable Housing Affordability Using a Multiple Criteria Decision Making Method. *Omega* **2013**, *41*. [CrossRef]
81. Wiesel, I.; Davison, G.; Milligan, V.; Phibbs, P.; Judd, B.; Zanardo, M. *Developing Sustainable Affordable Housing: A Project Level Analysis*; Australian Housing and Urban Research Institute, UNSW–UWS Research Centre: Sydney, Australia, 2012.
82. Maliene, V.; Malys, N. High-Quality Housing-A Key Issue in Delivering Sustainable Communities. *Build. Environ.* **2009**, *44*. [CrossRef]

83. Winston, N.; Eastaway, M.P. Sustainable Housing in the Urban Context: International Sustainable Development Indicator Sets and Housing. *Soc. Indic. Res.* **2008**, *87*. [CrossRef]
84. Mohamad, Z.Z.; Yang, F.C.; Charles Ramendran, S.P.R.; Rehman, M.; Nee, A.Y.H.; Yin, Y.C. Embedding Eco-Friendly and Smart Technology Features in Affordable Housing for Community Happiness in Malaysia. *GeoJournal* **2020**. [CrossRef]
85. Von Seidlein, L.; Ikonomidis, K.; Mshamu, S.; Nkya, T.E.; Mukaka, M.; Pell, C.; Lindsay, S.W.; Deen, J.L.; Kisinza, W.N.; Knudsen, J.B. Affordable House Designs to Improve Health in Rural Africa: A Field Study from Northeastern Tanzania. *Lancet Planet. Health* **2017**, *1*. [CrossRef]
86. Roufechaei, K.M.; Bakar, A.H.A.; Tabassi, A.A. Energy-Efficient Design for Sustainable Housing Development. *J. Clean. Prod.* **2014**, *65*. [CrossRef]
87. Obi, L.; Arif, M.; Goulding, J. Low-Cost Housing: A Cost Management Model for Process Integration and Evaluation. *Archit. Eng. Des. Manag.* **2020**, *16*. [CrossRef]
88. Hamid, S.H.A.; Jamaludin, S.Z.H.S.; Mahayuddin, S.A. Achieving Sustainable Affordable Housing Scheme from the Perspective of Multi Eco-System. *IOP Conf. Series Mater. Sci. Eng.* **2018**, *429*. [CrossRef]
89. Moore, T.; Doyon, A. The Uncommon Nightingale: Sustainable Housing Innovation in Australia. *Sustainability* **2018**, *10*, 3469. [CrossRef]
90. Ullah, W.; Noor, S.; Tariq, A. The Development of a Basic Framework for the Sustainability of Residential Buildings in Pakistan. *Sustain. Cities Soc.* **2018**, *40*. [CrossRef]
91. Ross, N.; Bowen, P.A.; Lincoln, D. Sustainable Housing for Low-Income Communities: Lessons for South Africa in Local and Other Developing World Cases. *Constr. Manag. Econ.* **2010**, *28*. [CrossRef]
92. Pullen, S.; Arman, M.; Zillante, G.; Zuo, J.; Chileshe, N.; Wilson, L. Developing an Assessment Framework for Affordable and Sustainable Housing. *Constr. Econ. Build.* **2010**, *10*. [CrossRef]
93. Muazu, J.; Oktay, D. Challenges and Prospects for Affordable and Sustainable Housing: The Case of, Nigeria. *Open House Int.* **2011**, *36*. [CrossRef]
94. Tupenaite, L.; Lill, I.; Geipele, I.; Naimaviciene, J. Ranking of Sustainability Indicators for Assessment of the New Housing Development Projects: Case of the Baltic States. *Resources* **2017**, *6*, 55. [CrossRef]
95. Albrecht, C.F.; Carlo, J.C.; Iulo, L.D.; Buckland, P.D. *International Transdisciplinary Approach to Sustainability Research Related to Place: Sustainable, Affordable Homes and Ecosystem Services in the U.S. and Brazil*; World Sustainability Series; Springer International Publishing: Cham, Switzerland; Berlin, Germany, 2020. [CrossRef]
96. Marjaba, G.E.; Chidiac, S.E.; Kubursi, A.A. Sustainability Framework for Buildings via Data Analytics. *Build. Environ.* **2020**, *172*. [CrossRef]
97. Dizdaroglu, D. Measuring Residential Sustainability Performance: An Indexing Approach. *Int. J. Sustain. Dev.* **2019**, *22*. [CrossRef]
98. Zarghami, E.; Azemati, H.; Fatourehchi, D.; Karamloo, M. Customizing Well-Known Sustainability Assessment Tools for Iranian Residential Buildings Using Fuzzy Analytic Hierarchy Process. *Build. Environ.* **2018**, *128*. [CrossRef]
99. Thompson, N.; Yang, J. Developing Affordable and Sustainable Housing through Energy, Transport, and Building Utility Integration. *J. Urban. Plan. Dev.* **2015**, *141*. [CrossRef]
100. Mousavi, S.M.; Khan, T.H.; Javidi, B. Environmentally Sustainable Affordable Design Elements in Housing in the Context of Malaysia: Focus on Middle Income Group. *Life Sci. J.* **2013**, *10*, 1138–1148.
101. McIntosh, J.; Guthrie, C. Structural Insulated Panels: A Sustainable Option for House Construction in New Zealand. *Int. J. Hous. Sci. Appl.* **2010**, *34*, 1–13.
102. J-MOUM, k.j. Affordable Low-Cost Housing and Community Assessing Economic and Health Impact. *EQA Int. J. Environ. Qual.* **2019**, *35*, 1–11. [CrossRef]
103. Sharpe, R.A.; Taylor, T.; Fleming, L.E.; Morrissey, K.; Morris, G.; Wigglesworth, R. Making the Case for "Whole System" Approaches: Integrating Public Health and Housing. *Int. J. Environ. Res. Public Health* **2018**, *15*, 2345. [CrossRef] [PubMed]
104. Lee, K.I. A Study on the Environmental Sustainability Assessment of Multi-Family Housing Estates in Korea. *J. Asian Archit. Build. Eng.* **2003**, *2*. [CrossRef]
105. Häkkinen, T. Assessment of Indicators for Sustainable Urban Construction. *Civ. Eng. Environ. Syst.* **2007**, *24*. [CrossRef]
106. Sharafeddin, A.; Arocho, I.; Anderson, J.C. Post Occupancy Evaluation of Affordable Housing in the USA: Toward Indicators for Sustainable Affordable Housing. In Proceedings of the Annual Conference—Canadian Society for Civil Engineering, Greater Montreal, QC, Canada, 12–15 June 2019.
107. Kylili, A.; Fokaides, P.A.; Lopez Jimenez, P.A. Key Performance Indicators (KPIs) Approach in Buildings Renovation for the Sustainability of the Built Environment: A Review. *Renew. Sustain. Energy Rev.* **2016**. [CrossRef]
108. Tibesigwa, B.M.; Hao, L.; Karumuna, B.V. The Concept of Spatial Quality and Its Challenges on Exercised Affordable Housing Design Typology in Dar Es Salaam—Tanzania. *Habitat Int.* **2017**, *59*. [CrossRef]
109. Akinyede, I.; Fapohunda, J.; Haldenwang, R. The Factors That Influence Human Resources on Affordable Housing Delivery within Restraint of Budget. *J. Multidiscip. Sci. J.* **2020**, *3*, 19. [CrossRef]
110. Mohit, M.A.; Mahfoud, A.K.A. Appraisal of Residential Satisfaction in Double-Storey Terrace Housing in Kuala Lumpur, Malaysia. *Habitat Int.* **2015**, *49*. [CrossRef]

111. Wakely, P. Partnership: A Strategic Paradigm for the Production & Management of Affordable Housing & Sustainable Urban Development. *Int. J. Urban. Sustain. Dev.* **2020**, *12*. [CrossRef]
112. Olanrewaju, A.L.; Woon, T.C. An Exploration of Determinants of Affordable Housing Choice. *Int. J. Hous. Mark. Anal.* **2017**, *10*. [CrossRef]
113. Soon, A.; Tan, C. An Analysis on Housing Affordability in Malaysian Housing Markets and the Home Buyers′ Preference. *Int. J. Hous. Mark. Anal.* **2020**, *13*. [CrossRef]
114. Dempsey, N.; Bramley, G.; Power, S.; Brown, C. The Social Dimension of Sustainable Development: Defining Urban Social Sustainability. *Sustain. Dev.* **2011**, *19*. [CrossRef]
115. Hashemi, A.; Cruickshank, H.; Cheshmehzangi, A. Environmental Impacts and Embodied Energy of Construction Methods and Materials in Low-Income Tropical Housing. *Sustainability* **2015**, *7*, 7866. [CrossRef]
116. Elkady, A.A.; Fikry, M.A.; Elsayad, Z.T. Developing an Optimized Strategy Achieving Design Flexibility in Small-Area Units: Case Study of Egyptian Economic Housing. *Alex. Eng. J.* **2018**, *57*. [CrossRef]
117. Zhao, J.; Meng, C.L. Discussion on Affordable Housing Design and Sustainable Development. *Appl. Mech. Mater.* **2013**, *409–410*. [CrossRef]
118. Zhou, Z.; Wang, Y. Study on the Interactive Relationship between Prefabricated Buildings and Sustainable Affordable Housing Construction. In Proceedings of the ICCREM 2018: Sustainable Construction and Prefabrication—International Conference on Construction and Real Estate Management 2018, Charleston, SC, USA, 9–10 August 2018. [CrossRef]
119. Maina, J.J. Uncomfortable Prototypes: Rethinking Socio-Cultural Factors for the Design of Public Housing in Billiri, North East Nigeria. *Front. Archit. Res.* **2013**, *2*. [CrossRef]
120. ASTM. *E1557-09: Standard Classification for Building Elements and Related Sitework—UNIFORMAT II*; ASTM International: West Conshohocken, PA, USA, 2020. [CrossRef]