Comparative Rich-Picture-Diagram for Assessment of Building Sustainability Labels

Sasha Nikolaus CISAR[a], Guillaume HABERT[b]

[a] *Chair of Sustainable Construction, ETH Zürich, Switzerland, cisar@ibi.baug.ethz.ch*
[b] *Chair of Sustainable Construction, ETH Zürich, Switzerland, habert@ibi.baug.ethz.ch*

ABSTRACT

This paper's goal is a framework for a comparative depiction of sustainability labels for buildings and other scales. Applying the method of a Comparative Rich-Picture-Diagram (cRPD) allows a multi-scalar and multi-objective analyse of building standards and labels for sustainable construction. This paper presents a two-step part of the method to display the structure of the label, weighting of indicators and translation into a multi-dimensional feature space. It entails the visualisation of the dimensions or pillars of sustainability (society, economy, environment), space (components, integrated systems or building, neighbourhood) and time (phases). The method is exemplified with the Standard Sustainable Construction Switzerland (SNBS) to display and evaluate the functioning of the label. The paper concludes the weighting of indicators show a diverging picture and thus allows to identify hidden drivers and barriers for sustainable construction.

Keywords: *policy and regulation, sustainability labels, sustainable construction*

1. INTRODUCTION

The aim of this paper is to present a theoretical framework for analysis and comparison of sustainability building labels applying the method Comparative Rich-Picture-Diagram (cRPD). Typically these labels, certifications or tools assess the environmental impact and overall sustainability and are sometimes referred to Green Buildings. Due to the complexity of the subject, the authors utilise the term labels to enable a comparison of on the scale of both buildings and neighbourhoods.

The UNEP (2011) states the development of the 20th Century poses a "significant progress of civilisation", which was accompanied by an enormous demand of resources including for the construction sector. The environmental impact of said economic activity has left its marks. The IPCC (2013) showed the impact of anthropogenic CO2-emissions as a main driver of Climate Change. Resource scarcity and Climate Change are accordingly two of the major societal challenges according to both UNEP and IPCC. They identify the construction sector and the increased construction activity as a main driver of the environmental impact. According to UNEP the above progress is accompanied by an unprecedented and ongoing urbanisation. To cope with the development of the increased construction activity results extensive demand of construction materials. The Global Alliance for Buildings and Construction (2016) concludes that "the global building sector consumed (…) over 30% of total final energy consumption", "buildings also accounted for half of the global electricity demand" and "the building sector therefore represents roughly 20% of global-related CO_2 emissions". Considering indirect and direct emissions "buildings and construction represent nearly 40% of energy-related CO_2 emissions.

To tackle the responsibility of the building sector towards the environmental degradation Herazo et al. (2015) and Perez-Lombard et al. (2009) describe the emergence of Green Building labels from 1990's onwards which introduced an assessment of green or environmental performance of buildings Two recognized examples include the Building Research Establishment's Environmental Assessment Method (BREEAM) from the UK and the Leadership in Energy and Environmental Design (LEED) from the U.S.A. Although a second generation of building labels move towards a more holistic approach concluding societal, economic and life-cycle aspects according to Markelj et al. (2013) and Herazo et al. (2015), LEED remains the most popular certification for buildings.

In Switzerland building labels have developed also according to the societal challenges. Similarly, to first generation labels, only covering energy aspects, then including environmental and then second generation aiming for more holistic approaches. The Minergie-Label exemplifies this development. The initial focus was on the criteria of energy efficiency. Later criteria comfort, indoor air quality, material availability and embodied energy were included for the further development into Minergie-Eco. Further consideration of the criteria thermal comfort and energy consumption in the use phase lead to the development of Minergie-P. To conclude the Minergie-A implemented a holistic approach towards assessing and labelling sustainability for buildings. A different example in Switzerland is the 2000-Watt-1t-CO2-society that combines the criteria life-cycle, use and mobility towards a normative goal of sustainability. Aside of assessing buildings it includes a label for districts. Furthermore, the Swiss government responded to the challenges with introducing the Energy-Strategy 2050 to increase energy efficiency and later a Strategy for Sustainable Development. Sustainability and sustainable development is cited in the constitution to seeks a „balanced relationship between nature, its capacity for renewal and supply for human demand", the implementation of said strategies is aimed for at federal and state levels. The Swiss Network Sustainable Construction (NNBS) initiated by the Swiss Federal Office of Energy explicitly builds upon the federal Strategy of Sustainable Development. The strategy identifies construction as a key component for the scale of buildings and sustainable neighbourhood and district development. The three pillars of sustainability, society, environment and economy should find application and certification in sustainable construction through the newly founded "Standard Sustainable Construction Switzerland (SNBS)". This building label integrates the existing Minergie labels in Switzerland, attempting to "close existing gaps and thus connect the three pillars of sustainability through a number of different criteria". Consequently this paper focuses on SNBS to exemplify and visualise the suggested cPRDframework.

1.1 Are building standards and labels expedient?

The societal challenges pose clear demands for sustainable construction and thus exists a need for building standards and label. However, are the so called "eco-label" or "green building label" really "green"? Or put differently, are the building standards and labels expedient for sustainable construction? The efficiency of the building standards and labels is unclear considering the goals of sustainable construction. The federal office for energy (BFE) conducted a study on the success monitoring of the label "Minergie" and showed that "planned values are only in part congruent with energy consumption values in use phase". This leads to the question how building standards and labels function.

1.2 Functioning and structure of building standards and labels

Building standards and labels are typically difficult to understand and complex structured. In literature different studies on building standards and labels focus solely on comparing the qualitative difference regarding the structure and aim. Sutrisna et al. (2007) have applied the "Rich Picture Diagram (RPD)" to model and visualise the complex interactions and procedures between different stakeholders in construction processes. This paper expands their approach to building standards and label that match the complexity of the statement of a problem to construction projects. It should facilitate the application of building standards, the communication thereof and reveal hidden drivers and potential barriers.

In literature only few studies suggest a common framework on the comparison of building standards and labels. This paper builds on the work of Wallhagen et al. (2012) who propose a generic framework with an underlying graphic method to display the hierarchical structure of building standards and labels.

2. APPROACH

2.1 Focus on SNBS

The approach of the proposed framework of a "comparative rich-picture for sustainability label and building standards" is introduced and exemplified in this paper with SNBS. The NNBS promotes the SNBS and establish as building standard. The SNBS states to equally weigh the three pillars of sustainability. The structure of SNBS is the following: The three pillars of sustainability are represented as the three "themes" society, economy and environment. The themes are divided into different categories, which contain each a number of criteria and finally indicators. During writing of this paper SNBS version 1.5 (office) was considered that contains 3 themes, 12 categories, 25 criteria and 76 indicators. On 24 August 2016 the SNBS version 2.0 was introduced that drastically reduced the amount of indicators and thus was also considered as a way to communicate the differences. SNBS 2.0 contains 3 themes, 12 categories, 24 criteria and 45 indicators.

2.2 Comparative rich picture diagram

This paper applies the RPD suggested by Sutrisna et al. to display building standards and label similarly to construction projects. The modelling and display of the hierarchical structure of building standards is applied from Wallhagen et al.. A further steps extends the analytical modelling expanded to a multi-dimensional feature-space which should enable to reveal the hidden drivers and potential barriers in building standards and labels. Therefore, it allows a comparative aanylsis of different labels revealing the structure and function. The approach of the adapted comparative Rich-Picture Diagram (cRPD) framework is divided in to several iterative steps: Structural display, weighting, translation into the feature-space.

The structure the themes, categories, criteria and indicators of the SNBS are summarised and displayed. The individual components build on each other and are brought together in the three themes of sustainability.The assessment of the SNSB calculates the weighting of indicators. The SNBS is equally divided into three themes. These are then divided by the amount of categories, criteria and indicators. This reveals the resulting weighting of individual indicators and their percentage on the entire building standard.The last step translates the individual components of the building standard into a three-dimensional feature-space. The three considered dimensions or features are sustainability, space and time. The sustainability feature has three magnitudes society, economy and environment. The magnitudes of the spatial feature has the magnitudes building components, integrated systems or buildings and neighbourhood. The temporal feature has the magnitudes of phases from planning, construction and use.

3. RESULTS

3.1 Weighing of Indicators

The results of the first two steps, structure and weighting of SNBS, show that the three themes society, economy and environment are equally weighted (Figure 1). The 3 themes are equally divided into 4 categories. The 25 criteria however are not equally distributed to the four categories. Furthermore, the 76 indicators are also unequally distributed to the 25 criteria. The initial 100%, which are divided equally at 33% to the three themes result in a range of 0.24% - 8.33% for individual indicators.

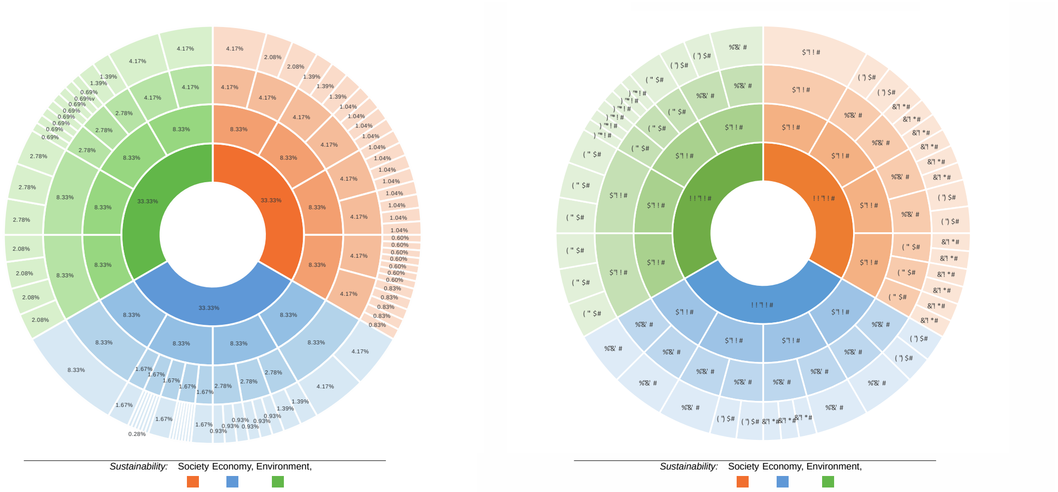

Figure 1: Structure of the label SNBS – Standard Sustainable Construction Switzerland. The innermost circle represents the themes (society = orange, economy = blue, environment = green) respectively the pillars of sustainability, then the categories and outside the indicators. The next circle are the categories, followed by the amount of criteria which are unequally distributed. The outermost circle are the indicators and their weighting in percentage. Left SNBS 1.5 with 76 indicators and right SNBS 2.0 with 45 indicators.

The indicators can be ranked according to their percentage. It displays which indicators have the largest influence on the assessment (Figure 2). The initial distribution on the themes society, economy and environment shift their relevance. The indicators of the theme economy receive the most weight with the largest weighted indicators. The theme economy is then followed by environment. The theme society falls to the third place with the most indicators weighted the smallest.

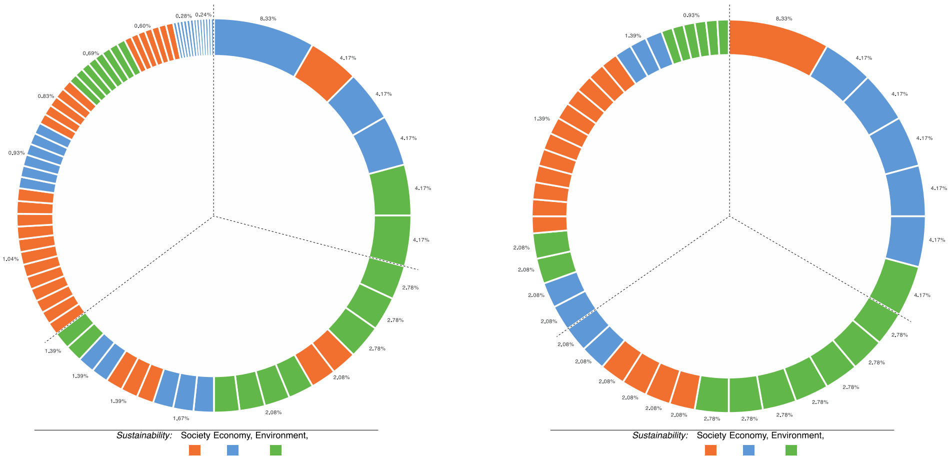

Figure 2: Structure of the label SNBS – Standard Sustainable Construction Switzerland displays the ranked indicators (society = orange, economy = blue, environment = green). Left SNBS 1.5, right SNBS 2.0. The indicators were ranked according to their percentage. The five most important indicators for SNBS 1.5 are the regional economic potential (8.33%), urban and architectural themes, life-cycle costs, total costs, use concept, flora and fauna (each 4.17%). The five most important indicators for SNBS 2.0 are the aims and functional description (8.33%), building materials and building substance, decision making, rent and retail price, demand and available uses (each 4.17%).

3.2 Positioning of indicators in a three-dimensional feature-space

The indicators are translated to their respective dimensions in to a three-dimensional feature-space. The result shows (Figure 3) that the themes society, economy and environment differ and are located in different dimensions or features.

The theme society is the first of the feature sustainability. The largest percentage of indicators of the theme society is located in the feature time during the phase of planning and during the feature space on the scale of the building. We could interpret that the societal focus of the indicators is on the user perspective.

The theme economy is the second magnitude of the feature sustainability. The largest percentage of indicators of the theme economy is located in the feature time during the phase of planning and in the feature space on the scale of the neighbourhood – meaning on a higher level. We could interpret that the economical focus displays the investor perspective.

The theme environment is the third magnitude of the feature sustainability. The largest percentage of indicators of the theme environment is located in the feature time during the phase of use and in the feature space divided between the scale of the neighbourhood and components. We could interpret that the environmental focus displays the embodied energy of construction materials.

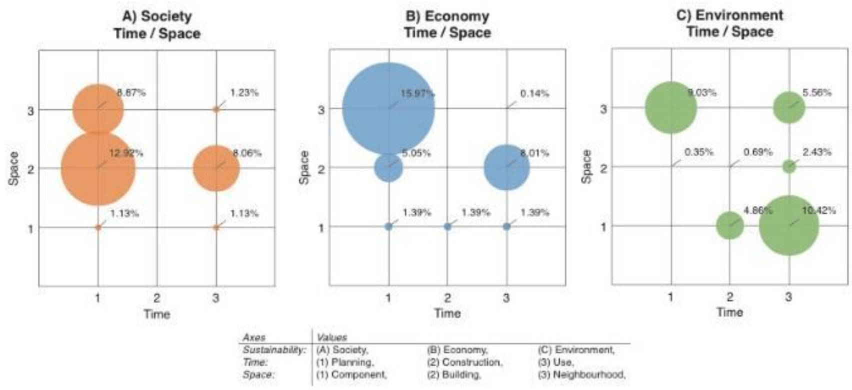

Figure 3: Translation of the indicators into the three-dimensional feature-space. Represented here are the temporal and spatial features regarding the magnitudes of sustainability (society, economy and environment). The size of the circle indicates the amount of indicators at each node.

This displays the focus of individual and potentially conflicting themes of sustainability. Furthermore, it reveals possible gaps and missing indicators. The theme society shows a balance between the planning and use phase.

Accordingly, user and comfort are important indicators. At the same time there is no indicator that covers the construction phase. The theme economy reveals that the focus of a higher level can be attributed to the investor and developer rather than the user of a building. The theme environment shows the opposite where the use phase is the main focus, which means which construction materials are planned and how they are implemented.

4. CONCLUSION

The aim of this paper is to present a cRPD framework that enables better understanding of function and comparison of building sustainability.

This is exemplified by the application of the framework on SNBS to display the label's function and weighting of individual indicators. The results show that the intended equality of the sustainability dimensions in SNBS collide with the unequal weighting of individual indicators. This allows the identification of hidden drivers which for SNBS results in a ranking of the sustainability dimensions according to importance, first economy, second environment and third society. Related to the sustainability dimensions, the feature-space displays drivers also related to temporal and spatial dimensions. For SNBS the societal focus is on the user perspective, the economical perspective is on the investor perspective and the environmental focus displays the embodied energy of construction materials. This clearly indicates diverging and possibly conflicting interests.

The proposed cRPD framework creates the possibility to reveal and discuss openly the potentially conflicting indicators and associated interests. The diverging interests of individual stakeholders from the planning process can be displayed to create a platform for their negotiation. Because the presumptive common goal amongst the stakeholders is sustainable construction. Lastly it would enable to include and consult missing stakeholders and integrate their interests in critical situations. The authors hope for a discussion on sustainable construction and how this is achieved by means of building standards and labels.

REFERENCES

[1] United Nations Environment Programme UNEP, 2009: „Buildings and climate change. Summary for Decision Makers“, Sustainable Buildings and Climate Initiative, UNEP-SBCI, Paris.
[2] Intergovernmental Panel on Climate Change IPCC, 2014: „Climate change 2014: Synthesis Report“, IPCC, Geneva.
[3] Global Alliance for Buildings and Construction GABC, 2016: "Global Status Report, Towards Zero-Emission Efficient and Resilient Buildings", GABC, Paris.
[4] Herazo, B., Lizarralde, G., 2015: "The Influence of green building certifications in collaboration and innovation processes", Construction Management and Economics, 33/4, pp. 279-298.
[5] Pérez-Lombard, L., Ortiz, J., Gonzáles, R. and Maestre, I. R., 2009: "A revuew of benchmarking, rating and labelling concepts within the framework of building energy certification schemes", Energy and Buildings, 41/3, pp. 272-278.
[6] BREAM. [online]. Retrieved from: http://www.breeam.com/communities [Retrieved on 10 August 2016].
[7] LEED. [online]. Retrieved from: http://ch.usgbc.org/articles/getting-know-leed-neighborhood-development [Retrieved on 10 August 2016].
[8] Markelj, J., Kuzman, M. K. and Zbašnik-Senegačnik, M., 2013: "A review of building sustainability assessment methods", Arhitektura Raziskave, 1, pp. 22-31.
[9] Herazo, B., Lizarralde, G., 2015: "The Influence of green building certifications in collaboration and innovation processes", Construction Management and Economics, 33/4, pp. 279-298.
[10] Minergie. [online]. Retrieved from: http://www.minergie.ch/baustandards.html.
[11] 2000-W-Gesellschaft. [online]. Retrieved from: http://www.2000watt.ch/die-2000-watt-gesellschaft/ [Retrieved on 1 August 2016].
[12] Bundesamt für Energie BFE, 2016: „Energie Strategie 2050“. [online]. Retrieved from: http://www.bfe.admin.ch/energiestrategie2050/index.html?lang=de [Retrieved on 10 January 2017].
[13] Bundesamt für Raumentwicklung ARE, 2016: „Strategie Nachhaltige Entwicklung“. [online]. Retrieved from: http://www.are.admin.ch/themen/nachhaltig/00262/00528/index.html?lang=de [Retrieved on 15 August 2016].
[14] Bundesverfassung der Schweizerischen Eidgenossenschaft, P 1, Art. 2, Ziffer 2. [online]. Retrieved from: https://www.admin.ch/opc/de/classified-compilation/19995395/index.html#a2 [Retrieved on 10 January 2017].

[15] SNBS. [online] Retrieved from: http://www.nnbs.ch/nachhaltiges-bauen/ [Retrieved on 1 August 2016].

[16] Bundesamt für Energie, 2016: „Erfolgskontrolle Gebäudeenergiestandards 2014-2015 Schlussbericht". [online] Retrieved from: http://www.bfe.admin.ch/energie/00588/00589/00644/index.html?lang=de&msg-id=61121 [Retrieved on 1 September 2016].

[17] Ameen, R. F. M., Mourshed, M., Li, H.; „A Critical Review Of Environmental Assessment Tools For Sustainable Urban Design", Environmental Impact Assessment Review, 55, pp. 110-125.

[18] Drupp, A. M., 2010: „Does the Gold Standard Label Hold Its Promise In Delivering Higher Sustainable Development Benefits? A Multi-Criteria Comparison Of CDM Projects", Energy Policy, 39/3, pp. 1213-1227.

[19] Happio, A., Viitaniemi, P. A, 2008: „Critical Review of Building Environmental Assessment Tools", Environmental Impact Assessment, 28, pp. 469-482.

[20] Cole, R.J., 1999: „Building Environmental assessment methods: Clarifying Intentions", Building Research & Information, 27, pp. 230-246.

[21] Todd, J.A., Crawley, D., Geissler, S., 2001: „Lindsey, G. Comparative assessment of environmental performance tools and the role of the Green Building Challenge", Building Research & Information, 29, pp. 324-335.

[22] Sutrisna, M., Barrett, P., 2007: „Applying rich picture diagrams to model case studies of construction projects", Engineering Construction & Architectural Management 14/2, pp.164-179.

[23] Giesekam, J., Barret, J. R., Taylor, P., 2015: „Construction Sector Views on Low Carbon Building Materials", Building Research & Information, 44/4, pp. 1-22.

[24] Wallhagen, M., Glaumann, M., Eriksson, O., Westerberg, U., 2013: „Framework for Detailed Comparison of Building Environmental Assessment Tools", Buildings 3, pp. 39-60.