A real estate life cycle meta-instrument assessing and enabling sustainable decision-making and management for real estate owners and stakeholders

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Abstract: There is a need for real estate lifecycle instruments to address the new regulations. So far, no instrument includes all sustainability dimensions in all phases of real estate, due to the heterogeneity of the underlying data. In addition, the leverage of the digital transformation in the sustainability transition is yet to be addressed. The aim of this study is how a meta-instrument should be structured to overcome the existing contradictory challenges in sustainability and to enable sustainable decision-making and management for real estate owners. This study examines this question by applying the following methodological approach: 61 literature studies were reviewed, and concepts and systems were examined, which contain partial solutions at individual levels, be it for sustainability assessment, for the monetarization of sustainability aspects or for the maturity of technical systems. These instruments have their shortcomings as they only map individual aspects, but do not offer a comprehensive life cycle management solution for portfolio holders. Within the framework of this study, a new concept for a tool was developed, allowing to combine the various levels of real estate life cycle, sustainability, and digitalisation in a single holistic model. This multidimensional model was optimised using experts' opinions collected in 2 workshops. The first results reveal the applicability of the developed instrument but remains difficult to manage by potential users. The novelty of the approach comes from considering the entire life cycle, technical and management processes enabled by digitalisation.

1. Introduction

The real estate market is confronted with meeting new and more stringent environmental regulations to cope with the climate crisis towards which buildings contribute significantly [1, 2], [4-6]. Due to population growth, there is an increasing demand for sustainable new development projects but especially sustainable transformation of the existing building stock [3]. In recent years, there has been a steady increase in the integration of sustainability principles and the acceptance of green building activities in the real estate industry [7, 8]. Reasons for this are numerous and also lie in the progress towards environmental sustainability, e.g. with regard to circular economy [9]. However, cost savings or higher returns predominate in the literature as reasons why green building certifications and standards are chosen [10]. Yet the positive financial contribution of sustainable certified buildings or the risk of unsustainable assets is empirically proven [11]. There is a need for sustainability instruments to keep up with the new regulations, such as the EU Taxonomy and respond to the urgency of the sustainability transformation. In addition, the leverage of the digital transformation in the sustainability transition is yet to be addressed.

2. Sustainability Instruments and the Increased Sustainability Requirements

2.1. Market Trends and Current Situation in the Swiss Market

The real estate market is evolving beyond the original economic incentives [12, 13]. There is a thematic shift from a responsible approach to sustainability to impact-oriented investments [14-16]. Sustainability is not only seen as minimising risks, but as a (market) opportunity. Finally, the implementation of the EU Taxonomy is also giving this topic further impetus [17]. There are efforts by market participants to establish various sustainability-related instruments in the real estate sector. On the one hand, these are instruments that address only one specific sustainability topic, such as the Life Cycle Costing (LCC) tool of the International Facility Management Association, Switzerland Chapter or the CO2 balancing-benchmark of REIDA Real Estate Investment Data Association [22, 23]. On the other hand, there are labels such as the Swiss Sustainable Real Estate Index (SSREI), which is based on the Sustainable Construction Standards Switzerland (SNBS), German Sustainable Building Council (DGNB) standard in operation by Swiss Sustainable Building Council (SGNI), greenproperty by Crédit Suisse, SméO from the French-speaking part of Switzerland, which considers the entire lifecycle in assessing sustainability on the economic, ecological and social dimensions [24-29]. Traditional cost-saving goals are complemented by a growing interest in the potential of sustainable buildings to address wider environmental sustainability issues, as well as issues related to health and well-being [18]. New products such as WELL and The Living Building Challenge at the building level are an expression of this change [19, 20]. Nevertheless, the social dimension is not yet sufficiently considered. Although the negative economic impacts and environmental impacts of buildings have received much of the attention, this is not necessarily true for the social dimension [21]. So far, none of these instruments has been able to establish itself on the market. The identified reasons for the absence of widely applied instruments are manifold because of different dilemmas, which are presented in the following section.

2.2. The Emerging Sustainability Dilemmas not yet addressed by existing sustainability instruments

The sustainability transformation of real estate portfolios calls for strategic decision-making made by the owner, the investor or the facility manager confronted with situations in which difficult choices need to be made between conflicting requirements. Therefore, the literature review in this study aimed at shedding light into the main sustainability dilemmas, the real estate portfolio manager is confronted with.

2.2.1. Financial Returns versus Environmental Gains versus Social Benefits. One main challenge is that portfolio managers make decisions primarily based on capital expenditures (CAPEX), with a focus on design and construction costs [30] rather than operational expenses (OPEX). One of the main reasons is the lack of long-term lifecycle perspective, either because of speculative development and the intention to sell or due to the lack of expertise or lifecycle data to conduct the financial modelling. However, research shows that from a financial perspective, sustainability requires higher capital investments which payoff over the life cycle as proven by life cycle costing analysis [31, 32, 33]. The review of existing sustainability certifications schemes and instruments shows that they predominantly consider environmental and economic aspects, while social aspects of sustainability are overlooked [22–29, 36]. One reason is the challenge to quantify the social benefits and include it in real estate valuation models. The transition to sustainable real estate portfolios can only be achieved when all stakeholders' views are being considered. However, sometimes the shareholders, namely the owners, the investors or asset managers views conflicts with the stakeholders' view – tenants, end-users, local and neighbourhood community. Literature studies show that the stakeholder feedback is only considered in the participatory design and construction process and unless they are required by law and regulations, but rarely does their opinion count during the operation of the buildings [34, 35]. For unbiased and sustainable investment decisions, the direct and indirect benefit value in the various impact dimensions socio-cultural, ecological, functional, and technical must also be considered in financial form.

2.2.2. Focus on the Construction Phase versus the Lifecycle of Real Estate. Most sustainability instruments focus on the development and construction phase of new buildings [22–29]. One reason is the lack of data for existing buildings in comparison to new development projects. However, most of the building stock already exists. There is an obvious need for a focus on the use phase and the integration of all phases in a holistic real estate life cycle-view for instruments.

2.2.3. Heterogeneity of data. Finding instruments outside of one's own project system boundary seems to be possible only to a limited extent: due to building typology and use, e.g., industrial buildings, residential buildings, etc., the data collected is limited or not comparable from the outset. One consequence is that real estate and portfolio owners and operators use very different sustainability instruments in Switzerland. Another consequence is that there are very large differences in practice regarding the (maturity) level of the underlying data, even when it concerns the same topic. There is not one recognised central and (label-)neutral overview on real estate data, and thus there is little or no further development and elaboration of key figures and evaluations.

3. Increasing sustainability market transparency with digitalisation

Digitalization can advance the integration of sustainability goals in the decision-making frameworks by providing valuable data to increase the transparency into the sustainability performance of real estate portfolios. The following emerging technologies have been reviewed and classified based on their application:

Table 1. Reviewed Technologies.

Technologies Classification	Names	Sources
Sustainability Data Creation	Laser Scanning, Photogrammetry, Scan2BIM, As Designed BIM, As Built BIM, IoT Live Data, GIS	[57] [58]
Sustainability Data Integration	CDE (CAFM, SAP etc.)	[59] [60]
Sustainability Data Analysis and Simulations	AI Machine Learning Algorithms	
Data Visualisation and Interaction	Virtual Reality, Augmented Reality, Extended Reality	[61]

4. Research Gap and Research Question

Even though there are various instruments to assess the sustainability of built assets, there is no holistic instrument for real estate portfolios which considers the following: 1) all dimension of sustainability including economic, ecological and social aspects; 2) the life cycle perspective including all phases of real estate; and 3) the heterogeneity of the real estate markets, building typologies and usages thus the underlying data. There is currently no holistic, widely accepted, and easy-to-use instrument for assessing the sustainability of buildings that is applicable to real estate portfolios and structurally aligned with Swiss or European sustainability standards. The main research question addressed by the study is how an instrument should be structured to overcome the above-described challenges in sustainability and to enable sustainable decision-making and management for real estate owners and stakeholders by the usage of digitalisation.

5. Material and Methods

5.1. Overall Methodical Approach

The methodological procedure developed moves beyond the conventional research methods. The criteria behind selecting the research tools was the potential to generate an innovative solution, namely a Real Estate Life Cycle Meta Instrument. Therefore, to achieve the research objective of the study, the mixed research methods employed to drive innovation is a combination of Design Thinking (DT), and Action Research (AR) approaches. To assure the validity of the methodological procedure, classical qualitative methods are integrated in each phase of the development of the instrument, e.g., literature review and focus group.

5.2. Definition of the Design Thinking and Action Research Approach

The Action Research method, coined by Kurt Lewin consists of repeated cycles of planning, action, observation and results which drove the development of the real estate life cycle instrument [37]. The method was based on research and action. In addition, the DT method was applied to use the creative process of design as a problem-solving method which can enable innovation. DT method was developed by the company IDEO founders Tim Brown and Barry Katz [38]. Later, the organisations IDEO, IDE, Heifer International and ICRW have developed Human-Centered Design (HCD) toolkit [39]. Both approaches have three main considerations: desirability – what society needs; viability which refers to the financial sustainability and feasibility – stakeholders views, technical considerations and organizational structure. To facilitate the innovation process, Brown defined three main stages: (1) inspirational space to identify problems and market opportunities; (2) ideation spaces to generate ideas through prototyping and (3) the implementation space.

5.3. Developed and Applied Research Design

To achieve the research objective, a methodological procedure was developed based on the considerations and steps outlined above, as described in the table below. It consists of three main phases: (1) Identifying real estate sustainability challenges and market opportunities; (2) The ideation phase for the development of the real estate life cycle meta instrument; (3) Validation and Implementation.

In a first phase, the methodological approach aimed to gain insight into the market needs by identifying the real estate sustainability challenges and opportunities. Based on the literature review synthesis and the market studies, a preliminary version of the “Real Estate Lifecycle Meta Benchmark” was proposed [41]. The result of this phase was the definition and validation of the feasibility study requirements; the market needs for a now-called Real Estate Life Cycle Meta Instrument.

The second phase of the study centers around the development of the framework. In the exploration stage, evidence is being assembled through an extensive literature review. It consists of bibliometric record analysis on sustainable building assessment methods, life cycle costing and assessment, and digital technologies for sustainability. The review helped clarifying the scope and dimensions of the Life Cycle Meta-Instrument based on the dilemmas identified (see section 2.2.). In the next stage, the market gap has been clarified and derived from various informal discussions with industry stakeholders, authors experience, screening and attendance of Swiss industry events i.e. Swissbau, REIDA [40, 23]. When selecting the experts, care was taken to ensure that, firstly, they have a wide range of technical expertise and, secondly, that this technical expertise complements each other. This ensured that the responses also took place over a wide bandwidth. In parallel, a focus group was included. The aim of this workshop series is the validation of the conceptual analyses of the requirements for an instrument design that generates a high level of utility for the user. The stakeholder views included in the focus group has expertise in portfolio, sustainability and real estate and facility management. The feedback was used to further specify the requirements for the applicability of the developed instrument.

The first two phases (1-2) are completed, the last stage of the research (3) is ongoing at the time of the paper submission. Then a second round of interviews is planned and is intended to provide in-depth thematic feedback on the various special topics of sustainability and digital technologies. A further focus group workshop is planned to validate the results.

Table 2. Development of the "Real Estate Life Cycle Meta Instrument".

Phases	Stages	Objectives
(1) Identifying real estate sustainability challenges and market opportunities	Strategic Definition of the Feasibility Study	• Formulating the feasibility study requirements • Identifying the industry main challenge, research gap, market potential
	Feasibility Study Consolidation and Validation	• Internal Research and Development: Organisation's department of the authors, Institutional, Research Competence Group • Industry Research
(2) The ideation phase for the development of the real estate life cycle meta instrument	Analysis and Exploration	• Conducting a Literature Review to identify the Status Quo, market challenges, sustainability dilemmas and business needs (61 studies reviewed) • Assessing the need for Case Studies
	Synthesis	• Literature Review Synthesis • Organisation and selection of themes and codes
	Preliminary Design of the framework	• Brainstorming workshops to define the three axes of the cube (see section 5 Key Findings)
	Major Iteration	• Iteration based on feedback from various experts and literature
	Design and Continuous Iterations	• Defining the model • Feedback loops for refinement
(3) Validation and Implementation	Industry Validation	• Testing in a Pilot Project • 2 workshops with 3 external experts • Analysis of material produced by participants
	Final Proposal for the Instrument	• Integrating the industry feedback into the final proposal of the Real Estate Life Cycle Meta Instrument
	Evaluation	• Evaluation of the Real Estate Life Cycle Meta Instrument

6. Key Findings

6.1. Requirements for and Framework of a future Real Estate Life Cycle Meta-Instrument

The dilemmas in sustainability of real estate are manifold. However, the stated above dilemmas give insight into how a sustainability instrument should be designed so that sustainability is considered holistically in all phases of real estate. For this it is necessary to consider: (1) all phases of the real estate life cycle; (2) all dimensions of sustainability; (3) digitalisation enabling to collect data not only once, but on an ongoing basis and to overcome data silos. Therefore, a useful measure could be the introduction of a strategic decision-making, management and monitoring instrument for real estate owners and their stakeholders to determine how far sustainability has progressed in their portfolio. This real estate life cycle meta instrument for real estate makes it possible to assess today's key sustainability issues (compare Sustainable Development Goals SDGs, EU Taxonomy, etc.) and their implementation not only from "outside" and via the real estate as a built and designed product [43, 44]. This instrument enables assessing, decision-making and management for real estate owners and stakeholders also from "inside" in terms of the maturity of strategic, methodological and prospective planning implementation at the technical level of digitalization as well as at the level of the associated management processes, and this with a view to all phases of the real estate life cycle.

On the conceptual level, many cross-references become apparent within the topics, so that a matrix-like representation could be appropriate. Furthermore, a good form of visualization is crucial to make complex relationships comprehensible and easy to use, especially for none of the matter-experts. For these reasons, a cube was developed as a form of representation to be able to adequately show and visualize the interrelationships of the three axes “Sustainability Topics”, “Digital Maturity” and “Life Cycle Phases” of the real estate. The embedded flexibility of the visualization framework allows for further development. The cube serves portfolio owners as an orientation as to where the portfolio stands in terms of sustainability in the first place [42]. By visualizing sustainability as a cube, non-experts can easily understand whether sustainability has been addressed at all or which aspects of sustainability have been considered. If sustainability were considered 100 percent in the life cycle of the real estate, the cube would be fully colored (see Figure 1.).

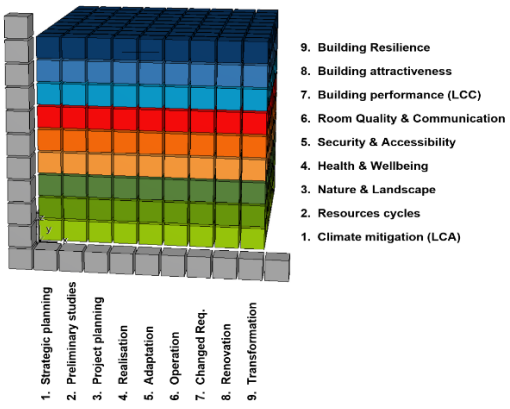

Figure 1. X-Axis: Real Estate Life Cycle Phases; Z-Axis: Management of Sustainability Topics.

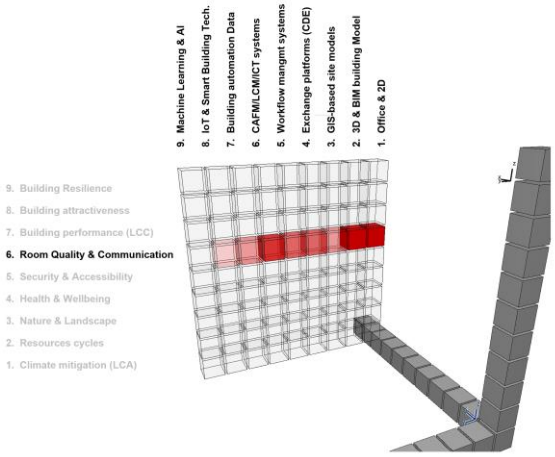

Figure 2. Y-Axis: Digital Maturity: Transparency to visualize levels of maturity using technologies.

It becomes easier to understand which aspects have not been considered or which gaps need to be closed. This would be evident from the non-coloured meaning transparent areas in the cube. If not, only the knowledge is available whether sustainability has been considered, but also backed up with data, this data can also be displayed. Based on the axis "Digital Maturity", it can be shown not only that data is available, but according to which maturity level the data is available in the status quo up to real-time collection. This would be evident by the strength of the coloured areas in the cube (see Figure 2).

6.2. The three Axes of the Real Estate Life Cycle Meta-Instrument

6.2.1. Axes 1: The Real Estate Life Cycle Phases. The investigations have shown that the following structuring is suitable at the level of the phase consideration. Phases 1-4 of the new developed model correlates with the content definitions of the Swiss Engineering and Architects SIA-phases 1 to 5 [45], although certain SIA-phases (Project planning and submission) were combined. The phase definitions 5 to 9 are the result of literature research and are based on possible interventions where measures can be taken [46-50]. The points in time when measures are triggered can differ greatly in the life cycle or never occur at all. The phases are: (1) Needs Definition, Repositioning and Strategic Planning; (2) Preliminary studies, Simulations; (3) Project Planning, Submissions; (4) Realisation; (5) Adaptation to Use and Operation; (6) Operation, Operation Optimisation; (7) Adjustments to changed Requirements from Use or Operation; (8) Renovation and Modernisation Measures; and (9) Transformation measures regarding Conversion, Expansion, Re-Use, Recycling.

6.2.2. Axes 2: The Management of Sustainability Topics. The sustainability topics of the developed instrument are based in a simplified form on the structure of an already existing instrument assesses the

sustainability of existing portfolios [51]. This allows the most important topics relating to the sustainability management of real estate to be presented in a compact form. Topics (1) Climate Protection and Energy: life cycle assessment, CO2, climate protection roadmap 2050, energy and mobility management; (2) Resources Cycles: 2a: Sustainable Procurement Management inclusive environmental Protection, hazardous Substance and 2b: Recyclables Management; and (3) Nature and Landscape: Water Management & Green Spaces & Biodiversity Management address ecological aspects of resource management. Topics (4) Health and Wellbeing: Interior Comfort Management; (5) Security and Accessibility: Design4All management; and (6) Room Quality and Communication: Management Quality of Stay-In and around the building cover socio-cultural and functional aspects. The topics (6) Building Performance: Management Influencing Factors Operating and Life Cycle Costs (LCC) and Management of the structural and technical Condition / Maintenance of Substance / Functionality; (7) Building Attractiveness: Management and Optimization of Usability and Space Efficiency and Management of identity-forming Values; (8) Building Resilience: Temperature and extreme Weather Resilience address value-relevant economic aspects. The six environmental goals of the EU taxonomy are also directly covered: climate protection (1), climate adaptation (9), water resources (3), circular economy (2a), environmental protection (2b) and biodiversity (3). This list of topics considers practically all instruments and their main topics that are used in Switzerland for the holistic assessment of the sustainability of real estate. These are SNBS, DGNB, SméO, LEED, BREEAM, and MINERGIE ECO [24-29, 52-54].

6.2.3. Axes 3: The Digital Topics. In addition to the lifecycle axis and the axis with the sustainability topics, there is also a third axis in the developed instrument for the digital support technologies used. Based on studies which show how digitalization can enable the sustainability transformation [55, 56], the use of these technologies is classified into (1) Use of alphanumeric description of object properties (texts, excels, etc.) and drawings (two-dimensional Computer Aided Designs 2D-CAD) for the building documentation; (2) Use of 3D CAD models (animations) and Building Information Modeling BIM models (Digital twin based on BIM standards); (3) Use of Geo Information Systems GIS-based site models (GeoBIM integration); (4) Use of project/object-related data exchange platforms (Common Desktop Environment CDE); (5) Use of integrated workflow management systems; (6) Use of Computer Aided Facilities Management CAFM systems for building management (basic modules); Integrated Life Cycle Management LCM of building portfolios (cross-phase planning) Integrated ICT landscape (connection CAFM with Enterprise Resource Planning ERP, etc.); (7) Use of building automation data for sustainability management; (8) Use of Internet of Things IoT and smart building technologies (real-time management), Artificial Reality AR-supported processes and use of new technologies; and (9) Use of Machine Learning & Artificial Intelligence on a technical or management level (see Figure 3).

The digital maturity axis in relation to sustainability topics and life cycle management is based on three main dimensions: (1) The degree of technology adoption is assessing the maturity level of integrating in the portfolio management the emerging technologies; (2) The degree of technology integration measures the real estate organization ability to connect different technologies, and fragmented data sets; and (3) The degree of data analysis capabilities assesses the ability to transform data into information and knowledge to conduct advanced sustainability simulations needed for lifecycle management across different scales from asset to portfolio and neighborhood.

6.3. Practical explanation based on an example case

An application example is shown below:

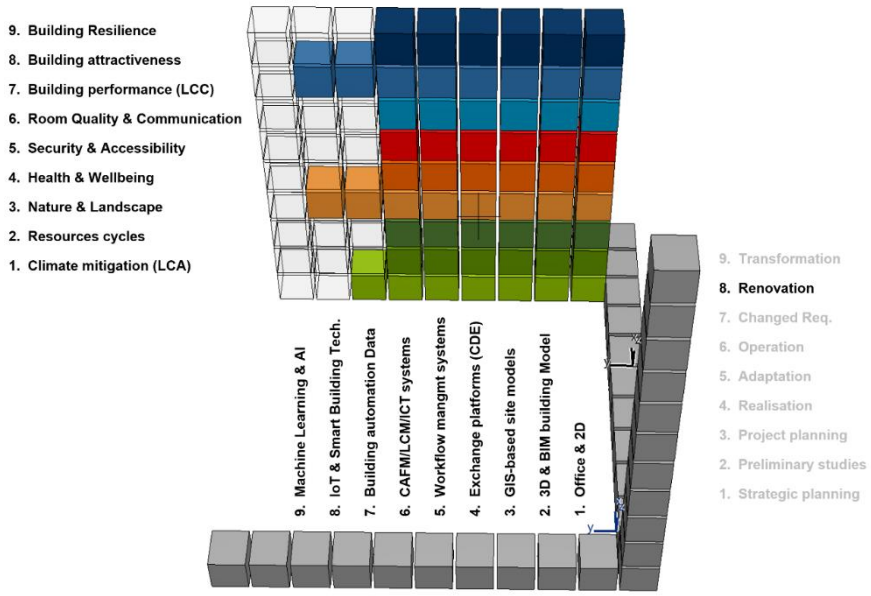

Figure 3. Y-Axis: Digitalisation Topics. Depicted by a pilot project managed with a CAFM system in the Phase of renovation.

The first application results show that the developed instrument is basically applicable but remains difficult to handle and interpret for potential users. As a conclusion, the instrument was therefore revised in the direction of a toolbox. For each of the nine essential use cases in the real estate lifecycle, a matrix is created where aspects of sustainability management are linked with the information levels from the technical systems. In the next step, the basic structure of the tool is to be used to optimise performance at the level of sustainability and digitally managed information management in a network and over the entire life cycle. This should ultimately lead to a significantly improved cost-benefit ratio for the human, time and technical resources used via holistic and integral knowledge management in the holistic, long-term and sustainable life cycle management of real estate.

7. Discussion

Rather than developing yet another instrument or methodology for assessing real estate sustainability, the authors' overall goal is to provide guidance on the real estate sustainability universe for owners and stakeholders. Real estate owners and their stakeholders are aware of the importance of sustainability in real estate. However, the knowledge of how to meaningfully assess sustainability in real estate and in portfolios is mostly held by a few experts. This is what the cube is designed for to solve. However, for this meta-instrument to retain its raison d'être, it is elementary that the sustainability topics presented include the relevant and current sustainability topics recognized in the market and by research. Thus, the sustainability topics presented above, such as "building attractiveness", should be understood as a suggestion. This implies a constant update of the sustainability cube. However, the goal is not to show how sustainability is evaluated, but whether sustainability issues are considered at all in the management of real estate and their portfolios. To check the sustainability topics for their timeliness and relevance, a pre-complied audit grid for the sustainability topics and the indicators assigned to the sustainability topics could be helpful. Furthermore, the heterogeneous data situation would be a particular challenge and apparently also the reason why, at least on the Swiss market, no generally valid and recognized instrument for measuring sustainability in real estate and portfolios for owners and their stakeholders has yet become established. In order to enable a structured and measurable, i.e. sustainable portfolio management in practice, it is necessary to systematically evaluate and analyse the heterogeneous landscape of data sources, databases and software solutions with regard to their informative value, relevance, timeliness, completeness and data quality. The developed instrument makes this possible in a clear manner by systematically linking sustainability topics to the maturity level of the underlying data.

Furthermore, the cube offers the assessment of sustainability not only in a specific phase but could represent it over the entire life cycle of real estate and thus portfolios.

8. Conclusion

Real estate contributes significantly to the negative environmental impact. Consequently, there are numerous instruments for assessing the sustainability of real estate. However, no generally valid instrument has yet become established on the (Swiss) market. The reasons for this are numerous. The authors believe that a sustainability tool that would be universally accepted by research and market participants should be able to solve several dilemmas: First, all life cycle phase should be considered. Second, all dimensions of sustainability should be addressed. Third, digitization should be integrated with sustainability in such a way that all three levels are guaranteed, from orientation for non-experts to information on the maturity level of sustainability. The real estate life cycle meta-instrument presented here enables assessing, decision-making and management for real estate owners and stakeholders from "inside" in terms of the maturity of strategic, methodological and prospective planning implementation at the technical level of digitalisation as well as at the level of the associated management processes, and this with a view to all phases of the real estate life cycle. However, there is a need for further development.

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