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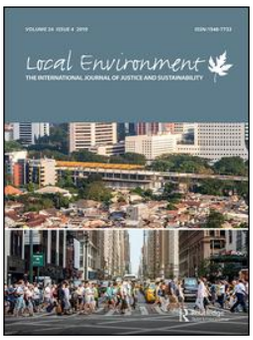

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Towards digitalisation of socially sustainable neighbourhood design

Sanjay Somanath, Alexander Hollberg and Liane Thuvander

Department of Architecture and Civil Engineering, Chalmers University of Technology, Gothenburg, Sweden

ABSTRACT

Digital tools for performance-assessment are commonly used to shorten the feedback loop in testing designs for buildings and neighbourhoods. However, these tools do not extend to the social dimension in the same way as the economic and environmental dimensions. This paper aims to contribute to the development of digital tools to design socially sustainable neighbourhoods. We analyse 115 academic articles to establish a theoretical understanding of Social Sustainability (SoSu). Based on these results, we propose a digital user-interaction model to operationalise SoSu in the digital design process of buildings. In the literature, we observe a lack of consensus on the theoretical discussion on SoSu. Several extrinsic and intrinsic factors are identified contributing to this fuzziness; the dependency on stakeholder value systems, the qualitative nature of social indicators, and comparison to environmental sustainability being the most common. Still, we distinguish two overarching categories, social equity and social capital, that are further divided into sub-themes. Having mapped the categories and hierarchies of social themes, we propose a user-interaction model that incorporates these findings into a digital environment. The user-interaction model creates a guided decision-making framework for architects and urban planners by enabling stakeholders to make conscious and informed decisions grounded in theory.

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Social sustainability; digital design; conceptual framework; digital tools; neighbourhood

Introduction

The "Brundtland Report" or "Our Common Future" (WCED 1987) is considered the springboard that led to the current state of discourse on Sustainable Development (SD) (Vallance, Perkins, and Dixon 2011; Boström 2012; Littig and Grießler 2005). However, SD as it emerged in the late 1980s, was underpinned by an environmental vision (Åhman 2013) as is evident by the title of the commission (*World Commission on Environment and Development*). The Brundtland report presented SD as a conceptual framework consisting of three dimensions, environmental, economic and social; which in synergy, would lead to "holistic" SD. This triple bottom line model of SD has since seen widespread adoption in the field of planning and architecture.

In the discourse on SD, Social Sustainability (SoSu) was left obscured compared to the economic and environmental dimensions. SoSu has since been described as a "concept in chaos" (Vallance, Perkins, and Dixon 2011), a "missing pillar" (Boström 2012), and a "forgotten pillar" (Opp 2017). According to Enyedi (2002), no environmental policy can truly be effective without a sound social

CONTACT Sanjay Somanath ssanjay@chalmers.se Department of Architecture and Civil Engineering, Chalmers University of Technology, Gothenburg SE-412 96, Sweden

policy. Now, with more than half of the world's population living in cities, SoSu in the urban context is of great importance to address all dimensions of sustainability, and the built environment is well-positioned to have a meaningful impact in doing so.

The effects of the environmental underpinnings of SD, along with the lack of consensus on the social dimension, is reflected in the digital tools available to architects and urban planners (referred to as *designers* henceforth) where the social dimension often is lacking. Developing new digital tools to facilitate socially sustainable design can enable broader adoption and implementation of the theories and concepts of SoSu.

This research aims to contribute to the development of digital tools to support socially sustainable design in the built environment at the neighbourhood level by proposing a model for the development of a digital SoSu design tool grounded in theory based on the recent scientific literature.

Background

The design process in the built environment and digital tools

Erickson and Lloyd-Jones (2001) describe the design process as not merely a linear process but an open-ended one, consisting of three phases, the *brief*, the *design solution* and *implementation* (See Figure 1). The design process in the built environment, like all design processes, is highly iterative and requires a feedback loop for designers to test scenarios and proposals. First, the architect or urban planner as the designer translates the initial goals of a project to a design criterion; followed by a proposed design solution. In the second phase, the proposed design is tested against the design criteria, forming an iterative design process that loops until the project brief is satisfied. The feedback loop (Figure 1) in the design solution phase is significantly reduced with the use of digital tools by expediting the designing and testing process. Designers can test the performance of multiple designs faster than in an analogue design process. The process of digitally testing a proposal requires a quantifiable metric to measure and compare the performance of the proposed solution. Over the past decade, designers have adopted three-dimensional modelling software or digital design environments to facilitate the Digital Design Process (DDP). Additionally, computer-supported visualisation (Isenberg et al. 2011) of proposals can improve collaboration and stakeholder participation. Such three-dimensional modelling software is well suited to analyse socio-spatial data in the built environment and serve as a digital design environment.

Design tools in the built environment vary by dimensions of scale, life-cycle phase, stakeholders and the design criteria. Dalsgaard (2017) describes a tool as an instrument of designerly inquiry and the relationship of tools and the design process as one that is "intertwined and co-evolving". In an exploration of the theory and praxis of architecture and digital technologies, Oxman (2008) describes digital design in the built environment through a taxonomy of three digital design models; *formation models*, *generative models* and *performance models*. Oxman (2008) also identifies two forms of digital design, Computer-aided Design (CAD) and Digital Architectural Design (DAD). DAD is understood as being more than re-introducing paper-based methods of conceptualisation into a different medium,

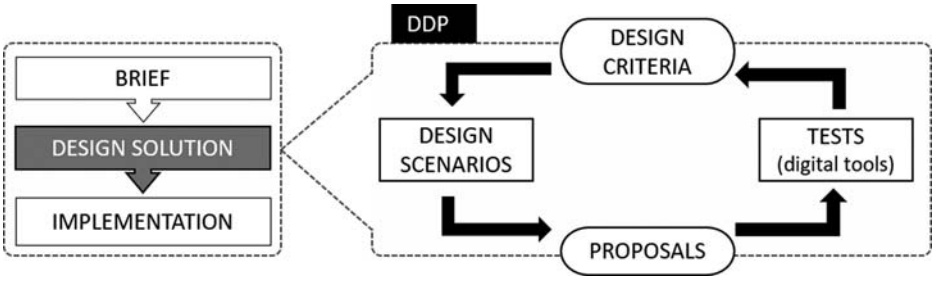

Figure 1. The Digital Design Process (DDP) to reach a design solution. Adapted from Erickson (Erickson and Lloyd-Jones 2001).

but also a means of building domain knowledge, like Dalsgaard's instruments of designerly inquiry. Henceforth, we use the term *digital tools* to refer to such instruments of designerly inquiry and knowledge building.

The disconnect between theory and policy regarding Social Sustainability

As the discourse on SD evolved over the years, researchers have argued for SoSu to be addressed in its own right (Åhman 2013; Littig and Grießler 2005). This resulted in comprehensive reviews of academic literature, discussions on the issues and definitions of SoSu, and various conceptual frameworks of SoSu with no or limited relation to the built environment (De Fine Licht and Folland 2019; Dempsey et al. 2011; Missimer et al. 2017; Shirazi and Keivani 2019; Eizenberg and Jabareen 2017; Wolbring and Rybchinski 2013; Larimian and Sadeghi 2019; Boström 2012; Littig and Grießler 2005; Vallance, Perkins, and Dixon 2011). However, in comparison to the academic literature on SoSu, policy initiatives and municipal planning tools have a direct relationship to stakeholders in the built environment.

Despite being a "concept in chaos" (Vallance, Perkins, and Dixon 2011), there are several reports, policy documents and tools developed by policymakers and researchers to aid the decision-making process of SoSu. Reports and policy documents are useful in demonstrating the political intent and will to address SoSu and measuring the effectiveness of current policies.

International policy documents are produced by inter-governmental bodies like the United Nations (UN) and the Organisation for Economic Cooperation and Development (OECD). Efforts of such organisations to promote holistic sustainability focus on the economic, environmental and social dimensions of SD, for example, with programmes such as the Sustainable development goals (SDG) (UN General Assembly 2015). In the UN agenda 2030, seven of the seventeen SDGs promote the social dimensions of SD (McGuinn et al. 2020). As the focus on the social dimension increased over time, regional organisations also began systematically reporting on social themes and indicators such as social wellbeing (OECD 2020), inequality (UNDESA and Yang 2020) and inclusiveness (Eurostat 2019). However, as Davidson (2019b) remarks – the uncertainty observed in the academic literature is not similarly reflected in the policy documents. Though the reason for such a disconnect between policy and theory is not clear, recent efforts on a policy level such as the report by McGuinn et al. (2020) on the theory and definitions of SoSu explore these questions.

Tools for SoSu

The scope of sustainability tools in the built environment primarily focus on the environmental and sometimes economic dimension of SD. Starting at the building scale – the most established international Green Building Assessment Tools such as LEED (Leadership in Energy and Environmental Design) (Olakitan Atanda 2019), BREEAM (Building Research Establishment Environmental Assessment Method) (Ali and Al Nsairat 2009), DGNB (German Green Building Council) (Stender and Walter 2019) and GSAS (Global Sustainability Assessment System) (Phondani et al. 2016) focus on the social dimension through occupant wellbeing and comfort. The WELL certification programme (Danivska et al. 2019) goes one step further to assess the personal wellbeing of an occupant mentally as well as physically. Extensions of Green Building Assessment Tools such as LEED neighbourhood and BREEAM neighbourhood focus on similar dimensions of SD but at the neighbourhood level. In some European countries, specifically in Sweden and Norway, the neighbourhood scale of SoSu has seen direct intervention from the city and municipal bodies. In Sweden, the city of Gothenburg has developed Sociala konsekvensanalyser (social impact assessment), Barnkonsekvensanalyser (child impact assessment) and Kulturkonsekvensanalys (culture impact assessment); there also exist complimentary planning tools such as PRISMA (Karl de Fine Licht and Molnar 2019), developed by researchers for use at the neighbourhood scale. General criticisms of these tools are the lack of transparency in the development of the tools, follow up on the results of the tool and the vague approach to dealing with stakeholder value systems (Eken et al. 2017).

To promote inclusivity and encourage citizen participation in the design process (Haklay and Jankowski 2018), stakeholders have increasingly used collaborative planning tools. These tools provide a structure to the discourse between stakeholders involved in a design project of the neighbourhood scale. Due to the coordination and data management involved in such projects, such tools are used to take advantage of a digital design environment for data collection, management, analysis and communication.

Some individual indicators of sustainability such as accessibility to urban amenities (Thériault and Des Rosiers 2004) or walkability scores (Carr, Dunsiger, and Marcus 2010) have been digitised and prove to be effective means on measuring the social performance of neighbourhoods. With increasing social indicators, databases, analytical methods such as exploratory spatial data analysis (Anselin, Sridharan, and Gholston 2007), insight into the social performance of neighbourhoods has never been more accessible. However, these indicators and methods explore individual aspects of SoSu and are limited to data exploration. They lack a holistic overview of SD and the means of integration into the DDP.

Research gap and scope

Though several SoSu tools have been developed across different scales, none of the tools mentioned above is directly integrated into the design process of neighbourhoods, and few are digital. These tools are designed as independent decision support tools for designers by providing a framework for enquiry and data to be collected. However, they rely on the domain expertise and contextual knowledge of the user, to structure the decision-making process and do not contain domain and contextual information. This absence of domain and contextual information makes tools such as SKA and BKA incompatible with the DDP.

In this paper, we focus our discussion on digital tools for SoSu, within the design process of neighbourhoods. The primary user group that we target are architects and urban planners. Currently, the economic and environmental assessment for design in the built environment can be modelled through digital tools by leveraging the advances made in access and availability of computational resources and data. SoSu, however, cannot be assessed in the same way. Though efforts have been made in the digitisation of the data collection process, through electronic surveys and polls, the analytic ability available in assessing the economic and environmental impact of design decisions enabling a shorter feedback loop in the early design stage is not available to SoSu.

To develop a theoretical background of the SoSu and develop a user-interaction model for digital SoSu tools, we frame the following questions and analyse the results.

- RQ1. What are the reasons for a fragmented discourse on Social Sustainability in the built environment?
- RQ2. What are the prevailing definitions of Social Sustainability in the built environment?
- RQ3. What are the core themes of Social Sustainability to be included in a digital design support tool?

Method

This research is based on a literature review resulting in a theoretical framework for the proposal of a conceptual model for a digital SoSu tool. Thus, this research is divided into the *theoretical background* and *conceptual model development*. The methodological steps follow a seven-step *conceptual framework analysis* proposed by Jabareen (2009) (Figure 2). Jabareen (2009) also suggests the following distinction between a conceptual framework and a model; a conceptual framework is based on concepts alone and how these concepts interact with one another. Once a conceptual framework employs factors and variables to develop the relationship between the concepts further, the term model is employed. The theoretical background comprises the first three steps of the methodology;

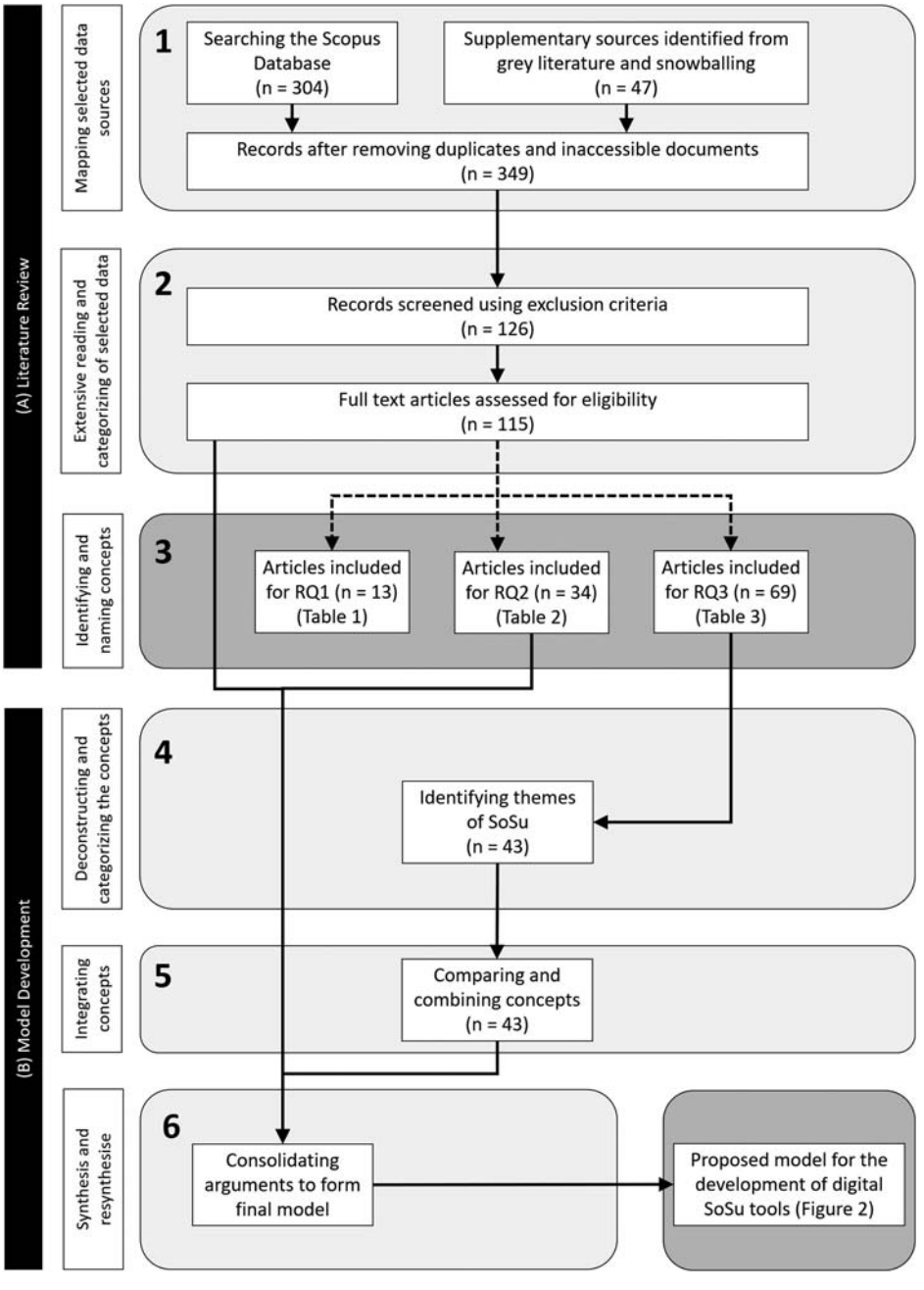

Figure 2. Method diagram.

mapping selected data sources (1), reading and categorising of data (2) and identifying and naming concepts (3).

The model development further builds on the theoretical background in the next three steps of the methodology; deconstructing and categorising the concepts (4), integrating the concepts (5) and, synthesis and re-synthesis (6). Finally, the seventh step consists of validating the conceptual framework through public discussion.

Mapping data sources

Using the online database *Scopus,* we queried "Social Sustainability" in the title and keywords of journal articles in the English language in all years. The search criteria resulted in 304 documents of academic literature on SoSu in various disciplines such as economics, supply chain, corporate Social Sustainability and Social Life Cycle Assessment. Next, we identified the literature addressing SoSu in the built environment and the issues accompanying it. To ensure a holistic mapping of data sources, we included relevant grey literature from the disciplines of social sciences, sustainable development, philosophy, politics, planning, policy documents and reports and *snowballing*. This provided 47 additional documents to form the supplementary literature sources.

Reading and categorising of data sources

In the following step, we filtered the documents based on:

- Title filtering – As a preliminary filtering step, we read the titles of the documents and exclude documents belonging to disciplines clearly out of the scope of this review such as supply chain management, energy, or manufacturing.
- Abstract filtering – A secondary filtering step was conducted by reading the abstracts of the documents and excluding those not directly relating to the SoSu or the built environment.

The reading of the document titles resulted in 89 documents and after the abstracts filtering 68 documents remained consisting of theoretical discussions and empirical case studies. Together with the 47 supplementary articles from the grey literature and through snowballing, we arrived at a final list of 115 documents.

Identifying and naming concepts

RQ1. Addressing the first question of *reasons for fragmented discourse in SoSu*, we catalogued the reasons presented by the authors in a table with the authors' names and extracted relevant supporting arguments. We then classified the reasons based on the causal relationship of the issues to SoSu.

RQ2. The second question of *a definition for SoSu in the built environment* required the analysis of accompanying definitions of SoSu with a focus on the built environment. We first catalogued the definitions by the authors as well as secondary sources as cited in the documents. Next, we tallied the terms used by authors to describe SoSu. We refer to these terms as *identifiers*.

RQ3. To address the third question of what the core themes of SoSu are, we catalogued the social themes specified by the authors and made notes on the context of the discussion. The social themes used by different authors discussing the same idea are then collapsed into overarching social themes. For each of the final social themes, we count the number of individual documents that discuss the social theme.

Deconstructing and categorising concepts

RQ1. We analysed the reasons presented by authors to classify them by common characteristics further.

RQ2. We list the various definitions of SoSu in the literature. We then analyse the structure of the definitions and extract the *identifier* that the author associates with SoSu and categorise them.

RQ3. We deconstruct the social themes and sub-themes of SoSu found in literature and list them. Then, we integrate and organise the themes to propose a common conceptual framework for SoSu.

Integrating concepts

The integration of the results from the previous steps in combination with the supplementary literature sources allows for a broader exploration of potential solutions to operationalising SoSu in a digital environment.

Synthesis and re-synthesis

Finally, we develop a model for a digital tool that supports socially sustainable decision making for neighbourhood scale projects. We incorporate concepts supported by the grey literature to address the operational issues identified from RQ1 and propose a user-interaction model for a digital tool that supports socially sustainable neighbourhood design.

Results

Section 4.1 correspond to the results on the theoretical background, and Section 4.2 corresponds to the model development.

Theoretical background

Following the research questions, this section identifies and compiles the reasons for the fragmented discourse of SoSu, the various interpretations and definitions of SoSu, and the various conceptual frameworks developed and presented in the literature.

The fragmented discourse of Social Sustainability in the built environment

From the literature, six commonly occurring reasons (factors) that indicate why the SoSu discourse has been fragmented and often results in a lack of consensus were identified and divided into two categories: **intrinsic factors** and **extrinsic factors** (Table 1). The factors represent a unique instance of a contributing factor to fragmentation described in the reviewed literature.

Intrinsic factors are factors that arise due to the nature of SoSu; the complexities of the actors involved in the social system as well as the overlapping disciplines that study it. We have identified four intrinsic factors.

The first factor, *dependency on stakeholder value systems*, results from the fact that people have different value systems. Conflicting value systems often result in disagreement and consequently a lack of consensus as to what SoSu means (Colantonio 2010; Boyer et al. 2016; Littig and Grießler 2005; Eizenberg and Jabareen 2017; Åhman 2013; Boström 2012). Here, stakeholders refer to those individuals or institutions that can influence, that are involved in or that are directly affected by decisions taken in the built environment.

The importance of considering stakeholder value systems is supported by a recurring view on SoSu in the built environment that, intervention in the physical dimension alone cannot be used to tackle social issues. Instead, the conceptual frameworks that underpin socially sustainable development need to address both physical and non-physical aspects of SoSu such as social interaction, participation and stability of the community (Eizenberg and Jabareen 2017; Shirazi and Keivani 2019; Vallance, Perkins, and Dixon 2011; Woodcraft et al. 2012); stakeholder values being a key component in all. An effective intervention must consider a holistic approach that involves an inclusive and collaborative design process, and the creation of social capital to empower the end-users of the built environment to achieve their goals and aspirations.

The second factor, *the multi-disciplinary nature of SoSu,* is related to the many disciplines involved in the study of societies. It introduces competing interests in the discourse of SoSu, once again leading to conflicting priorities (Shirazi and Keivani 2017; Åhman 2013; De Fine Licht and Folland 2019; Boström 2012).

Table 1. Reasons for a fragmented discourse of SoSu mentioned in the reviewed literature.

Category	Factor	Colantonio (2010)	Mehan and Soflaei (2017)	Eizenberg and Jabareen (2017)	Åhman (2013)	Eken et al. (2017)	Littig and Grießler (2005)	Boström (2012)	Shirazi and Keivani (2017)	Boyer et al. (2016)	McKenzie (2004)	Dillard, Dujon, and King (2009)	Landorf (2011)	Shirazi and Keivani (2019b)
Intrinsic	Dependency on stakeholder value systems	•		•	•		•	•		•				
	Multi-disciplinary nature of Social Sustainability				•	•		•	•					
	Quantifiable nature of social interactions		•					•			•		•	•
	Tangibility of social consequences			•			•	•	•	•				
Extrinsic	Chronology of Sustainable Development discourse	•		•	•		•	•				•		
	Comparison with Environmental sustainability	•					•	•	•	•	•	•		

The third factor, *quantifiable nature of interactions,* is due to the nature of social data. Social data is often complicated, nuanced and best represented qualitatively (Landorf 2011; McKenzie 2004; Boström 2012). Most primary gathering of social data in the built environment is through interviews and questionnaires. Translating qualitative information to quantitative indicators often results in the loss of information. Hence the disagreements of how SoSu should be measured or even represented.

The fourth factor relates to the *tangibility of social consequences*. Social consequences that emerge from interactions between people are often intangible concepts. Emergent consequences such as wellbeing, quality of life, happiness often mean different things to different people, which in turn results in a lack of consensus on what SoSu means (Eizenberg and Jabareen 2017; Littig and Grießler 2005; Boström 2012; Boyer et al. 2016; Shirazi and Keivani 2017).

In addition to the intrinsic factors, we have also identified two extrinsic factors. These are factors that arise due to the political climate or stakeholder perception of SoSu.

The first extrinsic factor is the *chronology of SD discourse*. Boström (2012) discusses the historical roots of the SD discourse and the chronology of the various dimensions. The environmental and economic dimensions evolved before the social, causing the social dimension to systemically receive lesser focus than the other two counterparts (Colantonio 2010; Eizenberg and Jabareen 2017; Åhman 2013; Littig and Grießler 2005; Dillard, Dujon, and King 2009).

The second extrinsic factor is SoSu's comparison to environmental sustainability. In the sustainability discourse, environmental sustainability has several desirable quantitative features that allow it to be represented, measured and tracked (Dillard, Dujon, and King 2009; Colantonio 2010; Littig and Grießler 2005; Shirazi and Keivani 2017; Boyer et al. 2016; McKenzie 2004). For instance, the human-made contributions to climate change correlate with worsening ecology. However, in the social dimension, it is difficult to establish causal relationships. It is also unclear what exactly one must aim to improve or sustain (Boström 2012). Another drawback of the comparison to environmental sustainability is the possibility of developing physics envy and oversimplify of the qualitative aspects of SoSu as a result (Boström 2012).

Definitions of social sustainability in the built environment

In the reviewed literature, we found a total of 41 definitions of Social Sustainability relating to the built environment. These definitions often vary between a formal and operational definition, but we also observed a common structure used in the definitions of SoSu; authors use an *identifier* or a *class* associated with SoSu. This identifier represents the characteristics of SoSu as perceived by the author(s) and under which conditions the definition holds true. In some cases, SoSu is defined through the necessary conditions alone. In this case, SoSu is considered a condition. Below is an example of a definition and the identifier. The authors use the identifier "process" to describe SoSu and proceed then to present the necessary conditions for the definition.

> Social Sustainability is a **process** for creating sustainable, successful places that promote wellbeing by understanding what people need from the places in which they live and work. Social Sustainability combines design of the physical realm with design of the social world – infrastructure to support social and cultural life, social amenities, systems for citizen engagement and space for people and places to evolve. (Woodcraft et al. 2012)

Our literature review resulted in SoSu identifiers within the following three main categories; an *ability, a conditional state, and a process*. Sometimes a weak identifier or a loose definition is used; we catalogue such instances as a *vague concept* (Table 2).

We have defined the identifiers as follow:

Ability – An ability of a society to satisfy a given condition implies that it must possess the resources to facilitate positive interaction between various actors in society. An ability also emphasises the exhaustive nature of these resources. "Ability" has the inherent implication of a limitation to the ability.

Table 2. Identifiers used in the definition of SoSu.

	Identifier			
Source	Ability	Conditional state	Process	Vague Concept
Atanda and Öztürk (2018)				•
Bacon et al. (2012)				•
Bacon et al. (2012)			•	
Baehler (2007)	•			
Barron and Gauntlet (2002)		•		
Barron and Gauntlet (2002)		•		
Boschmann and Kwan (2008)		•		
Bramley et al. (2006)				•
Chiu (2003)				•
Chiu (2003)			•	
Colantonio (2007)	•		•	
Colantonio (2010)			•	
Coleman (1988)				•
Davidson (2009a)			•	
Dillard, Dujon, and King (2009)			•	
Dillard, Dujon, and King (2009)	•	•	•	
Dillard, Dujon, and King (2009); McKenzie (2004)		•	•	
Eizenberg and Jabareen (2017)			•	
Enyedi (2002)		•		
Holden (2013)			•	
Laguna (2014)		•		
Landzelius and Thodelius (2017)	•			
Littig and Grießler (2005)				
Littig and Grießler (2005)			•	
Shirazi and Keivani (2017)		•		
Shirazi and Keivani (2017)			•	
ODPM (2003)		•		
Opp (2017)		•		
Pieper, Karvonen, and Vaarama (2019)	•			
Ročak, Hospers, and Reverda (2016)		•		
Sachs (1999)				•
Søholt, Ruud, and Braathen (2012)				•
Stender and Walter (2019)				•
Stren and Polèse (2017)		•	•	
Stren and Polèse (2017)			•	
Valdes-Vasquez and Klotz (2013)			•	
Vallance, Perkins, and Dixon (2011)			•	
Woodcraft (2015)			•	
Yiftachel and Hedgcock (1993)		•		•
Yoo and Lee (2016)	•			

Conditional state – SoSu as a conditional state implies that SoSu is achieved as a result of successfully satisfying a set of conditions proposed in the definition. Here, SoSu is often described as an end state of the social system; when achieved, results in positive interactions between stakeholders.

Process – SoSu as a process implies that it is a series of decisions, actions or steps taken to achieve an expected outcome of positive interactions between stakeholders.

Vague Concept – SoSu is often defined using terms such as "a quality" or by describing it through a relationship to certain necessary but not satisfactory. Hence the meaning is vague and often left open to interpretation.

There is debate on the flexibility in the definition of SoSu, whether it is to be fluid or static. Dempsey (2017) and Shirazi and Keivani (2017) consider SoSu to be a dynamic concept that will change over time in a place. Boström (2012) notes that "the proliferation of various frameworks and not one hegemonic theory is constructive because SD is enormously complex" and such flexibility is seen as both a strength and weakness. When presented with a binary perspective to either develop or maintain (Vallance, Perkins, and Dixon 2011) a social theme, Åhman (2013) argues against the tendency to deny pluralism in western philosophy, concluding that a one-sided focus on either

development or maintenance would inevitably lead to a stagnation of social vitality. However, Missimer et al. (2017) presents a similar argument for a static definition of SoSu. They challenge the pluralist notion on SoSu, stating that "vagueness in the definition of SoSu allows unsustainable action to be couched and presented as suitable". They draw parallels to the arguments used to discourage the attempts of the Framework for Strategic Sustainable Development (FSSD) in finding a definition of environmental sustainability despite which, the existing definition of environmental sustainability by the FSSD has proven to be operational at any scale irrespective of the specifics of the activity, organisation and region. Åhman (2013) makes an important point to support the practical adoption of SoSu in societies unable to fulfil an individual's basic needs; there will always be different social agendas as compared to a society that can afford to focus its resources on addressing themes such as participation, justice and sense of place.

Apart from the fluid or static definitions of SoSu, Davidson (2019b), proposes a third view of SoSu as an "empty signifier". This structural framework simply plays the role of organising various concepts coherently and perform foundational ideological functions. Empty signifiers inherently hold a nominal status; they can accommodate conflicting value systems and do not impair normative decision making. Davidson suggests that rather than dilute the meaning from the core concepts, an empty signifier delivers coherence to an idea. Normative decisions must be informed by normative values, ethics, and ideas to prioritise some ethical judgements over others and recommend pathways to achieve this imagined condition (2019b).

The literature shows that SoSu is not an absolute concept and has various meanings. Regardless of the variation in the interpretation of SoSu, a common aim is to ensure positive interactions between members of society. From the perspective of defining a conceptual framework for the DDP, it is most useful to view SoSu, as suggested by Davidson (2019b) – as an *empty signifier*. By being able to accommodate the different value systems of the stakeholders analysing a social situation, an empty signifier challenges the binaries and the glittering generality of a rigid, prescriptive conceptual framework in the current SoSu discourse, while preserving the freedom of stakeholders to choose what is appropriate within the scope of their needs.

Conceptual frameworks of SoSu

We compared 79 conceptual frameworks of SoSu found in literature and catalogued 38 unique social themes and sub-themes. We observed inconsistencies in the semantics of phrasing social themes. We attribute this to the interdisciplinary nature of SoSu and the literature sources. We also observed social themes with misaligned hierarchies placed next to each other such as *social equity* and *cleanliness of public spaces;* viewing SoSu through the lens of an "empty signifier" performs an organising duty within social discourse. According to Davidson (2019b, chap. 2), in an empty signifier, disordered concepts can come together to form a coherent understanding so long as the concepts are organised by the essential features they possess.

In the instance highlighted above, social equity is a much broader concept. It lacks any definitive content in itself. Rather, it comprises of various ideas such as equitable access to resources and justice for all. In contrast, the cleanliness of public spaces may contribute to achieving such wider concepts, but it is a definitive idea. This organisational quality of empty signifiers can alleviate such misaligned hierarchies. The categorisation of distinct social themes at a lower level allows stakeholders to define their scope of SoSu depending on the context while maintaining coherent relationships between the themes.

We observed that social themes with the highest mentions in the literature match the conceptual framework by SoSu presented by Bramley et al. (2006) and further elaborated in the context of the built environment by Dempsey et al. (2011). In discussing SoSu and the urban form, Bramley et al. (2006) proposes two main categories of Social Sustainability – *social equity* and *sustainable communities*.

The conceptual framework developed by Bramley et al. (2006) and Dempsey et al. (2011) was able to accommodate a wide range of social themes within itself while providing sufficient structure to

the concepts in the way they relate to one another. The authors from the academic literature identified the social themes under Bramley's category of "sustainable communities" most commonly as "social capital"; we adopted the term social capital as well. The identified social themes from the literature are grouped under two overarching categories – social equity and social capital (see Table 3). We observed a variety of subthemes listed in the literature depending on the focus of the discipline. There can be an indefinite sub-theme under individual social themes, depending on the area of interest and the availability of data and indicators. Under the sub-themes column, we add examples that the social themes could be extended to.

Social themes under *social equity* arise from opportunities for interactions between members of society and their physical environment. Social equity concerns itself with the availability of and access to services, facilities, and amenities (the distributive notions of social justice). The social themes of social equity are *amenities, community infrastructure, recreation and open spaces, connectivity, jobs and housing*. The social theme of *amenity* is the most referenced in the literature and has the most availability of data and indicators.

Social themes under *social capital* are the emergent properties that arise from social interactions between members of society through interpersonal relationships. Social capital is closely linked to the notion of community cohesion. In the literature, social capital and community cohesion are often used interchangeably. Social capital can also be seen analogous to Colantonio's (2010) *soft* or *emerging* themes of Social Sustainability. The social themes of social capital are *interaction, participation, the stability of the community, sense of attachment, and safety and security*. The social theme of *sense of attachment* is the most referenced in the literature.

The distribution of social themes under social equity and social capital is once again supported by the view that socially sustainable development needs to address both physical and non-physical aspects of SoSu; with themes of social equity reflecting the physical aspects and themes of social capital reflecting the non-physical aspects of SoSu.

Development of a conceptual model

Having developed a theoretical background and understood the reasons for contention in the discourse of SoSu, we move towards developing a *conceptual model* to create digital tools that

Table 3. Conceptual framework for neighbourhood SoSu (Adapted from Bramley et al. (2006) and Dempsey et al. (2011)).

Number of documents out of 79		Social Themes	Sub-Themes (Indefinite)
60	SOCIAL EQUITY	Amenities	Health (27) Food (7) Facilities and Services (25)
43		Community infrastructure	Education/Child Care/health (33) Aesthetic/ Maintenance (9)
40		Recreation and Open spaces	Availability of open spaces, recreation, public realm (28) Pedestrian Comfort/ Microclimate (10)
42		Connectivity	Transport, Location and connectivity, Accessibility (28) Walkability (12)
24		Jobs	Distribution of wealth, Economic Welfare, Employment. (24)
34		Housing	Housing / Living Conditions (34)
49	SOCIAL CAPITAL	Interaction	Social Interaction in Society (38) Social Networks (10)
50		Participation	Public Participation (50)
30		Stability of the community	Stability of the community/Tolerance (30)
65		Sense of Attachment	Sense of belonging, community responsibility (41) Culture (23)
36		Safety and Security	Safety, Security, Crime, Peace and Justice (30)

integrate SoSu in the DDP. To operationalise the findings from the theoretical discussion a digital tool must achieve three goals; first – provide the user with a guided decision-making process, second – enhance the user's understanding of existing levels of SoSu and third allow the freedom to define the scope of SoSu and the design criteria.

In this section, we identify a scale for socially sustainable design intervention, the stakeholders and target users, data and indicator requirements for a digital SoSu tool and finally, a user-interaction model for such a tool.

Scale and SoSu in the built environment

The built environment is a part of the complex social system and plays a significant role in SoSu (Mehan and Soflaei 2017), resulting in a considerable amount of literature focussing specifically on SoSu in the built environment (Arnett 2017; Colantonio and Dixon 2011; Nicola Dempsey et al. 2011; Mehan and Soflaei 2017; Shirazi and Keivani 2017). SoSu in the built environment can be viewed as being a multidimensional framework (Dempsey 2017; Shirazi and Keivani 2019). It spans across stakeholders, social themes (Table 3) as well as spatial scales (Boyer et al. 2016). Improved social themes under social equity and social capital such as – amenities, connectivity, interaction, participation and stability of the community result from the positive interactions between people and their built environment and can be observed across spatial scales. These social themes can range from the neighbourhood scale to the urban scale; such as social interaction and local connectivity within neighbourhoods, to social interaction and connectivity between neighbourhoods.

While the scale is an essential dimension of SoSu, we recognise that not all social themes relate to the different levels of scale in the same way. Hence, it is important to note that there is no scalar significance in terms of prioritising one scale over the other (Shirazi and Keivani 2019). However, for the practicality of discussion, existing social development efforts, a place where urban social qualities are observed, and the emergence of neighbourhood sustainability assessment tools, we focus our efforts on the neighbourhood scale. For architects and urban planners, the neighbourhood scale serves as a safe departure point to engage in the SoSu discourse (Shirazi and Keivani 2019).

Stakeholders and target users

As described in 4.1.1, we identify stakeholders as those individuals or institutions that can influence, that are involved in or that are directly affected by decisions taken in the built environment such as – residents, neighbours, owners and local authorities.

To achieve the three goals of a digital SoSu tool, the user must be capable of communicating with multiple stakeholders while also possessing the domain knowledge of the built environment and DDP. This in combination with the development of digital design tools along with the DDP discussed in 2.1 leads us to identify architects and urban planners as best suited to actively participate in the digitalisation of SoSu at the neighbourhood scale.

Social data and indicators

To digitalise SoSu and support the goals of a digital SoSu tool, social data, and social indicators used in this process must leverage the recent growth computational ability. In addition to the validity and quality of social indicators, they must also be quantitative. However, as presented in Table 1, the *non-quantifiable nature of social indicators* is one of the limitations in operationalising SoSu. Addressing this dichotomy between qualitative and quantitative social indicators, Dwyer, Zoppou, and Nielsen (2004) have proposed six selection criteria that apply to social indicators. The criteria are support concept, validity, data availability and quality, sensitivity, simplicity and quantitativeness.

For SoSu, both quantitative and qualitative data is used to capture the complexity in the themes of social capital and social equity. To represent the nuances of qualitative social indicators as quantitative indicators, researchers have used different methods of developing composite indicators (Greco et al. 2019) through weighting and aggregation of individual quantitative components

such as a walkability index. The step of weighting and aggregation is crucial in the sustainability assessment through composite indicators (Gan et al. 2017). In addition to capturing the qualitative nuances, aggregating multiple quantitative components of social indicators allow the user to weight and rank social themes, incorporate stakeholder views and collectively decide on a design criterion.

As discussed in the previous sections, neighbourhood design in the DDP has a significant spatial component; hence, the indicators of social themes must be selected with the spatial component in mind. Based on these concepts, we propose the following classes of social indicators to be selected to represent social themes for the DDP.

- **Measure geographic phenomena** – Indicators that measuring a spatial dimension of distance, area or volume, either referring to the design itself or linked to a geographical location. (Indicators of the general nature "distance from X" or "access to X")
- **Measure rate of geographic phenomena** – Spatially extensive indicators that measure a variable to a spatial dimension of distance, area or volume (indicators of the general nature "number of X per unit area") of the design proposal or the local physical context.
- **Proxy indicators** – Indicators that represent a phenomenon in the absence of a direct, measurable metric through a correlated and measurable phenomenon. (Global and Local Integration measure as an indicator for presence of people in a space.)
- **Measure statistical dispersion** – Indicators that measure the extent to which a variable is dispersed in the distribution and linked to a geographical location. (Gini coefficient, Generalised Entropy Index, Atkinson index, Hoover index)

User-interaction model and pre-requisites

To enable a guided decision-making process for architects and urban planners in collaboration with other stakeholders, we propose a four-step user-interaction model for the development of digital tools for SoSu; demonstrating how the user interacts with the digital tool (Figure 3).

- Step one provides the stakeholders with the ability to choose their scope of SoSu. It requires the user to select the site and the social themes deemed important by the stakeholders. This allows users to explore the data available for the selected area and iterate on the social themes selected for the study, in collaboration with the stakeholders.
- Step two addresses the problem of conflicting stakeholder values identified in 4.1.1. It allows the stakeholders to consolidate the various weights on the social themes based on the requirements of the project.
- Step three addresses the issue of the quantifiable nature of SoSu, by aggregating indicators developed from available data sources as discussed in 4.2.3.
- Once the stakeholders collectively establish a design criterion, step four allows the user to measure the existing social performance of the selected area. The user can further make design proposals informed by the existing social performance and evaluate different design proposals and provide the stakeholders with a basis for decision making.

We suggest the following pre-requisites for the implementation of the proposed user-interaction model.

- Adopt an inclusive and collaborative planning process in the design development of the project (From 4.1.1).
- View SoSu as an empty signifier, capable of accommodating different value systems (From 4.1.2).
- Use a digital design environment capable of communicating with the geodatabase. The digital design environment should preferably be one that is commonly used by architects and urban planners in the region (From 2.1).

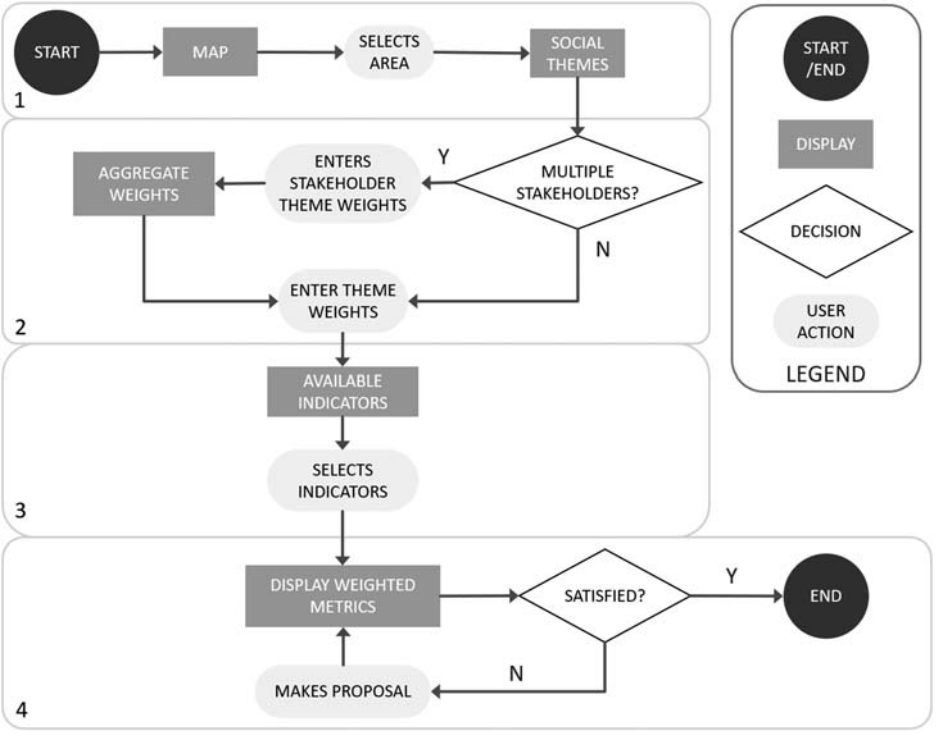

Figure 3. User interaction diagram for a digital SoSu tool to support architects and planners design process.

- Build a database consisting of available spatial data such as administrative boundaries, street networks, building footprints, locations of trees, street furniture and, pedestrian crossings (From 4.2.3).
- Identify meta-data concerning residents and buildings such as population, demographics and building function (From 4.2.3).

Discussion

Social Sustainability has often been considered a "concept in chaos" (Vallance, Perkins, and Dixon 2011) with different interpretations of what it means and how to address it. There exist several views of SoSu from different disciplines of research and hence a considerable amount of contention in its meaning. We analysed this literature and built a theoretical background of SoSu. This resulted in a conceptual framework of SoSu in the built environment that is divided into two categories of social themes; social capital and social equity. There can be multiple sub-themes under individual social themes, depending on the availability of data and indicators.

Though there are several tools to support socially sustainable neighbourhood design across different scales, general criticisms of these tools include the lack of transparency in the development of the tools, follow up on the results of the tool and the vague approach to dealing with stakeholder value systems (Eken et al. 2017). Additionally, none of them is directly integrated into the DDP of neighbourhoods. These findings are incorporated into our proposed user-interaction model and corresponding pre-requisite conditions to serve as a blueprint for the development of digital tools to support the design of socially sustainable neighbourhoods.

Advantages of the approach

The proposed model addresses the theoretical challenges within SoSu identified in the literature review. Intrinsic factors contributing to the contentious discourse of SoSu, such as dependency on stakeholder value systems, are addressed by viewing SoSu as an empty signifier and incorporating multiple stakeholder priorities. The tangibility of social consequences is addressed by identifying social equity and social capital as core categories of SoSu and recognising the hierarchy of social themes within them. Having a robust conceptual framework can aid in avoiding misinterpretations in the lexicology of terms used to describe social themes.

The model also addresses the operational challenges of digitalising SoSu. It can serve as a platform for discourse between stakeholders and designers through a guided decision-making process. The recommendations provided in the pre-requisites for the user-interaction model facilitate a low threshold for participation by removing technical barriers and fostering discussions around their needs. It also allows both the users and stakeholders the freedom to define the scope of SoSu and design criteria as suited to the project brief and local context. By integrating multiple data sources and social themes, it enhances the user's understanding of existing levels of SoSu as well as allows the user to propose multiple design scenarios along with their potential social consequences.

Limitations

The proposed model does not explicitly address the disparity in decision making power between stakeholders and their abilities to deploy resources. The model does not address potential gaps in the availability of social indicators, methods of analysis and data and may not be applicable in regions with scarce social data. We also do not describe the methodology of aggregating and ranking social themes in detail. Finally, while the process of aggregating quantifiable components of qualitative indicators is useful in a digital workflow, nuances of the qualitative aspect may be lost in the process.

Outlook

The next steps in the digitalisation of SoSu are related to the availability of social data. Due to privacy and data protection concerns, there are significant gaps in the availability and access of large validated social data sets. Practitioners, researchers and local governments must actively participate in discussions to address where more data is required and what data is available.

The second step is the translation of SoSu indicators into digitally compatible indicators. There is a need for innovative methodologies of measuring social themes beyond traditional quantitative indicators. Novel methods for evaluating complex human interaction have been developed in the field of Computational Social Sciences, Traffic Planning and Integrated Urban Modelling, but these methods have not yet been applied to the problem of evaluating the SoSu of neighbourhood design.

This paper focussed on challenges within the social dimension of sustainability. As a third step, the proposed model could be extended to assess the social dimension in parallel to the economic and environmental. This allows for the potential for a cost–benefit analysis of design options, for example. Finally, the tools need to be validated through discussions with users and stakeholders in the design process.

Conclusion

Social Sustainability is a complex and interdisciplinary concept. The chronology of its origin, its multidisciplinary nature and the role of stakeholder value systems has caused contention at several stages

of SoSu's conceptual development. The existing body of literature shows that though the core concept is grounded in theory, SoSu has many interpretations. The literature shows that incorporating stakeholder values, and the ability to analyse social themes quantitatively play an essential role in designing socially sustainable neighbourhoods. To address this, we suggest viewing SoSu as an empty signifier and the adoption of a collaborative planning process to ensure multiple stakeholder perspectives are considered to form the design criteria of a project.

The model proposed in this paper serves as a blueprint for the digitalisation of SoSu by addressing core issues in the theorisation and operationalisation of SoSu. It provides the user with a guided decision-making process, enhances the user's understanding of existing levels of SoSu and provides stakeholders with the freedom to define the scope of SoSu and the design criteria. Architects and Urban planners are best suited to mediate the collaborative planning process and are identified as the target users for a digital tool to enable socially sustainable neighbourhood design. The users can then incorporate the views of the other stakeholders such as residents, neighbours, owners and local authorities in the design process by using their input through the digital model. Digital design tools developed using the pre-requisite conditions, and the user-interaction model can serve as a common digital platform to enable a collaborative, inclusive and informed decision-making process while removing the technical barriers in the flow of information.

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Data availability statement

The data that support the findings of this study are openly available in Mendeley Data at http://doi.org/10.17632/vgmytzpty5.1.

ORCID

Sanjay Somanath http://orcid.org/0000-0001-8561-1588
Alexander Hollberg http://orcid.org/0000-0002-9756-2362
Liane Thuvander http://orcid.org/0000-0002-9031-4323

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