

How to link sustainability assessments with local governance? – Connecting indicators to institutions and controversies

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ABSTRACT

The concept of sustainability is growing in importance for local urban governance, and indicator-based assessments represent a popular means for its operationalization. While much effort has been spent developing the technical aspects of these assessments, less attention has been given to their potential for influencing real-world governance processes. To address this issue, we put forward an assessment approach that systematically embeds the assessed indicators within their sociopolitical and institutional contexts, thereby aiming to enhance the informational value of the assessment for local governance. We apply the approach to the assessment of the City of Geneva's (Switzerland) housing system, for which an assessment model is first developed, covering 13 goals and 26 indicators. The indicators reveal the most critical issues of Geneva's housing system, which include energy performance, availability and affordability, and certain aspects of the urban environment (noise, moderation of traffic, green areas, and mobility). We then deepen the analysis by connecting the indicators to ongoing controversies around the housing system, and to the stakeholders and institutions that these controversies touch upon. As the case study demonstrates, the proposed assessment approach can elucidate a richer picture of the challenges identified in the assessment than a typical quantitative-only analysis of indicators. Therefore, it offers more complete support to local governance stakeholders for learning about and acting upon the problem under assessment. Overall, our work aims to contribute to a productive alliance between sustainability assessment methodologies and urban governance stakeholders, thereby leading to more informed steering of cities towards sustainability.

1. Introduction

The concept of urban sustainability has come to occupy a central position in both the political and scientific domains (UN, 2017; Acuto et al., 2018). In response, literature on the assessment of urban sustainability has flourished (Cohen, 2017), often based on sets of sustainability indicators (Merino-Saum et al., 2020). These assessment methodologies act to translate the abstract concept of sustainability to a more operational form at the local urban scale (Waas et al., 2014). This implies understanding the nature of sustainability assessment not only as a technical measurement method providing direct input for decision-making, but also as a possible medium for supporting broader 'deliberative governance' (van Zeijl-Rozema et al., 2008), which involves dialogue and social learning among the various local stakeholders present in urban contexts (Bond et al., 2012).

For making sustainability assessments relevant and thereby

influential in such deliberative local governance of urban sustainability, the assessment methodologies face a number of challenges (Gudmundsson et al., 2009; Sébastien et al., 2014; Lehtonen et al., 2016). First, the concerns related to sustainability always reflect context-specific values and key challenges. Therefore, to increase their local pertinence, assessments (e.g., in terms of indicator selection) must be tailored to local specificities (Hartmuth et al., 2008). Second, a wide variety of interconnected concerns and competing goals weigh upon decisions related to sustainability (Finco and Nijkamp, 2001). Thus, any assessment aiming to support governance must adequately recognize this complexity when delineating what is included in the assessment (O'Connor and Spangenberg, 2008). To address these challenges of local pertinence and adequate comprehensiveness, many assessments employ forms of participatory and integrated methodologies (Reed et al., 2006; Weaver and Rotmans, 2006).

A third, less frequently addressed challenge, however, concerns the

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quality of the information produced by sustainability assessments, particularly in terms of its ability to generate useful learnings and serve as a basis for local policymaking (Cash et al., 2003; Hák et al., 2016). We propose to address this challenge by *systematically embedding and interpreting the analyzed indicators within the sociopolitical governance context of the assessments* (Astleithner et al., 2004; Holman, 2009; Pahl-Wostl, 2009). While contextual considerations form a part of many existing methodologies when selecting and weighting the assessment goals and indicators (e.g., Lee, 2006; Reed et al., 2006; Turcu, 2013; Feleki et al., 2020), approaches that propose ways to systematically embed and interpret the assessed indicators in given contexts are lacking (see Binder, 2007). Consequently, the information produced by sustainability assessments risks remaining abstract and disconnected from the complex real-world debates and decision-making situations faced by the relevant stakeholders, thereby reducing the ability of the assessments to provide useful guidance.

The present article puts forward an indicator-based assessment approach that addresses the first two challenges presented above (local pertinence and adequate comprehensiveness) by utilizing a participatory methodology, but that also, more importantly, tackles the third challenge related to the quality of the information produced by the assessment. For this third challenge, the approach employs a conceptual framework that systematically embeds the assessed indicators within their sociopolitical and institutional contexts, thus enhancing the relevance of the information produced for local stakeholders. The aim is thereby to address the gap that exists in current knowledge concerning the third challenge in ensuring the potential of sustainability assessments for exerting influence in governance processes.

To demonstrate the approach, it is applied to the assessment of the City of Geneva's housing system. Housing plays a key role in achieving sustainability for cities (UNECE, 2015; UN, 2017). It also traverses all dimensions of sustainability and involves a broad set of local stakeholders (Marcuse, 1998; Lovell, 2004; Feige et al., 2011). This renders it a pertinent case study topic for illustrating the assessment approach, as the latter aims particularly to address such complex local urban governance problems. The City of Geneva presents an interesting case study setting with its growing and diverse population, densely-built urban area, and ageing building stock (FSO, 2019, 2020), factors which contribute to making housing an urgent sustainability challenge. Through the case study, the present work secondarily also contributes to literature on the governance and assessment of housing sustainability (Winston and Pareja Eastaway, 2008; Pagani et al., 2020; Adamec et al., 2021).

The article is organized as follows: Section 2 introduces the conceptual framework central to the assessment approach; Section 3 presents the research methodology applied in the case study. Section 4 presents the assessment results. Section 5 discusses the findings and elaborates on the value of the proposed approach. Section 6 summarizes the main points and concludes with a brief look ahead.

2. Conceptual framework for contextual embedding of sustainability assessments

As argued in the introduction, the relevance of sustainability assessments for supporting deliberative urban governance can be enhanced by systematically contextualizing the indicators analyzed in the assessments. Fig. 1 presents a conceptual framework developed for this purpose and used to guide the case study assessment of Geneva's housing system.

The framework contains two parts that distinguish between the assessment model and the assessment context. The first part, the assessment model, consists of four levels that progressively define the assessed problem (in this case, 'sustainable housing system'). At the most abstract level, *system dimensions* list the principal categories to be covered by the assessment (e.g., 'buildings', 'neighborhoods'). The *goals* define the desired qualities of these dimensions (e.g., 'durable buildings', 'convivial neighborhoods'). The *sub-themes* represent constitutive factors of the goals, providing a link between the goals and their possible

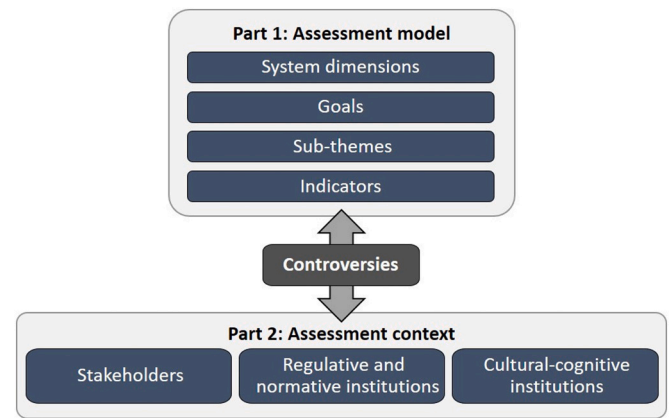


Fig. 1. The conceptual framework guiding the assessment.

indicators. For example, the goal of 'convivial neighborhoods' consists of sub-themes such as 'social links', 'public spaces', etc. The model culminates in a set of *indicators* for expressing the status of the assessed problem with regard to each goal. The model establishes a logical structure that ensures that the selection of indicators for the assessment is coherent and transparent (McCool and Stankey, 2004).

The second part of the framework refers to the assessment context. The first contextual element concerns the assessed problem's stakeholders, defined here as those affected by or affecting the governance of the problem (Reed, 2008). The second element refers both to the regulative institutions (i.e., formal rules, regulations and policies) and the normative institutions (i.e., socially defined standards of appropriate behavior) involved in the governance of the sustainability problem (Scott, 2014). The third contextual element considers the cultural-cognitive institutions (i.e., the conceptions and mental models through which reality is given meaning) related to the problem at hand (Scott, 2014). Cultural-cognitive institutions define the context-specific meanings and expectations associated with the problem in question ('sustainable housing system'). Together, these three categories of contextual elements represent central drivers of the assessed problem, and to a great extent they determine the opportunities and obstacles in acting upon any results gained from the assessment model (Pahl-Wostl, 2009).

The final element in our framework considers current controversies related to the assessed problem (Marres, 2007). These are contentious challenges or strategies that are the subject of ongoing public debate (e.g., the planning of a new neighborhood, a particular piece of legislation, etc.). Such controversies play a special role in that they represent entry points through which people practically engage with sustainability-related problems. They are also occasions for stakeholders to become involved and connected with each other, and in which the above-mentioned social institutions are subjected to public scrutiny and possible re-definition (Latour, 2007). Controversies can therefore presage imminent changes to the status quo. As Fig. 1 indicates, controversies act as connecting hubs between the assessment model and the assessment context, in a way that will be demonstrated below in Section 4.2.

3. Methodology

The conceptual framework presented in the previous section was applied to a case study assessing the City of Geneva's housing system. The design of the case study built on two guiding principles. Firstly, *participation* of local stakeholders was emphasized, viewing them not only as informants within a predefined problem framing, but as co-constructors of the definition of the problem (Reed et al., 2006). This principle was followed to address the two first challenges (local pertinence and adequate comprehensiveness) in ensuring relevance for local governance. Secondly, to increase the internal validity of the research, the case study design used *triangulation* (Meijer et al., 2002). Data was

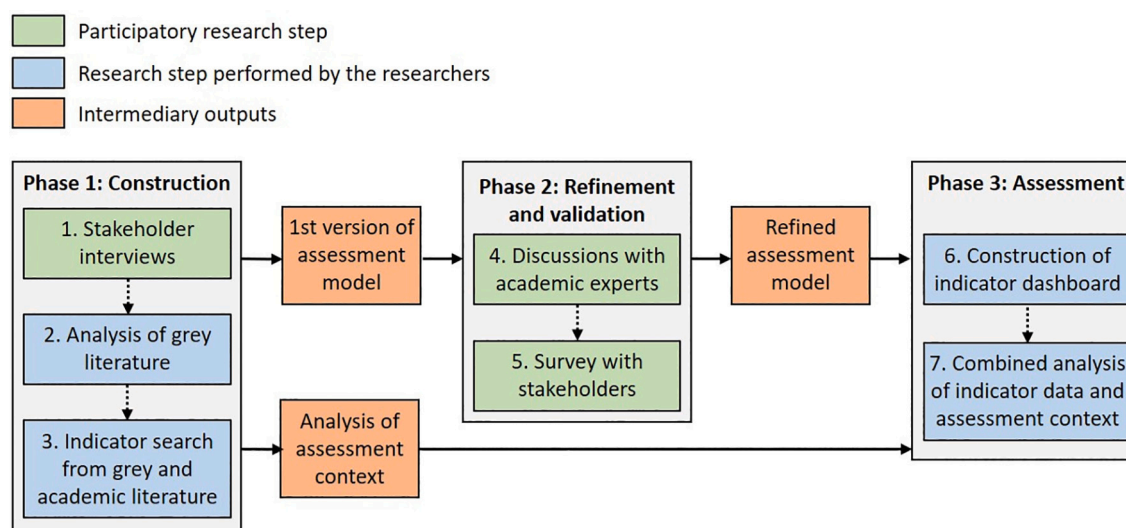


Fig. 2. The methodological steps followed.

collected using multiple methods and sources of evidence, including a balancing of inputs from the aforementioned local stakeholders with those from grey and academic literature, and from topical experts (Reed et al., 2006). Fig. 2 illustrates the overall research procedure.

To begin the first phase, qualitative semi-structured interviews were conducted with fourteen local stakeholders selected as representing a broad range of viewpoints on the problem. The interviewees included five persons from different departments of the municipal government, two technical professionals (an architect and an employee of a construction company), four citizen representatives (one from an owners' association, one from a tenants' association, and two from cooperatives of owner-tenants), and three local academics. The interviews sought the interviewees' perspectives on criteria defining sustainable housing and on the current challenges facing Geneva's housing system (see interview guide in supplementary material). As a second step, analysis of relevant grey literature was performed to elaborate and triangulate the interview data (see Appendix 0). The combined data from the first two steps was then subjected to qualitative content analysis (Mayring, 2000) in order to produce the first version of the assessment model, as well as to construct a picture of the assessment context and the prominent ongoing controversies. Importantly, the interview data was given primacy in determining what system dimensions should be included in the assessment model and which goals are adopted for these dimensions. In the final step of the first phase, a pool of candidate indicators was identified for expressing the goals and sub-themes of the assessment model. The indicators were collected from the same archive of grey literature, complemented by scanning the databases of federal and cantonal statistical offices, and by reviewing academic literature on indicators for housing sustainability (see supplementary material).

The second phase of the research aimed to refine and validate the assessment model. It consisted of two steps, the first involving discussions with eight academics whose combined expertise covered all aspects of the assessment model. This step served as a second instance of triangulation, whereby the academics were asked to review the assessment model with the aim of arriving at a *reasonably* thorough set of goals and related sub-themes. In addition, through the discussion, six indicators for each goal were shortlisted from the pool of candidate indicators. The shortlisting was based on two criteria: 1. Scientific relevance (the indicator is scientifically credible and plays a central role in satisfying the goal at hand); 2. Informational value (the indicator's ability to communicate to a non-expert audience). In the next step, as a final means of triangulation, an online questionnaire with two questions was sent to the interviewed local stakeholders (see Appendix 0). The first question asked the shareholders to express their opinion on the relative importance of the goals vis-à-vis

each other, with the purpose of validating the presence of each goal within the set of goals. The second question asked the stakeholders to prioritize the most pertinent indicators for Geneva among the six indicators shortlisted in the previous step.

The final phase concerned the actual assessment. First, a dashboard of the stakeholders' preferred indicators was constructed. This involved specifying a precise metric for each indicator, searching for data, and benchmarking the current indicator value of Geneva against its historical values, against other comparable Swiss cities (Zürich and Basel), and/or against existing policy targets. For certain selected indicators, appropriate metrics and data was difficult to find. In such cases, the indicator was kept in the dashboard to signal the need for development of appropriate metrics and data for the indicator in question. As a final step, the indicators were systematically connected to the contextual analysis in order to provide the full assessment sought with the proposed assessment approach.

4. Case study - assessing Geneva's housing system

This section presents the results of the Geneva¹ housing system case study. Table 1 presents key numbers about the case study context. The City of Geneva is the urban center for both the eponymous canton (pop.

Table 1
Basic statistics for the City of Geneva (FSO, 2017, 2019, 2020).

	Geneva (city)	Comparison
Population	203,951	
(Yearly growth; 5-year average)	(0.9%)	(Zürich 1.4%; Basel 0.5%)
Population density	12,669 per km ²	Zürich 4724 per km ² ; Basel 7223 per km ²
Foreign resident population	48%	Zürich 32%; Basel 38%
Average taxable income per taxpayer	83,823 CHF	Zürich 79,012 CHF; Basel 76,701 CHF
Employment rate (ages 20–64)	70%	Zürich 81%; Basel 74%
Share of owner-occupied dwellings (data for cantons)	18%	Zürich 28%; Basel 16%
Share of dwellings built after 1981	19%	Zürich 24%; Basel 12%

¹ For brevity, 'Geneva' is henceforth used to refer to the city; references to the Canton of Geneva are made explicit.

System dimensions	Dwellings	Buildings		Neighborhoods						Markets			Culture
Goals	Goal 1 Comfortable and healthy dwellings	Goal 2 Durable and adaptable buildings	Goal 3 Buildings with low energy and material footprint	Goal 4 Buildings and neighborhoods in harmony with their physical surroundings	Goal 5 Safe neighborhoods	Goal 6 Participatory neighborhoods	Goal 7 Connected neighborhoods	Goal 8 Convivial neighborhoods	Goal 9 Diverse neighborhoods	Goal 10 Economically viable markets	Goal 11 Accessible and fair markets	Goal 12 Markets with adequate supply	Goal 13 Cultural and aesthetic value
Sub-themes	1a Quality and quantity of living space 1b Services and equipment 1c Thermal and aural comfort 1d Indoor air quality 1e Lighting and view 1f Privacy 1g Accessibility	2a Lifetime of structure, materials and technologies 2b Quality of workmanship 2c Maintenance and renovation 2d Adaptability of space 2e Structural modularity	3a Energy, climate and material footprint of structure 3b Critical materials 3c Energy, climate and material footprint in operation 3d Waste management	4a Land use 4b Integration with surroundings 4c Green areas and infrastructures	5a Crime 5b Traffic safety 5c Hazards	6a Associative life 6b Participatory governance	7a Proximity to workplaces 7b Proximity to public transport 7c Transport infrastructure 7d Proximity to services	8a Social links 8b Neighborhood spirit 8c Public spaces 8d Sharing	9a Social diversity 9b Functional diversity	10a Investment attractiveness 10b Operational costs 10c Impact on local economy	11a Rental market affordability 11b Ownership affordability 11c Subsidized housing 11d Security of tenure	12a New construction 12b Quantity of supply 12c Diversity of supply	13a Heritage protection 13b Local sensitivity 13c Aesthetic quality
Selected indicators	1.1 Noise 1.2 Natural light	2.1 Investments in maintenance, renovation or conversion 2.2 Ease of refurbishing installations	3.1 Energetic efficiency of buildings 3.2 Share of renewable energy	4.1 Construction considering the natural conditions of the site 4.2 Percentage of green coverage	5.1 Pedestrian and low speed limit zones 5.2 Existence of risk maps	6.1 Availability of community facilities 6.2 Membership in community associations	7.1 Capacity of public transport system 7.2 Soft mobility infrastructure	8.1 Architecture encouraging social links 8.2 Amount of public spaces	9.1 Age distribution of residents 9.2 Share of residents receiving social benefits	10.1 Cost of maintenance and retrofitting 10.2 Access to funding for investment	11.1 Average rental price per m ² 11.2 Subsidized housing ratio	12.1 Construction rate relative to population growth 12.2 Vacancy rate	13.1 Preservation of local characteristics and identity 13.2 Satisfaction with aesthetics of surroundings

Fig. 3. The assessment model for the sustainability of Geneva's housing system. Note that only the two most popular indicators per goal from the stakeholder questionnaire are shown and considered in the ensuing assessment. This means that not all sub-themes are covered by the selected indicators in this instance. Nevertheless, making all sub-themes transparent serves the purpose of defining the meaning of each goal more explicitly, and in a subsequent application of the model, other indicators (relating to some of the sub-themes ignored here) may be prioritized by the stakeholders.

500,000) and the greater agglomeration (pop. 950,000). The city's housing system is composed of a high number of rented apartments and an ageing housing stock. Recently, steady population growth (0.9% annually on average) has been putting pressure on the housing system of this already densely populated city.

Geneva's housing system falls under a complex governance structure of stakeholders, regulations and norms (Feige et al., 2011; Debrunner et al., 2020). Although Switzerland is known for its decentralized political system with a considerable share of regulatory power located at the cantonal level, in the case of housing, several relevant powers are held at the federal level. Swiss constitution-mandated federal authority on the topic particularly stems from Articles 108 (encouraging construction of housing and home ownership), 109 (against abuse in tenancy matters), 73 (sustainable development), 75 (spatial planning), and 89 (energy efficiency and renewable energy). The City of Geneva further complements federal and cantonal regulations through voluntary action in several relevant fields, including policies on social housing and cohesion, and land use planning (see Appendix 0).

4.1. Assessment model and indicator dashboard

Fig. 3 depicts the assessment model for Geneva's housing system, spanning five dimensions: dwellings, buildings, neighborhoods, markets and culture. Across these dimensions, the model specifies thirteen goals for the housing system to satisfy and balance. Sub-themes are defined for each of the goals (i.e., their principal constitutive factors). In Fig. 3 we

present only the two top-ranked indicators from the stakeholder questionnaire (see Appendix 0), which subsequently serve as the basis of the assessment. The questionnaire also validated the goals included in the assessment model, as even the worst-rated among the thirteen goals (Goal 6; see Appendix 0) was seen as having below-average importance by only 30% of the respondents, strongly indicating that all of the goals included in the model are pertinent to the case in question.

Table 2 presents a dashboard of the selected indicators (see methodological notes and data sources in supplementary material). Unless otherwise noted, the value displayed is for the City of Geneva.² As mentioned above, for some indicators finding suitable metrics and data was not possible (within the scope of this research); the presence of these indicators in the dashboard signals the need for development of appropriate operationalizations in the future.

A number of critical observations can be made from the dashboard. Firstly, Geneva's housing market is characterized by a shortage of supply, as evidenced by the low vacancy rate of 0.6%³ (Indicator 12.2). This is exacerbated by a ratio of new dwellings to new residents (0.38; Indicator 12.1) that, despite an increase over the last decade, remains low in comparison with Basel (0.91) and Zürich (0.43). Furthermore, the strained situation in the market is accompanied by comparably high monthly rent levels (29.8 CHF/m²; Indicator 11.1). To combat this challenge with affordability, the canton has set a target of doubling the amount of subsidized housing.⁴ However, as seen in Indicator 11.2, the share of subsidized dwellings has not increased in recent years (9.8% in 2019; 10.0% in 2015).

² The values represent the latest data at the time of writing (January 2021).

³ According to estimates, a well-functioning housing market in Switzerland should have a vacancy rate of 1% - 1.5% (Thalmann, 2012; RTS, 2018).

⁴ Cantonal Act for the Construction of Socially Beneficial Housing (LUP)

Table 2

Indicator dashboard for the sustainability of the City of Geneva housing system.

Goal	Indicator	Metric [unit, year]	Value	Evolution [Year]	Benchmark
1	1.1 Noise	Share of population disturbed at night by >55 dB(A) [%; 2015]	42.2	N/A	Zürich - 15.1 Basel - 13.9
	1.2 Natural light	<i>To be operationalized</i>			
2	2.1 Investments in maintenance, renovation or conversion	Investments in expansions, transformations and demolitions per capita [CHF, 2018]; data for cantons	3786	2941 [2013]	Zürich - 2640 Basel - 4847
	2.2 Ease of refurbishing installations	Price of renovating installations [index, 2020]; data for cantons	100.5	100 [2015]	Zürich - 92.0 National - 91.3
3	3.1 Energy efficiency of buildings	Average heat consumption index [MJ/(m ² a), 2019]	486	507 [2014]	Cantonal target: 350 by 2030
	3.2 Share of renewable energy	Share of residential buildings with wood, electricity, heat pumps or solar collectors for heating; (if district heating is included) [%; 2015]; data for cantons	10.8; (11.7)	8.8; (9.5) [2010]	Zürich - 24.4 (27.6); Basel - 1.7 (31.7)
4	4.1 Construction considering the natural conditions of the site	<i>To be operationalized</i>			
	4.2 Percentage of green coverage	Share of wooded and recreational areas [%; 2013–2018]	18.6	18.9 [2004–2009]	Zürich - 35.5 Basel - 12.6
5	5.1 Pedestrian and low speed limit zones	Share of moderated traffic zones [%; 2017]	40.9	34.9 [2013]	Zürich - 55.4 Basel - 72.6
	5.2 Existence of risk maps	Binary indicator for existence of risk maps [yes/no; 2021]	Yes	N/A	Zürich - Yes Basel - Yes
6	6.1 Availability of community facilities	Number of neighborhood centers [1/10000 inhabitants, 2020]	0.54	N/A	Zürich - 0.43 Basel - 0.87
	6.2 Membership in community associations	Population (>15 years) involved in a communal or neighborhood association [%; 2020]; data for regions	6.2	N/A	Zürich - 4.2 National - 5.4
7	7.1 Capacity of public transport system	Amount of public transport stops [1/1000 inhabitants, 2019]	0.7	0.8 [2015]	Zürich - 1.1 Basel - 1.0
	7.2 Soft mobility infrastructure	Bicycle friendliness [index points, 2019]	3 pts.	N/A	Zürich - 2 pts. Basel - 8 pts
8	8.1 Architecture encouraging social links	<i>To be operationalized</i>			
	8.2 Amount of public spaces	Density of public benches [1/ha, 2020]	1.17	N/A	N/A
9	9.1 Age distribution of residents	Dependency ratio: Number of residents outside working age per those in working age; (std. dev. between neighborhoods) [%; 2020]	50.9; (9.8)	51.7; (10.1) [2011]	Zürich - 47.6 (14.3) Basel - 56.1 (11.9)
	9.2 Share of residents receiving social benefits	Share of residents receiving social subsidies; (std. dev between neighborhoods) [%; 2017]	11.2; (8.7)	10.8 [2014]	Geneva Canton - 9.7
10	10.1 Cost of maintenance and retrofitting	Price of renovations and transformations [index, 2020]; data for cantons	101.4	100 [2015]	Zürich - 98.0 National - 98.0
	10.2 Access to funding for investment	<i>To be operationalized</i>			
11	11.1 Average rental price per m ²	Average rent (CHF) per net floor space [CHF/(m ² month), 2017]	29.8	19.8 [2005]	Zürich - 25.7 Basel - 18.9
	11.2 Subsidized housing ratio	Share of subsidized dwellings of total number of dwellings [%; 2019]	9.8	10.0 [2015]	Cantonal target: 20%
12	12.1 Construction rate relative to population growth	Ratio of new dwellings to new residents [dwellings/persons, 2015–2019]	0.38	0.26 [2011–2015]	Zürich - 0.43; Basel - 0.91
	12.2 Vacancy rate	Dwelling vacancy rate [%; 2019]	0.6	0.3 [2011]	Zürich - 0.1; Basel - 1.0
13	13.1 Preservation of local characteristics and identity	<i>To be operationalized</i>			
	13.2 Satisfaction with aesthetics of surrounding architecture	<i>To be operationalized</i>			

Secondly, while the energy performance of the housing stock is improving (486 MJ/m²a in 2019; 507 MJ/m²a in 2014; Indicator 3.1), the improvement rate is slow when benchmarked against the cantonal target of 350 MJ/m²a for 2030.⁵ Also, renewable energy use for housing purposes is low in Geneva: for example, only 10.8% of the heating energy in 2015 came from sustainable sources, compared with 24.4% in Zürich (Indicator 3.2). Meanwhile, per capita investments in the existing housing stock have increased considerably in recent years (3786 CHF in 2018; 2941 CHF in 2013; Indicator 2.1), despite that, against the trend

elsewhere the country, the prices of this type of work (Indicators 2.2 and 10.1) have been slightly increasing. For example, the index price of renovations and transformations in the Canton of Geneva in 2020 was 101.4 (100 in 2015) compared with 98.0 in Zürich.

Thirdly, in terms of the livability of the urban environment, several indicators display room for improvement, including: the share of population disturbed by noise (42.2% in Geneva; 15.1% in Zürich; 13.9% in Basel; Indicator 1.1); the share of moderated traffic zones (40.9% in Geneva; 55.4% in Zürich; 72.6% in Basel; Indicator 5.1); and the share of

⁵ Cantonal Energy Plan 2020–2030 (PDE)

green coverage (18.6% in Geneva; 35.5% in Zürich; 12.6% in Basel; Indicator 4.2). Geneva also trails the reference cities in the area of mobility, as shown by the amount of public transport stops (0.7 per 1000 inhabitants; 1.1 in Zürich; 1.0 in Basel; Indicator 7.1) and the index score of bicycle friendliness (3 points; Zürich 2 points; Basel 8 points; Indicator 7.2). When it comes to neighborhood diversity, the city's residents represent a broad range both in terms of age distribution (the number of residents either under 20 years or over 64 years summing to half of those between 20 and 64 years; Indicator 9.1) and socioeconomic groups (11.2% of residents receive social benefits; Indicator 9.2). However, as the standard deviations between neighborhoods show, (especially the 8.7% for Indicator 9.2), this diversity varies strongly between areas of the city.

In the absence of appropriate metrics and data, there is a lack of visibility with regard to certain key aspects of the housing system, including indicators for natural light (1.2), construction that considers the site's natural conditions (4.1), architecture that encourages social links (8.1), preservation of local characteristics and identity (13.1), and satisfaction with the aesthetics of surrounding architecture (13.2). The commonality among these blind spots is their relation to the architectural aspects of the housing system. To avoid being overlooked in future policymaking, this can be taken as a strong signal of a general need to develop operational indicators and generate data for this key area.

4.2. Contextualizing indicators

To summarize the indicator dashboard observations, the sustainability challenges of Geneva's housing system relate particularly to: (i) the energy performance of the housing stock (both quantitatively and qualitatively; Indicators 3.1 and 3.2); (ii) availability (Indicators 12.1 and 12.2), especially when it comes to affordable housing (Indicators 11.1 and 11.2); (iii) selected aspects of the urban environment, including noise and traffic (Indicators 1.1 and 5.1), the amount of green areas (Indicator 4.2), and mobility (Indicators 7.1 and 7.2). As we have argued above, this initial assessment can be enriched by connecting the indicators to different contextual elements, in particular through the analysis of ongoing controversies. The argument is illustrated with the example of two salient controversies from the Genevan context, presented diagrammatically following Fig. 1.

4.2.1. Controversy 1: regulation on demolitions, transformations and renovations

The first controversy (see Fig. 4) concerns a long-running debate in Geneva around the cantonal law on demolitions, transformations and renovations (LDTR). The law was intended to curb the loss of residential housing in the city center by restricting the ability of owners to remodel or change the use purpose of their properties. In addition, the law sets a ceiling on possible rent increases following these types of work. In other words, the law is an attempt to address both Goal 12 (sub-theme 'quantity of supply') and Goal 11 (sub-themes 'rental market affordability' and 'security of tenure') of the assessment model. As discussed above, the indicators expressing these goals display values that attest to the urgency of action to support them, especially the comparably high average rental price of 29.8 CHF/m² (Indicator 11.1) and the sub-optimal vacancy rate of 0.6% (Indicator 12.2).

However, the law is also often criticized, especially on two accounts: Firstly, by limiting the ability of owners to alter their properties, the law directly reduces the adaptability of dwellings (Goal 2, sub-theme 'adaptability of space') to different family sizes, preferences, etc.,

thereby further adding to the rigidity of the housing market in responding to changing demand (Goal 12, sub-theme 'diversity of supply'). Secondly, by reducing the ability of owners to recuperate investment costs through rent increases, the law also disincentivizes improvement of the housing stock (Goal 2, sub-theme 'maintenance and renovation'; Goal 3, sub-theme 'energy and climate footprint'). The critical value of Indicator 3.1 concerning the energy efficiency of buildings (486 MJ/m²a vs. the target of 350 MJ/m²a) emphasizes the need to address this line of argumentation in order to better promote the renovation of the city's housing stock.

The controversy directly sets two groups of local stakeholders, i.e., tenants and owners, in opposition, and involves regulations and norms from the local to national scale. Interestingly, the central cantonal law (LDTR) in this debate exceeds the federal tenancy regulations on rent protection, making the Canton of Geneva a special case in the Swiss context. The new cantonal energy plan for 2030, which sets ambitious targets for the renovation rate of the housing stock, will most likely further fuel the controversy and increase calls for reconsidering the level of rent protection offered by the current regulations.

At the cultural-cognitive level, the controversy touches upon two fundamental questions. First, it contrasts two conflicting ideas about the nature of housing, i.e., whether housing should be considered a market commodity best regulated by the open market, or whether it is a public good that should be guaranteed for everyone at affordable prices through public policies and regulations. Second, the controversy highlights a dilemma between social objectives (maintaining affordability, tenure security, etc.) and environmental ones (incentivizing renovation of the housing stock). Unless solutions are found that support both of these dimensions of sustainability, the dilemma suggests that gaining public support for improving the environmental performance of housing may require efforts for reconfiguring deeper conceptions about the objectives that housing is supposed to serve.

4.2.2. Controversy 2: densification of the city

The second controversy (see Fig. 5) concerns efforts to densify already built areas in the city. Densification is aimed at meeting the housing demand in the city while also limiting the encroachment on natural and agricultural land by urban sprawl. As such, these efforts relate to Goal 4 (sub-theme 'land use'), Goal 7 (sub-themes 'proximity to workplaces', 'proximity to public transport' and 'proximity to services') and Goal 12 (sub-themes 'new construction' and 'quantity of supply') of the assessment model. Densification is a particularly pertinent topic for Geneva, because, as shown by the indicator dashboard, the city is behind the reference cities in constructing new housing (Indicator 12.1), a crucial challenge given the low vacancy rate prevailing in the market (Indicator 12.2).

The densification of the city faces strong opposition, especially given that Geneva is already densely populated compared to other Swiss cities (see Table 1). The argument from this point of view is that densification leads to a less livable and attractive urban environment, with a loss of existing neighborhood spirit and identity. Thus, the opposition relates specifically to Goal 4 (sub-theme 'green areas and infrastructures'), Goal 8 (sub-themes 'neighborhood spirit') and Goal 13 (sub-themes 'local sensitivity' and 'aesthetic quality') of the assessment model. The argument is supported by Indicator 4.2 showing that the amount of green coverage in Geneva is already fairly low compared to Zürich (although high compared to Basel). Notably for this debate, the operationalization of Indicators 13.1 (Preservation of local characteristics and identity) and 13.2 (Satisfaction with aesthetics of surrounding architecture) would

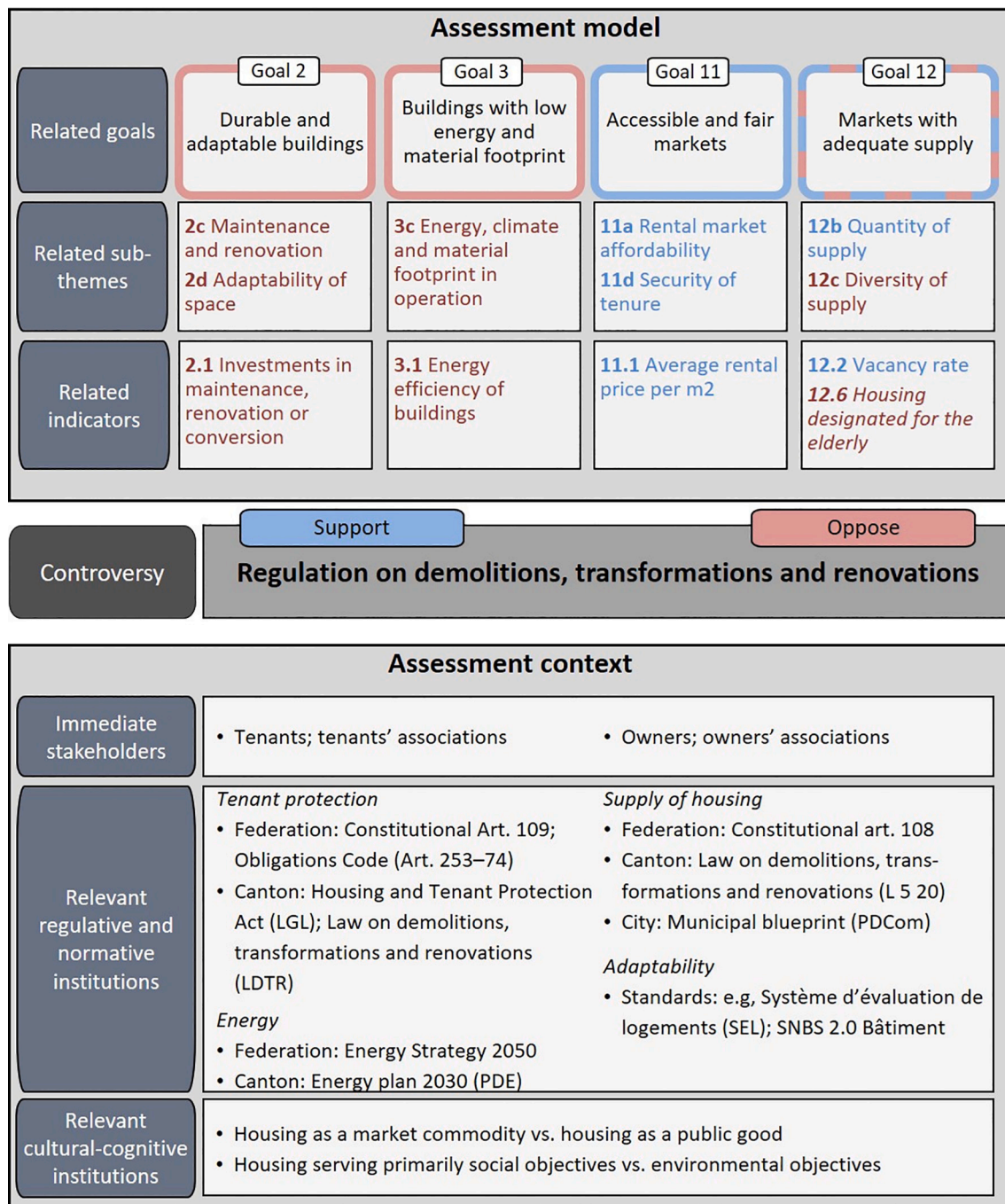


Fig. 4. Diagram of the regulation on demolitions, transformations and renovations controversy. The blue-and-red color-coding signals a supporting link between the goals, sub-themes and indicators, and the two positions on the controversy (blue for 'support' and red for 'oppose'). The indicators marked in *italics* were not among those selected for the dashboard (Table 2), but that would nevertheless, be pertinent for the controversy. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

bring much needed evidence to support fact-based future policymaking.

In terms of regulations, the objective of densification features centrally in the Federal Spatial Planning Act (SPA), which explicitly requires cantons to curb their land use by directing future construction activities to already built areas. The Canton of Geneva is responsible for implementing the objectives of the SPA through its cantonal masterplan. The latter, in turn, is translated to the municipal blueprint that sets goals for spatial development in The City of Geneva. The city also imposes its own land use plan (endorsed by the canton, which has the regulatory authority on this matter) aimed at a higher density of housing within the city. Importantly, all of these regulations state that densification must be

accompanied by adequate attention to retaining the quality and livability of the urban environment. Apart from governmental regulations, interestingly, many newer certification standards have extended their scope to include spatial aspects such as density and livability of the urban environment. Despite being a clear priority at all levels of government, densification in practice remains a controversial topic. In fact, several referenda have taken place concerning densification measures of specific neighborhoods within the City and the Canton of Geneva, and in many cases the public has rejected these proposals.

Two underlying cultural-cognitive dilemmas can be detected in this controversy. The first concerns the selection of overarching principles to

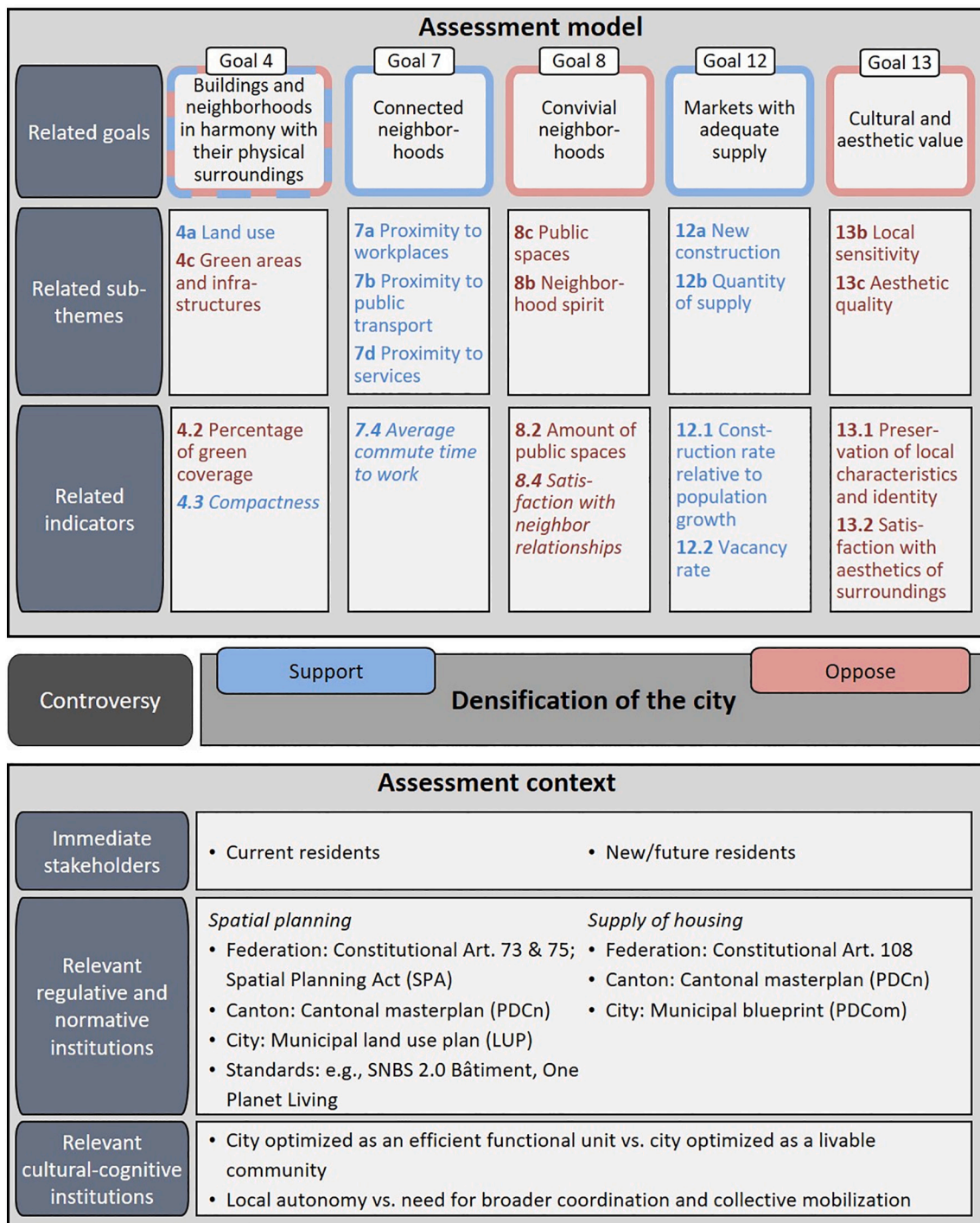


Fig. 5. Diagram of the densification of the city controversy. See explanatory notes in the caption of Fig. 4.

guide urban development. Specifically, in this case, the choice is between optimizing the city in terms of functional efficiency (e.g., in land use and mobility) or in terms of livability. The second dilemma relates to the tension between, on the one hand, the autonomy of (current) local residents to decide on the development of cities and neighborhoods, and on the other hand, the need for policy coordination and collective action on a broader scale, which may entail mandatory top-down requirements. This dilemma is particularly pertinent in the Swiss context, where there is a tradition of strong local autonomy and direct democracy.

5. Discussion

In this article, we have proposed a sustainability assessment approach targeted at supporting deliberative local urban governance. In this section, we discuss (i) the methodology used to construct the assessment model and the results gained in the case study; (ii) the framework used to embed the assessed indicators in their contexts; (iii) the overall contributions and limitations of the research.

5.1. Assessment model and its application to Geneva

The assessment model elaborated in the case study complements the trend observed by Adamec et al. (2021) of research applying an increasingly comprehensive set of criteria for the sustainability assessment of housing. With our methodology, in which the definition of the problem is delineated based on the inputs of the stakeholder-interviewees, we produced an assessment model that makes explicit the range of goals that local urban governance needs to balance if the housing system is to be sustainable. As such, the assessment model is comparable in scope, for example, to the principles promulgated by the Geneva UN Charter on Sustainable Housing (UNECE, 2015). In other words, the assessment model gathers under a single umbrella the concerns of a broad set of stakeholders, all involved in the housing system in some way (Feige et al., 2011).

The assessment of Geneva's housing system highlighted the most critical aspects concerning its sustainability: (i) the energy performance of the housing stock; (ii) availability and affordability of housing; (iii) particular aspects of the urban environment, including noise, moderation of traffic, the number of green areas, and public and soft mobility. In fact, many of these challenges already feature centrally in the city's policy agenda.⁶ In addition to these themes that are already receiving attention (and for which data exists that allows for monitoring), the case study also highlighted the difficulty of operationalizing certain key areas of the assessment model. These related mainly to the architectural aspects of the housing system. Until appropriate indicators and data are created to cover these aspects, they are at risk of remaining overlooked in future policymaking on housing, which in turn translates into an imbalance in attempts at creating a sustainable housing system in Geneva.

Certain critical points can be mentioned concerning the methodology employed to construct and apply the assessment model. First, the methodology unavoidably entails a level of subjectivity, and making certain choices differently (e.g., interviewee sampling, selection of participatory methods, etc.) would have resulted in a somewhat different set of goals and indicators (Vatn, 2009). However, the methodology employed triangulation to reduce this subjectivity, and the results can be expected to represent with an adequate accuracy the relevant concerns related to the assessed system. Another critical issue is that assessments like ours targeting the local scale require considerable resources for the definition of appropriate metrics and collection of data, as also evidenced by our inability to fully operationalize the indicator dashboard within the scope and schedule of this work. Furthermore, benchmarking the indicator values of cities against each other should be taken only as an *indication* of the sustainability status of the cities in question and not as a fully objective comparison. This is, firstly, due to the varying ways in which municipal boundaries are drawn, which makes direct comparisons between cities problematic. Furthermore, what can be considered as an appropriate and sustainable level for a given indicator depends on the unique geographical, climatic and historical circumstances of each city, and on the cultural expectations prevailing in different contexts.

5.2. Contextual embedding of the assessed indicators

As we have argued, the potential of the indicator assessment presented above for informing governance can be enhanced by systematically embedding the indicators and the signals they send into the context of the assessment, as proposed in Fig. 1. Using the example of the regulations on demolitions, transformations and renovations controversy (Fig. 4), the following observations and assertions can be made:

- There is a tradeoff between two crucial sustainability challenges for Geneva's housing system identified by the indicators, namely, the energy performance of the housing stock and the availability of affordable housing. Therefore, proposed solutions on these challenges must consider simultaneous impacts on both sides of the tradeoff. (To generalize, the analysis of controversies can reveal tradeoffs between goals and indicators, thus laying the groundwork for comprehensive policymaking that acknowledges different aspects of sustainability.)
- The controversy opposes the interests of owners with those of the tenants, which makes the participation of these stakeholder groups crucial when developing related policies. (To generalize, the analytical approach makes explicit relevant stakeholder groups in the controversy. This is important, as the composition of these groups is not static across the entire broader problem – in this case, sustainable housing – but is dependent on the controversy at hand. In participative policymaking, failure to acknowledge this can lead to the selection of participants that do not represent the diversity of stakeholder positions.)
- The analysis of the controversy shows that several competing regulations and norms are implicated in the tradeoff. For example, if meeting the energy efficiency targets set by the cantonal Energy Plan 2030 is given priority, the level of rent protection offered by the current regulations may need to be reconsidered and combined with financial carrots and sticks to incentivize further owner investment. (To generalize, by analyzing the regulative and normative institutions in place, the proposed approach highlights the structures within which local governance must maneuver when addressing the sustainability challenges revealed by the indicators.)
- The analysis also reveals that underlying the tradeoff are deeper conflicting meanings and expectations related to the housing system. In this case, these conflicts relate especially to conceptions related to the social and environmental priorities that housing should serve, as well as to ideas about the nature of housing as either a market commodity or a public good. (To generalize, by making explicit the underlying cultural-cognitive institutions, the approach elucidates not just the conflicting arguments related to a controversy, but also the assumptions and values that buttress these arguments; this expedites deeper and more productive debates on the sustainability problem at hand.)

As these examples demonstrate, our analysis elucidates a more complete picture of the challenges identified by the indicators and the possibilities to act upon them. This elevates the indicators from mere data points to more complete 'stories', and thereby makes them less abstract and more salient for the ongoing governance issues and debates of given contexts (Hartmuth et al., 2008; O'Connor and Spangenberg, 2008). This is useful for local urban governance in two distinct ways. Firstly, it can serve as a basis for learning, dialogue and networking among local actors, which is crucial for creating the needed social foundation for the sustainability transformations of cities (van Zeijl-Rozema et al., 2008). Here, connecting the assessment to ongoing debates is valuable, as it makes the goals and indicators of the assessment model more relatable for these local stakeholders. Secondly, in terms of policymaking, the approach can serve as a preliminary agenda-setting stage in which the sustainability problem in question is defined and given structure, afterwards feeding to the development of more concrete policies (for the latter, see Feleki et al., 2016; Feleki et al., 2020). In particular, through the analysis of controversies, the approach helps to locate particular policymaking challenges (e.g., regulation on renovations) within the broader sustainability problem (e.g., sustainable housing) and the multi-scale governance system that steers it, thus setting the stage for comprehensive policies that acknowledge the complexity involved.

Arguably, the conceptual framework developed to guide the contextual embedding (Fig. 1) is a meta-framework that is readily

⁶ E.g., the municipal blueprint (PDCom)

transferable also to other geographical contexts than Switzerland and that can be applied to multiple sustainability problems relevant for local governance, since the contextual aspects that are analyzed (stakeholders, institutions and controversies) have universal pertinence. In other words, although the content of the boxes shown in the conceptual framework will vary depending on the case, the boxes themselves are generalizable. Using the framework, however, is not without its challenges. In particular, given the inherent breadth of concerns included in the analysis of a complex problem like sustainable housing, reaching sufficient depth in the contextual analysis requires considerable efforts.

5.3. The contributions and limitations of the research

This article has demonstrated an assessment approach that addresses three challenges that sustainability assessments must face when attempting to support and influence local urban governance, the first two of them (local pertinence, adequate comprehensiveness) by using a participatory methodology (Fig. 2), and the third (quality of information) with the help of a dedicated conceptual framework (Fig. 1) that systematically integrates the assessment model into relevant contextual aspects affecting the governance of the assessed problem. The approach thus responds to calls for balancing the existing focus on developing assessment methodologies that are technically increasingly sophisticated while neglecting the need for real-world relevance (Sébastien et al., 2014; Håk et al., 2016).

The novelty of the work for assessment scholarship resides in two particular contributions. The first is to propose an approach that simultaneously addresses all the three challenges mentioned above. While earlier scholarship (e.g., Lee, 2006; Reed et al., 2006; Turcu, 2013; Feleki et al., 2020) has often emphasized the value of participatory methodologies for addressing two of these challenges (local pertinence and adequate comprehensiveness), our approach augments this focus to expressly also address the third challenge, i.e., matching the information provided by assessments with the needs of the target audience. This ensures that making assessments involves not merely providing numbers, but also systematically discussing the meaning of those numbers and possible ways for influencing them going forward. In doing so, our approach builds on scholarship that has acknowledged the importance of interpreting indicators in particular contexts (Astleithner et al., 2004; Holman, 2009) and provides a concrete operationalization of this idea. Such systematic, contextually sensitive interpretation is rarely found in existing literature (see Binder, 2007). The second novel contribution is the particular solution offered to address the third challenge mentioned above, i.e., using ongoing controversies as lenses that reveal connections and patterns between indicators and their contextual drivers. In other words, the originality is in combining the qualitative analysis of such controversies (Latour, 2007; Marres, 2007) with quantitative indicator-based assessments.

An important limitation of the work reported in this article is that its scope did not include a final step to gain feedback from the stakeholders on the usefulness of the results. Therefore, a crucial future task for research would be to investigate the true potential and added value of the proposed approach for making indicator-based assessments relevant and influential in local governance. Another limitation is that the work is based on a single case study. However, the selected case study object (housing system of the City of Geneva) represents a typical example of the kind of complex sustainability challenges faced by local governance

around the world. Therefore, arguably, the insights of the study have general pertinence for scholarship on locally relevant sustainability assessments.

6. Conclusion

This article seeks to bridge the gap between indicator-based sustainability assessments and urban governance. As we have argued, a disconnect currently exists between indicator-based sustainability assessments and the challenging real-world decision-making situations faced by those involved in the governance of urban sustainability problems. Rather than simply offering facts, assessments aiming to serve governance should tell a 'story' that brings the indicators to life by discussing them in their context. Too often such contextualization is relegated to some sentences in a discussion section, instead of being an integral part of the assessment.

As we show, engaging with ongoing controversies can provide a fruitful avenue forward as they offer enlightening glimpses into the interconnections and conflicts within complex urban governance problems in a way that would otherwise be difficult to discern. In this way, indicator-based assessments can become richer and more useful for urban governance, especially if the latter is understood not simply as making decisions, but as a deliberative process that considers different points of view, and involves social learning and dialogue among the diverse set of stakeholders present in urban contexts.

In building on the approach presented in this paper, two possible interesting directions can be envisioned. First, the analysis of the controversies could be connected with qualitative and/or quantitative scenario analyses and multi-criteria assessments. This would be a way to make the approach more directly operational for policymaking. Secondly, the overall approach could be used to construct an initial assessment model, which could be periodically updated with new indicators and/or modules as new challenges and controversies arise. In this way, the model would serve as a modular assessment platform, dynamically responding to changing governance challenges over time.

Author contributions

PH: Conceptualization, data collection and analysis, writing and editing of manuscript. AMS and CRB: Critical feedback and support at all stages.

Declaration of Competing Interest

The authors declare that they have no competing financial interests or personal relationships that could have influenced the work reported in this paper.

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1. Grey literature

Table A1

The archive of analyzed grey literature (see also supplementary material for a mapping of actors involved in the governance of Geneva's housing system).

Name of document/website	Author/responsible actor
<i>Federal</i>	
Constitutional Articles 73, 75, 78, 89, 108, 109	Swiss Confederation
Sustainable Development Strategy 2016–2019; 2030	Federal Office for Spatial Development (ARE)
Loi fédérale sur l'aménagement du territoire (LAT)	Federal Office for Spatial Development (ARE)
Loi fédérale encourageant le logement à loyer ou à prix modérés (LOG)	Federal Office for Housing (FOH)
Système d'évaluation de logements (SEL)	Federal Office for Housing (FOH)
Quartiers durables	Federal Office for Spatial Development (ARE); Federal Office of Energy SFOE (SFOE); Canton Vaud; City of Lausanne; Schéma directeur de l'Ouest lausannois (SDOL)
Energy Strategy 2050	Federal Office of Energy (SFOE)
Federal Act on the Protection of Nature and Cultural Heritage	Federal Inventory of Heritage Sites (ISOS)
<i>Cantonal</i>	
Concept cantonal du développement durable 2030	Département du territoire (DT); Service Cantonal du Développement Durable
Plan climat cantonal	Département du territoire (DT); Service Cantonal du Développement Durable
Plan directeur cantonal	Département du territoire (DT); Office de l'urbanisme
Plan directeur de l'énergie 2020–2030	Département du territoire (DT); Office cantonal de l'énergie (OCEN)
<i>Municipal</i>	
Feuille de route du Conseil administratif (2015–2020)	Administrative Council
Plan directeur communal Genève 2020	Département de l'aménagement, des constructions et de la mobilité; Service d'urbanisme
Politique énergétique	Département de l'aménagement, des constructions et de la mobilité; Service de l'énergie
Engagements et actions municipales en faveur d'un développement durable	Département des finances, de l'environnement et du logement; Service Agenda 21
Politique sociale du logement	Département des finances, de l'environnement et du logement; Gérance Immobilière Municipale
Plan stratégique de végétalisation de la Ville de Genève	Département des finances, de l'environnement et du logement; Service des espaces verts
Politique sociale de proximité	Département de la cohésion sociale et de la solidarité; Service social
<i>Normative</i>	
SIA 112/1; SIA 2040	The Swiss Society of Engineers and Architects (SIA)
SNBS 2.0 Bâtiment	Sustainable Construction Network Switzerland (NNBS)
Gestion Immobilière Durable	Interessengemeinschaft privater, professioneller Bauherren (IPB); Koordinationskonferenz der Bau- und Liegenschaftsorgane der öffentlichen Bauherren (KBOB)
Qu'est-ce que Minergie?	Association Minergie
Certificat énergétique cantonal des bâtiments (CECB)	L'Assemblée plénière de l'EnDK; L'association CECB
Manuel relatif au certificat pour les Sites 2000 watts (2019)	Site 2000 watts
One Planet Living - Plan d'Action de Durabilité SméO	Association suisse pour des quartiers durables Canton Vaud; City of Lausanne

2. Stakeholder questionnaire

As part of the validation of the assessment model, the 14 stakeholders that were interviewed in the beginning of the research were asked through an online questionnaire to express their opinions on the relative importance of the goals and the shortlisted indicators. More specifically, the first question was “How do you estimate the importance of the following goals with regard to the sustainability of housing in the city of Geneva?”, with the respondents choosing between three options (Below-average importance; Average importance; Above-average importance) for each goal. Having relative response options rather than absolute (e.g., Not at all important; Important; Very important) was an attempt to elicit greater distinction between the goals, as the absolute scale could have easily led to every goal being evaluated as important or very important. The second question aimed at selecting the most pertinent indicators among the candidate indicators by asking the respondents “Which of the following indicators do you think are most relevant for assessing the [respective goal]? Please choose a maximum of three indicators.”

The results of the first question are displayed in the [Table A2](#) below ($N = 10$). The ranking of the goals is defined, firstly, by how many respondents estimated a given goal to be of above-average importance, and in case of a tie, secondly by the number of respondents rating the goal to be of average importance. The results of the second question are shown in [Appendix 0](#).

Table A2

The relative importance of the goals according to the stakeholders ($N = 10$).

Goals	Below-average importance	Average importance	Above- average importance
1. Comfortable and healthy dwellings	0	4	6
2. Durable and adaptable buildings	1	2	7
3. Buildings with low energy and material footprint	1	1	8
4. Buildings and neighborhoods in harmony with their physical surroundings	2	2	6
5. Safe neighborhoods	2	6	2
6. Participatory neighborhoods	3	3	4
7. Connected neighborhoods	0	6	4
8. Convivial neighborhoods	2	5	3
9. Diverse neighborhoods	0	3	7

(continued on next page)

Table A2 (continued)

Goals	Below-average importance	Average importance	Above- average importance
10. Economically viable markets	1	6	3
11. Accessible and fair markets	1	5	4
12. Markets with adequate supply	1	6	3
13. Cultural and aesthetic value	1	6	3

3. Shortlisted indicators

Table A3

The shortlisted indicators for each goal. The number in parentheses after the indicator title is the number of votes the indicator received in the stakeholder questionnaire.

Goals	Shortlisted indicators	
1. Comfortable and healthy dwellings	1.1 Noise (9) 1.2 Natural light (7) 1.3 Thermal comfort (6)	1.4 Living space per person (4) 1.5 Accessibility for persons with reduced mobility (3) 1.6 View to outside (2)
2. Durable and adaptable buildings	2.1 Investments in maintenance, renovation or conversion (8) 2.2 Ease of refurbishing installations (7) 2.3 Structural adaptability (5)	2.4 Lifetime of appliances (4) 2.5 Service life of building (4) 2.6 Ease of changing the floor plan independently (2)
3. Buildings with low energy and material footprint	3.1 Energetic efficiency of buildings (9) 3.2 Share of renewable energy (9) 3.3 Grey energy (7)	3.4 Type of heating system in use (2) 3.5 Share of residential waste recycled (2) 3.6 Material use (non-recycled) in construction (0)
4. Buildings and neighborhoods in harmony with their physical surroundings	4.1 Construction considering the natural conditions of the site (6) 4.2 Percentage of green coverage (5) 4.3 Compactness (5)	4.4 Preservation of local ecosystems (5) 4.5 Natural water management (4) 4.6 Use of green roofs and walls (2)
5. Safe neighborhoods	5.1 Pedestrian and low speed limit zones (8) 5.2 Existence of risk maps (6) 5.3 Delinquent act density (6)	5.4 Burglary rate (3) 5.5 Properties at risk of flooding (3) 5.6 Percent of drivers exceeding the speed limit (3)
6. Participatory neighborhoods	6.1 Availability of community facilities (8) 6.2 Membership in community associations (6) 6.3 Existence of participatory budgeting (5)	6.4 Citizen participation meetings (4) 6.5 Number of people in volunteer work (3) 6.6 Activity factor of senior citizens (2)
7. Connected neighborhoods	7.1 Capacity of public transport system (9) 7.2 Soft mobility infrastructure (9) 7.3 Availability of shared vehicles (6)	7.4 Average commute time to work (3) 7.5 Proximity to commercial centers (2) 7.6 Transport energy consumption (1)
8. Convivial neighborhoods	8.1 Architecture encouraging social links (10) 8.2 Amount of public spaces (5) 8.3 Shared spaces (5)	8.4 Satisfaction with neighbor relationships (4) 8.5 Share of inhabitants feeling they can get help from others (4) 8.6 Existence of sharing programs (1)
9. Diverse neighborhoods	9.1 Age distribution of residents (10) 9.2 Share of residents receiving social benefits (7) 9.3 Ethnic diversity of residents (7)	9.4 Mix of sizes of dwellings in one building (3) 9.5 Commercial and office space per dwelling (3) 9.6 Outdoor quiet spaces (1)
10. Economically viable markets	10.1 Cost of maintenance and retrofitting (7) 10.2 Access to funding for investment (6) 10.3 Cost of land (5)	10.4 Regionally added value in construction (4) 10.5 Return on investment over life-cycle (4) 10.6 Jobs in building retrofitting (1)
11. Accessible and fair markets	11.1 Average rental price per m2 (9) 11.2 Subsidized housing ratio (6) 11.3 Households whose housing costs are more than 40% of income (6)	11.4 Number of years of salary required to purchase a home (4) 11.5 Tenure insecurity (2) 11.6 Mortgage interest rate (2)
12. Markets with adequate supply	12.1 Construction rate relative to population growth (7) 12.2 Vacancy rate (7) 12.3 Ratio of single and multifamily dwellings (6)	12.4 Available land for construction (3) 12.5 Investments in real estate development (2) 12.6 Housing designated for the elderly (1)
13. Cultural and aesthetic value	13.1 Preservation of local characteristics and identity (8) 13.2 Satisfaction with aesthetics of surroundings (6) 13.3 Satisfaction with landscape (5)	13.4 Satisfaction with aesthetics of dwelling (5) 13.5 Satisfaction with maintenance and cleanliness (3) 13.6 Protected buildings (2)

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.eiar.2022.106741>.

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