Introduction
Sustainability and Resilience in the Built Environment

Ruben Paul Borg

President SBE Malta, Faculty for the Built Environment - University of Malta

Sustainability originates from the Latin; *Sustinere*, to hold, maintain support and endure. Resilience also originates form the Latin; *Resilire*, rebounding and bouncing back. (Liotta et al, 2010; Alexander, 2013).

The concept of sustainable development emerged as an important political vision and rose to prominence in the late 1980s. In 1987 the World Commission on Environment and Development referred to Sustainable Development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Bruntland Commission, WCES 1987). In this period, the construction industry began to generate the first sustainable building assessment systems addressing environmental, economic and social aspects for buildings through their life cycles.

Resilience is the ability to withstand and recover rapidly from disruptive events and has been considered to directly depend on the ability of the built environment to maintain and support the functions upon which modern society relies. Resilience is usually related to the occurrence of extreme events and disasters during the life cycle of structures and infrastructures. In the last decade it has been used to minimize specifically direct and indirect losses from hazards through enhanced resistance and robustness to extreme events, as well as more effective recovery strategies (Bocchini et al, 2014).

Therefore, in general sustainability is usually defined through the triple bottom line of environmental, social and economic system considerations, while resilience is usually viewed as the ability of a system to be prepared to absorb impacts and recover and adapt following persistent stress or a disruptive event.

Resilience is a property of a complex system and may indeed be counter to sustainability goals: for instance, efficiency reduces diversity and redundancy and yet, both of these, are key features of resilience. High-density urban areas are considered to promote more efficient energy distribution, communications and waste management but are more vulnerable to extreme actions such as flooding because they are less diverse and have less redundancies (Elmqvist, 2017). The differences and synergies between sustainability and resilience need to be appreciated first, for these concepts to be then applied in policy and practice.

A difference reported between sustainability and resilience, is referred to as the temporal scale of implementation, where sustainability efforts are often understood on longer time scales than resilience (Marchese et al, 2018). The primary objective of sustainability is to create desirable conditions for future generations (Meacham, 2016) and the effects of sustainability policies may have substantial effects on future conditions and may not directly influence present conditions. Resilience is in many situations understood to apply to more immediate temporal scales (Lew et al., 2016; Mejia-Giraldo et al., 2012) and policies that increase the resilience of a system will protect the system in the short term from potential disturbances. There is significant opportunity to develop sustainability practices that are more consistent with resilience methods (Marchese et al, 2018). For example, sustainability can be considered as a critical function of a project, policy or system, which is to be maintained during and after a disturbance.

However, the Sendai Framework for Disaster Risk Reduction, encompasses 'the risk of small-scale and large-scale, frequent and infrequent, sudden and slow-onset disasters, caused by natural or manmade hazards as well as related environmental, technological and biological hazards and risks.' (United Nations, 2015). Furthermore, Building Back Better (BBB) is an approach proposed in post-disaster recovery that is intended to reduce vulnerability to future disasters and builds community resilience to address physical, social, environmental, and economic vulnerabilities and shocks (GFDRR, 2019). Therefore, Building Back Better supports sustainable practices.

Both resilience and sustainability analyses are of importance in the assessment of infrastructure and the impact on the community, and neither can be neglected (Bocchini et al, 2014). Sustainability and Resilience approaches attempt to optimize a system, such as a civil infrastructure system, with respect to structural design, material used, maintenance plans, management strategies, and impacts on society. However, researchers and practitioners focusing on either sustainability or resilience usually operate without mutual consideration leading to severe inefficiency. It is suggested that resilience and sustainability are complementary and should be used in an integrated perspective through the well-established framework of risk assessment (Bocchini et al, 2014). The impact of the infrastructure and its service states on society in normal operational conditions - assessed by sustainability analysis - and after exceptional events - assessed by resilience analysis - should be weighted by the associated probabilities of occurrence and combined in a global impact assessment (Bocchini et al, 2014).

It is reported that there is a lack of an integrated framework that combines both sustainability and resilience indicators for the assessment of energy technologies. The integration of sustainability and resilience indicators is required in an overall assessment framework for low-carbon energy technologies (Grafakos et al, 2018). High performance building design presents demands for greater resilience, which can be achieved at a minimum environmental cost. The integration of sustainability and resilience and the synergies or differences between the two is reported as a persistent knowledge gap (Phillips, 2017). In this regard quantitative modelling and hazard resistance are proposed within life cycle assessment of strategies to produce resilient and sustainable building designs. It is also important to note that materials science has an important role in enabling informed decisions for resilience and identify knowledge gaps, such as the service life of the materials designed for new construction or system repair (Watson et al, 2018).

Climate change presents challenges for future-proof and climate resilient buildings and infrastructure. Green Buildings address Climate Change primarily through a reduction in greenhouse gas emissions. However, greenhouse gas reductions are considered as climate change mitigation. The US Green Building Council (US GBC) Leadership in Energy and Environmental Design (LEED) allocates more than 25% of available points for reducing greenhouse gas emissions associated with building systems transportation, water, waste and construction materials (US Green Building Council, 2008). Both mitigation and adaptation strategies are however required in Green Buildings to achieve a built environment which is responsive and resilient to future climate extremes (Larsen et al., 2011). Climate related vulnerabilities are identified, and design, construction and operation strategies are defined for increasing resilience and to facilitate climate adaptation (Larsen et al, 2011). The impacts of climate change at different scales from regional scale to building scale are addressed with respect to a range of predicted future characteristics in different categories and probable impacts. This is intended to define modified performance goals at neighbourhood and building level, to increase resilience and adaptive capacity. Synergies between green building and resilience are identified: addressing the implications of climate change for green building and identifying opportunities for resilience through the design, construction, and operation of buildings and communities; assessing how individual LEED credits support regional adaptation needs, such as enhanced water conservation in arid climates and water-sensitive regions; analysing how consideration of climate resilience in buildings can increase the likelihood of achieving performance goals throughout the lifetime of a project (Larsen et al, 2011).

SBE Malta (Sustainable Built Environment Malta) was founded as the Green Building and Sustainable Built Environment organisation in Malta, as the National Chapter of iiSBE (International Initiative for a Sustainable Built Environment). The organisation is committed to Sustainable Development, education and research in green buildings and sustainability in the built environment. SBE Malta organised the SBE 16 Malta Conference (Europe and the Mediterranean: Towards a Sustainable Built Environment) and the SBE 19 Malta Conference (Sustainability and Resilience), as part of the World SBE 19 Series addressing key areas promoting sustainable development and resilience in the built environment: resource efficiency, waste management, materials and structural engineering, smart systems, strategies for cultural heritage and building refurbishment, strategic planning and urban design, transport infrastructure, energy efficiency and renewable energy, disaster resilience, economic, social and education aspects. The objective of SBE 19 Malta is to create a forum for experts to address the knowledge gaps which exist in sustainability and resilience in the built environment and to promote the development of sustainable and resilient design.

Implementation of Sustainability and Resilience in the Built Environment can be achieved in policy and also in practice through practical applications in the built environment, if the fundamental differences and synergies between the two are well appreciated by the academic community and effectively communicated to policy makers.

Bibliography

D.E. Alexander, (2013), Resilience and disaster risk reduction: an etymological journey, Natural Hazards and Earth System Sciences, Vol 13, 2707–2716. doi:10.5194/nhess-13-2707-2013

Paolo Bocchini, Dan M. Frangopol, Thomas Ummenhofer, Tim Zinke, (2014), Resilience and Sustainability of Civil Infrastructure: Toward a Unified Approach, Journal of Infrastructure Systems, 2014, 20(2): 04014004, ASCE, doi:10.1061/(ASCE)IS.1943-555X.0000177

Thomas Elmqvist, (2017), Sustainability and Resilience differ, Nature, Vol 546, 15th June 2017 (Correspondence, T Elmqvist, Stockholm Resilience Centre, Stockholm University, Sweden).

Stelios Grafakos, Elena Marie Enseñado & Alexandros Flamos, (2016), Developing an integrated sustainability and resilience framework of indicators for the assessment of low-carbon energy technologies at the local level, International Journal of Sustainable Energy, 2016, Taylor and Francis, doi:10.1080/14786451.2015.1130709

Larissa Larsen, Nicholas Rajkovich, Clair Leighton, Kevin McCoy, Koben Calhoun, Evan Mallen, Kevin. Bush, Jared Enriquez, (2011), Green Building and Climate Resilience, Understanding Impacts and Prearing for Changign Conditions, University of Michigan, US Green Building Council, 260p.

Lew, A.A., Ng, P.T., Ni, C., Wu, T., (2016), Community sustainability and resilience: similarities, differences and indicators. Tourism Geographies Vol 18:18–27. doi:10.1080/14616688.2015.1122664.

G. Liotta, L. Rossi, F. Gaffiot, (2010), Dizionario della lingua latina, Latino Italiano, Hachette Livre, Il Capitello, Torino.

Dayton Marchese, Erin Reynolds, Matthew E. Bates, Heather Morgan, Susan Spierre Clark, Igor Linkov, (2018), Resilience and sustainability: Similarities and differences in environmental management applications, Science of the Total Environment 613–614 (2018) 1275–1283, Elsevier, doi:10.1016/j.scitotenv.2017.09.086

GFDRR, 2019, Global Facility for Disaster Reduction and Recovery (www.gfdrr.org/recovery-hub)

Mejia-Giraldo, D., Villarreal-Marimon, J., Gu, Y., He, Y., Duan, Z., Wang, L., 2012. Sustainability and resiliency measures for long-term investment planning in integrated energy and transportation infrastructures. Journal of Energy Engineering Vol 138:87–94. doi:10.1061/(ASCE)EY.1943-7897.0000067.

Robert Phillips, Luke Troup, David Fannon, Matthew J. Eckelman, (2017), Do resilient and sustainable design strategies conflict in commercial buildings? A critical analysis of existing resilient building frameworks and their sustainability implications, Energy and Buildings, Elsevier, 146 (2017) 295–311, doi:10.1016/j.enbuild.2017.04.009

Meacham, B.J., (2016). Sustainability and resiliency objectives in performance building regulations. Building Research and Information Journal, Vol 44 : 474–489. doi:10.1080/09613218.2016.1142330.

United Nations, (2015), Sendai Framework for Disaster Risk Reduction 2015-2030, United Nations Office for Disaster Risk Reduction.

World Commission on Environment and Development, 1987. Our Common Future. Oxford University Press, Oxford 019282080X, p. 27.

Stephanie S. Watson, Chiara F. Ferraris & Jason D. Averill, (2018), Role of materials selection in the resilience of the built environment, Sustainable and Resilient Infrastructure, 3:4, 165-174, doi:10.1080/23789689.2017.1405656