University of BRISTOL

Lessons Learned on Software Engineering for Sustainability

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Work done in collaboration with the Karlskrona Manifesto Team

KARLSKRONA MANIFESTO
FOR SUSTAINABILITY DESIGN

University of BRISTOL

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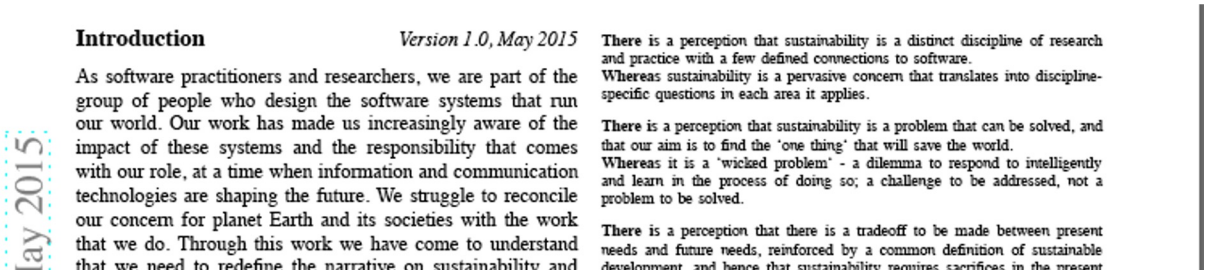


Introduction *Version 1.0, May 2015*

As software practitioners and researchers, we are part of the group of people who design the software systems that run our world. Our work has made us increasingly aware of the impact of these systems and the responsibility that comes with our role, at a time when information and communication technologies are shaping the future. We struggle to reconcile our concern for planet Earth and its societies with the work that we do. Through this work we have come to understand that we need to redefine the narrative on sustainability and

There is a perception that sustainability is a distinct discipline of research and practice with a few defined connections to software.
Whereas sustainability is a pervasive concern that translates into discipline-specific questions in each area it applies.

There is a perception that sustainability is a problem that can be solved, and that our aim is to find the 'one thing' that will save the world.
Whereas it is a 'wicked problem' - a dilemma to respond to intelligently and learn in the process of doing so; a challenge to be addressed, not a problem to be solved.

There is a perception that there is a tradeoff to be made between present needs and future needs, reinforced by a common definition of sustainable development, and hence that sustainability requires sacrifices in the present

As designers of software technology, we are responsible for the long-term consequences of our designs. Design is the process of understanding the world and articulating an alternative conception on how it should be shaped, according to the designer's intentions. Through design, we cause change and shape our environment. If we don't take sustainability into account when designing, no matter in which domain and for what purpose, we miss the opportunity to cause positive change.

Ref: "Sustainability design and software: The Karlskrona manifesto." *2015 ICSE*. Vol. 2. IEEE, 2015.

Sustainability - what is that?

sustainability

NOUN

1 The ability to be maintained at a certain rate or level.

'the sustainability of economic growth'

'the long-term sustainability of the project'

+ More example sentences

1.1 Avoidance of the depletion of natural resources in order to maintain an ecological balance.

'the pursuit of global environmental sustainability'

'the ecological sustainability of the planet'

+ More example sentences

https://en.oxforddictionaries.com/definition/us/sustainability

Category	Finding
Individual findings	Sustainability as environmental or financial
	Sustainability as separate from SE
	Sustainability as a nice-to-have quality
The professional environment	Lack of methodological support
	Need for mentality change
	Assumed costs as barrier
	Concerns of small companies
	The role of the customer
	Companies lack time
	Engineers lack management support for it
	Doubts about benefits for business
	Perception of trade-offs and risks
Norms in SE practice	Project success assessed at delivery only
	Poor communication of sustainability values
	Regulations are drivers for sustainability

Ref: "Sustainability design in requirements engineering: state of practice" ICSE: SEIS 2016

Lesson 1 On need for methods and tools: e.g., UN Sustainable Development Goals

Software requirements – key to sustainability

“Requirement: necessary (or desired) function, attribute, capability, characteristic, or quality **of a system** for it to have **value and utility** to a **customer** or other stakeholder”

What the software system will implement (is Sustainability here?)

What the client will check as an acceptance criteria (is Sustainability here?)

Ref: "Requirements: The key to sustainability." *IEEE Software* 33.1 (2015): 56-65.

Lesson 2 On need for dimensional & temporal link up: Sustainably Awareness Questions

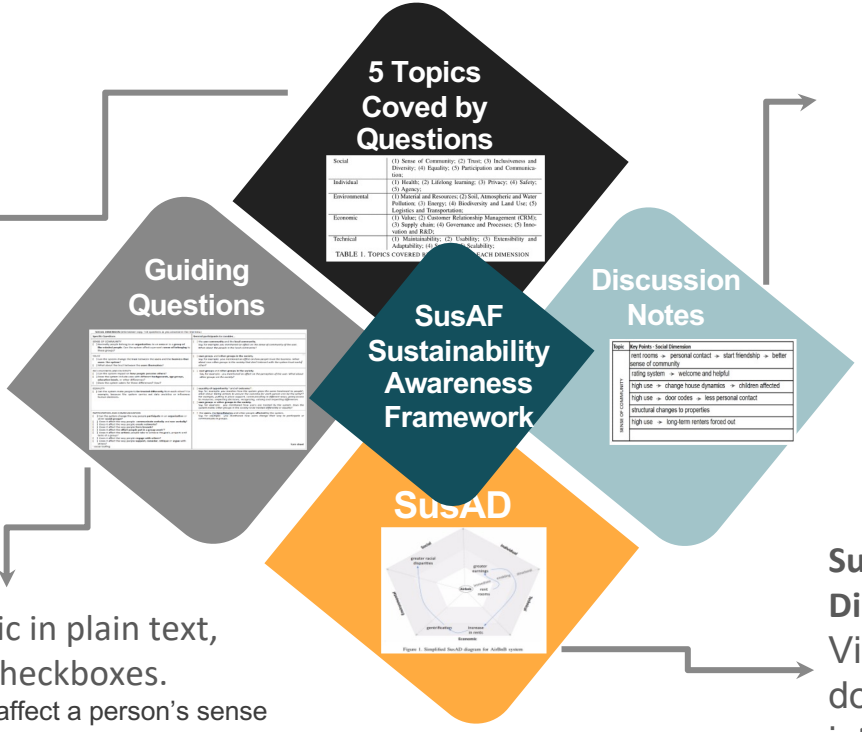
Dimension	Topics
Social	Sense of community; Trust; Inclusiveness & Diversity; Equality; Participation & Communication
Individual	Health; Lifelong learning; Privacy; Safety; Agency
Environmental	Materials and Resources; Soil, Atmospheric and Water Pollution; Energy; Biodiversity and Land Use; Logistics and Transportation
Economic	Value; Customer Relationship Management; Supply chain; Governance and Processes; Innovation and R&D
Technical	Maintainability; Usability; Extensibility and Adaptability; Security; Scalability

Big Success: what effects will the long term continuous and large-scale use of your system will have on its in-situ environment?

Ref: "Requirements engineering for sustainability: an awareness framework for designing software systems for a better tomorrow'. *Requirements Engineering* 25.4 (2020): 469-492.

Lesson 3 On Need for Examples: Sustainability Awareness Framework

5 Topics per Dimension,
E.g.,
Social: Sense of Community, Trust, Inclusion and Diversity, Equity, Participation and Communication
Environmental: Materials and Resources, Energy, Biodiversity and Land Use, Logistics, Soil and Atmosphere



Guiding Questions per topic in plain text, examples, reminders and checkboxes.
E.g., How can the product/service affect a person's sense of belonging to these groups?

Conclusions on:

- Identifying **chain-of-effects**;
- **Impact** of widespread and long-term use;
- **Risks and Opportunities**

E.g. New York Airbnb, homeowners earn 55% more than long term rental -> 7,000 - 13,000 units of housing off rental market in NY -> 1.4% long term rental increase -> gentrification and segregation.

Sustainability Awareness Diagram (SusAD):
Visualisation tool, breaks down graph into the five interrelated dimensions of sustainability.

Ref: SusAF Workbook 6.0

Lessons on Practical Use

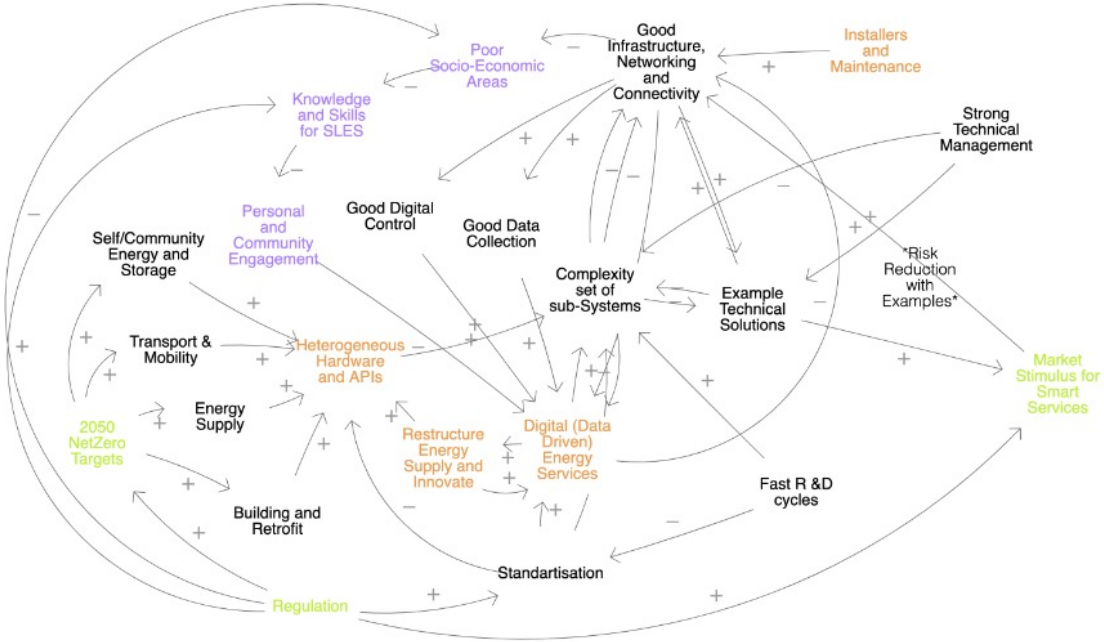
- Lesson 4: On efficiency of analysis:
  - Quick recording of relevant issues and results
  - Help to focus on areas of interest

- Lesson 5: On adaptation to context of use
  - Introductory Use
    - Single dimension
    - Introductory format
  - Use for teaching and training

Ref: "Lessons Learned from Developing a Sustainability Awareness Framework for Software Engineering Using Design Science", ToSEM, 2024

Sustainability: a systems crosscutting concern - More challenges than solutions

- Integration into software management processes
- Integration into software development tool chain
- Supporting adaptation of system of systems



Ref: “What Can Requirements Engineering Do for Emerging System of Systems? Case of Smart Local Energy”, ICSE SEIS 2024