The SusA Workshop - improving sustainability awareness to inform future business process and systems design

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Abstract—**When software systems are integrated into our society, the economy, and the environment, they have far-reaching effects. Therefore, they should be designed for the sustainability of the socio-technical system they belong to. This requires a paradigm shift in the way in which we create software systems. Requirements Engineering (RE) is key to drive this change, which should start by raising awareness of the relationship of a software-intensive system with sustainability.**
The workbook at hand provides the instruments used to carried out the Sustainability Awareness Workshops we are using when working with companies. Keywords: sustainability, software, socio-technical systems, requirements engineering

1. Introduction

In Duboc et al. [2], we presented a question-based framework for raising awareness of the potential effects of software systems on sustainability, as the first step towards enabling the required paradigm shift. A feasibility study of the framework was carried out with two groups of computer science students. The results of the study indicate that the framework helps enable discussions about potential effects that software systems could have on sustainability.

The framework is composed of the Sustainability Awareness Diagram — a radar chart for visualising potential sustainability effects of a software system, across dimensions and order of effects, and five question sets for guiding semi-structured interviews to help filling out the diagram. The

questions cover 5 topics per each of the 5 sustainability dimensions. The questions are not meant to be exhaustive, instead they have been developed as a "starters kit" to guide conversations on software systems' potential effects on sustainability. This facilitates the initial exploration of the broader systemic impact of the system-to-be. This realization may highlight stakeholders that are affected but not presently involved with the development of the system-to-be, as well as additional issues that need to be considered. Such exploration can be a first step towards a deeper sustainability analysis, as discussed in Becker et al. [1].

We explore these questions by means of a feasibility study of using the framework in two application cases with computer science students in Duboc et al. [2], seeking to answer the following research questions (RQ):

RQ1: Does the framework encourage insightful discussions about the potential effects of software systems on sustainability?

RQ2: Does the framework help to identify potential chains-of-effects of software systems on sustainability?

RQ3: How practical is the proposed approach?

Our results in Duboc et al. [2] demonstrated the utility of the question-based framework in raising sustainability awareness and initiating relevant discussions with the stakeholders.

Contribution The workbook at hand provides the instruments used to carried out the Sustainability Awareness

Workshops we use with companies.

2. Sustainability Awareness Framework

Modern society's reliance on software systems has resulted in the emergence of sustainability as a growing area of interest in the field of software and requirements engineering [4]. In the context of this paper, sustainability is defined as the capacity of a socio-technical system to endure [1].

The sustainability awareness framework is composed of a diagram and five-question sets for guiding semi-structured interviews [2].

2.1. Sustainability Awareness Diagram

To visualise the effects that a software system could have on the sustainability of its socio-technical environment, we use an adapted radar chart (in line with [1]), which we refer to as the *Sustainability Awareness Diagram (SusAD)*. The diagram is a visualisation tool which breaks down the radar chart graph into the five interrelated dimensions of sustainability. Each dimension is further divided into three *order of effects*, denoting the effect that a software system can cause across time; These are: *immediate* (i.e., caused by the direct function of the system or its development), *enabling* (i.e., arising from the application of a system over time), or *structural* (i.e., referring to persistent changes that can be observed at the macro level) [3]. An example excerpt of a diagram is provided in Fig. 1.

2.2. Questions Framework

The framework is composed of five sets of questions (a set per dimension) for guiding semi-structured interviews, supplemented with templates for taking notes. Each set of the guiding questions, has five topics (though additional topics could well arise for each dimension as requirements are elicited), and are to be used as a "starter kit" to guide conversations on software systems potential effects on sustainability.

When creating the questions sheets, we did not aim to have an exhaustive list of topics or questions to address every aspect of sustainability (which is quite impossible). Instead, we aimed to give requirements engineers a *starting point* for discussing possible sustainability effects. Thus, we chose to cover only five topics for each dimension, although additional (system and domain-specific) topics could well arise for each dimension as the interview progresses. Our starting sample of topics is listed in the Table 1.

2.2.1. Social Dimension Questions. The **social dimension** covers the relationships between individuals and groups, see Fig. 2. The questions are about how the system may affect people's sense of belonging, their trust on its surroundings, their perception of others, how they participate in social groups, or whether they are receiving the equitable treatment compared to others.

Social	(1) Sense of Community; (2) Trust; (3) Inclusiveness and Diversity; (4) Equality; (5) Participation and Communication;
Individual	(1) Health; (2) Lifelong learning; (3) Privacy; (4) Safety; (5) Agency;
Environmental	(1) Material and Resources; (2) Soil, Atmospheric and Water Pollution; (3) Energy; (4) Biodiversity and Land Use; (5) Logistics and Transportation;
Economic	(1) Value; (2) Customer Relationship Management (CRM); (3) Supply chain; (4) Governance and Processes; (5) Innovation and R&D;
Technical	(1) Maintainability; (2) Usability; (3) Extensibility and Adaptability; (4) Security; (5) Scalability;

TABLE 1. TOPICS COVERED BY QUESTIONS IN EACH DIMENSION

2.2.2. Individual Dimension Questions. The **individual dimension** covers the individual's ability to thrive, exercise his/her rights, and develop freely, see Fig. 3. The questions are about how the usage of the system may affect the individual him/herself, that is, a person's physical and mental health, level of knowledge, privacy, safety and ability to act on his/her surroundings.

2.2.3. Environmental Dimension Questions. The **environmental dimension** covers the use and stewardship of natural resources,, see Fig. 4. The questions refer to how the system may affect the consumption of resources, the production of waste, pollution and emissions and biodiversity.

The version for the interviewer is more extensively described, so they have additional prompts in case the conversation is getting stuck, see Fig. 5.

2.2.4. Economic Dimension Questions. The **economic dimension** covers the financial aspects and business value, see Fig. 6, 7. The questions are about how the system creates or destroys value, how it affects the relationship between businesses and customers, whether it alters a business supply chain, governance, processes, or R&D.

2.2.5. Technical Dimension Questions. Finally, the **technical dimension** covers the software system's ability to change while providing the required features and capabilities, see Fig. 8. The questions aim to identify how the system is maintained and use over time, and to illustrate the system's ability of change and adaptability of the functionalities into the change environment, and whether the security of the system and privacy of its users are considered.

2.3. Extreme Scenarios and Chains of Effects

The questions (exemplified in Figure 2) are intended to help uncover possible immediate and longer-term effects. In order to encourage identification of such impacts, the framework complements questions with a simple note-taking form (shown in Figure 9) which explicitly draws the attention of the interviewer to noting down the chains-of-effects [2].

Yet, interviewees might not consider long-term, compounded impacts. To foster this, the framework suggests posing an imaginary "extreme" scenario, where the intended
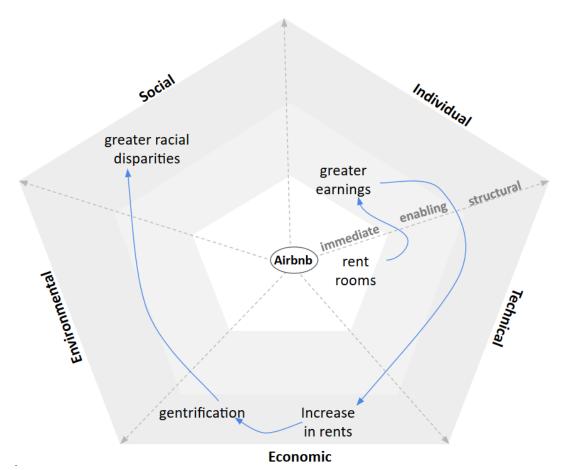
Figure 1. Example SusA Diagram for AirBnB [2]

software system is accepted and used by millions of people worldwide for a long period of time. The interviewee is then invited to reflect on the impact that such a wide-spread, long-term use of the system may have. For example, *"Imagine that many people worldwide are using this system for decades. Think about how one thing may lead to another. We call this a chain of effects. If people feel closer to their neighbours, they may choose to buy from local shops or choose proximity products, which can then foment local businesses, and finally better distribute wealth."* [2].

3. Conclusions

The workshop materials are free for use under creative commons attribution share-alike. We are looking forward to your feedback. We are currently working on a complete set of guiding slides and a workbook for participants and will make this available as well.

Acknowledgments

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SOCIAL DIMENSION (Interviewer copy. Tick questions as you advance in the interview.)

Specific Questions	Remind participants to consider...
SENSE OF COMMUNITY [ ] Normally people belong to an **organization**, to an **area** or to a **group of like-minded people**. Can the system affect a person's **sense of belonging** to these groups?	[ ] the **user community** and the **local community**. Say, for example: *you mentioned an effect on the sense of community of the user. What about the people in the local community?*
TRUST [ ] Can the system change the **trust** between the **users** and the **business that owns** the system? [ ] What about the trust between the **users themselves**?	[ ] **user groups** and **other groups in the society**. Say, for example: *you mentioned an effect on how people trust the business. What about how other groups in the society that don't interact with the system trust each other?*
INCLUSIVENESS AND DIVERSITY [ ] Can the system impact on **how people perceive others**? [ ] Does the system include uses with different **backgrounds, age groups, education levels,** or other differences? [ ] Does the system caters for these differences? How?	[ ] **user groups** and **other groups in the society**. Say, for example: *you mentioned an effect on the perception of the user. What about other groups on the society?*
EQUALITY [ ] Can the system make people to **be treated differently** from each other? For example, because the system carries out data analytics or influences human decisions.	[ ] **equality of opportunity** [1] and **of outcome** [2]. Say, for example: *you mention how the system gives the same treatment to people[1], what about taking actions to ensure the outcome for each person can be the same[2]? For example, putting in place support, communicating in different ways, giving access to resources, respecting decisions, recognizing, valuing and respecting differences.* [ ] **user groups** or **other groups in the society**. Say, for example: *you mentioned how users are treated by the system. Does the system makes other groups in the society to be treated differently or equally?*
PARTICIPATION AND COMMUNICATION [ ] Can the system change the way people **participate** in an **organization** or other **social groups**? [ ] Does it affect the way people **communicate verbally** and **non-verbally**? [ ] Does it affect the way people **create networks**? [ ] Does it affect the way people **form bounds**? [ ] Does it affect the **effort people put in a group work**[1]? [ ] Does it affect the **actions** people take to achieve the goals, projects and tasks of a group? [ ] Does it affect the way people **engage with others**? [ ] Does it affect the way people **support, consider, critique** or **argue** with others? [1] social loafing	[ ] the **users**, the beneficiaries and other people **affected** by the system. Say, for example: *you mentioned how users change their way to participate or communicate in groups.* **Turn sheet**

Figure 2. Question sheet for the social dimension (Interviewee version)

INDIVIDUAL DIMENSION (Interviewee copy)

Specific Questions	Final Questions
HEALTH [ ] Can the system **improve** (or **worsen**) a person's **physical health?** [ ] What about a person's **mental**, and **emotional health?** [ ] Can the system make a person feel **undervalued** or **disrespected**? [ ] What about **dependent** on the system or anyone? [ ] What about **coerced to do something** that she is not conformable with? [ ] Can the system make a person feel any other feeling that he or she might perceive as **negative**? **LIFELONG LEARNING** [ ] Can the system **improves** (or **worsen**) the **knowledge** of a person? [ ] Can it change her **education level?** **PRIVACY** [ ] Can the system **expose (or help to hide)** a person's **identity?** [ ] What about her **whereabouts** or **preferences**? [ ] What about her **relation to friends and family**? [ ] Can the system make a person **feel** more (or less) **exposed** in any way? **SAFETY** [ ] Can the system **expose** (or protect) a person to **physical harm**? [ ] Even if the system is safe, can it make a person **feel** more (or less) **exposed** to **physical harm**? [ ] What if used in an **unintended way**? **AGENCY** [ ] Can the system **empower** a person to **take an action** when necessary? [ ] If it doesn't empower, can it **prevent** her from taking an action? For example, because the user interface does not allow her to. [ ] Can a people affected by the system truly **understand its implications**? [ ] Can a person realistically **voice her concerns** about the system? For example, does the person feel comfortable enough to say no? [ ] If a person cannot voice her concerns, **who can represent her**?	[ ] Extreme scenario: ● Imagine that many people worldwide are using this or similar system for many years or decades. ● Think about how one thing may lead to another. ● For example, if an employee feels undervalued, he or she may feel less motivated at work, and eventually leave the company, and if that happens frequently, the business may be affected. [ ] Looking at this list of key points you mentioned during the interview, can you think of a chain of effects for some of these key points in the extreme scenario above?
Is there any **other issue** that is relevant to the **individual** that the system may affect?	

Figure 3. Question sheet for the individual dimension (Interviewee version)

ENVIRONMENTAL DIMENSION (Interviewer copy. Tick questions as you advance in the interview.)

Specific Questions	Remind participants to consider...
MATERIAL AND RESOURCES [　] Think about the **equipment** and **supplies** that are part of the system. Which materials may be consumed to **produce** them? [　] What about to **use** the system? For example, supplies. [　] Does the system change the way people **consume material**? For example, encourage people to buy more?	[　] different types of material, e.g., raw materials, recycled materials. 　　Say, for example: *you mentioned packaging. What is this made of?* [　] the consumption of material by the **user, beneficiary (person or institution) *** or any other **person or institution that might be affected** by the system. 　　Say, for example: *you mentioned the system does not increase the consumption of material. What about his institution? What about other people or institutions that do not directly interact with the system?* *a beneficiary does not necessarily use the system, but may benefit from it. E.g. a baby for a monitoring device.
SOIL, ATMOSPHERIC AND WATER POLLUTION [　] Think again about the **equipment** and **supplies** that are part of the system. Does **producing** them generates **waste** or **emissions**? [　] Does the system itself produces **waste** or **emissions**? [　] Does the system influence how much **waste** or **emissions** people or institutions generate? [　] Or, alternatively, does it promote (or impair) **recycling**?	[　] hazardous waste, solid waste, emissions, wastewater, hardware components, etc. 　　Say, for example: *you mentioned the systems does not increase emissions, but can it create other kinds of waste like solid waste or wastewater?* [　] waste and emissions generated by the **user**, by the **beneficiary** (person or institution)**, or by any other person or institution that might be affected** by the system. 　　Say, for example: *you mentioned that the system promotes recycling among its users. Can it affect the waste generated by other people or institutions that do not directly interact with the system?*
BIODIVERSITY AND LAND USE [　] Can the system impact the **plants** or **animals around it**? [　] What about **elsewhere**? [　] Can the system change the **size, use, of composition of the soil around it?** For example, by **occupying** land or by converting land into **cropland**? [　] What about **elsewhere**?	[　] the animals, plants and soil affected by the **user**, by the **beneficiary** (person or institution)**, or by any other person or institution that might be affected** by the system. 　　Say, for example: *you mention how the system does not change the way company uses land. Can it affect the way other people or institutions that do not directly interact with the system use land?*
ENERGY [　] Does the system affect the **production of energy**? [　] What about the **use of energy**? E.g. enables or encourages less energy consumption or consumption from renewable sources. [　] Does the energy to **run the system hardware** comes from **renewable energy sources**?	[　] *the energy consumption of its **user**, its **beneficiary** (person or institution) or any **other person or institution that might be affected** by the system.* 　　Say, for example: *you mention how the system encourages the user to be always connected, spending more energy. Can it affect the energy use by other people or institutions that do not directly interact with the system?*
LOGISTICS AND TRANSPORT [　] Does the system affects the **need for movement** of **people** or **goods**? [　] Does the system affect the **means** by which **people** or **goods** move? [　] Does the system affect the **distance** that **people** or **goods** move?	[　] *the transportation of its **user**, its **beneficiary** (person or institution) or any **other person or institution that might be affected** by the system.* **Turn sheet**

Figure 4. Question sheet for the environmental dimension (Interviewee version)

ENVIRONMENTAL DIMENSION (Interviewee copy)

Specific Questions	Final Questions
MATERIAL AND RESOURCES [ ] Think about the equipment that are part of the system. Which materials may be consumed to **produce** the system? [ ] What about to **use** the system? For example, supplies. [ ] Does the system change the way people **consume material**? For example, encourage people to buy more?	[ ] Extreme scenario: • Imagine that many people worldwide are using this or similar system for many years or decades. • Think about how one thing may lead to another. • For example, if the system encourages people to buy more clothes, companies will produce more, generating more jobs in the developing world, but also creating greater environmental damage. [ ] Looking at this list of key points you mentioned during the interview, can you think of a chain of effects for some of these key points in the extreme scenario above?
SOIL, ATMOSPHERIC AND WATER POLLUTION [ ] Think again about the **equipments** and **supplies** that are part of the system. Does **producing** them generates **waste** or **emissions**? [ ] Does the system itself produces **waste** or **emissions**? [ ] Does the system influence how much **waste** or **emissions** people or institutions generate? [ ] Or, alternatively, does it promote (or impair) **recycling**?	
BIODIVERSITY AND LAND USE [ ] Can the system impact the **plants** or **animals around it**? [ ] What about **elsewhere**? [ ] Can the system change the **size, use, of composition of the soil around it?** For example, by **occupying** land or by converting land into **cropland**? [ ] What about **elsewhere**?	
ENERGY [ ] Does the system affect the **production of energy**? [ ] What about the **use of energy**? E.g. enables or encourages less energy consumption or consumption from renewable sources. [ ] Does the energy to **run the system hardware** comes from **renewable energy sources**?	
LOGISTICS AND TRANSPORT [ ] Does the system affects the **need for movement** of **people** or **goods**? [ ] Does the system affect the **means** by which **people** or **goods** move? [ ] Does the system affect the **distance** that **people** or **goods** move?	
Is there any **other issue** that is relevant to the **environment** that the system may affect?	

Figure 5. Question sheet for the environmental dimension (Interviewer version)

Specific Questions	Final Questions
VALUE [ ] How does the system **creates** or **destroys monetary value**? [ ] For **whom**? **CUSTOMER RELATIONSHIP MANAGEMENT (CRM)** [ ] Does the system affect the **relationship** between the **business** and its **customers?** [ ] Systems sometimes enables the **co-creation** or **co-destruction** of value[2] when **the customer** interacts with the **business.** For example, when customer misbehave, front-line employees experience mental stress; when a customer cannot self-serve as expected, her experience is affected; when a customer cannot turn information (resource) into knowledge (operational resource), she may feel she lost money (resource). Does the system enables this kind of **co-creation** or **co-destruction of value**? [ ] Do these changes in the relationship between the business and its customers impact the **financial situation** of the **business** and their **partners?** [ ] Can it also impact the **financial situation** of their **customers** and **other people/institutions?** [2] In the **consumer market**, **co-creation** emerges due to dialog, customer engagement, self-service, customer experience, problem-solving, co-designing and co-developing. Value **co-destruction** can happen when the customer misbehave, don't perform expected tasks, or when the two parties fail to integrate resources. More info here. **SUPPLY CHAIN** **SUPPLY CHAIN** [ ] Does the system alter the **supply chain** of the **business who owns it?** [ ] Systems sometimes enables the **co-creation** or **co-destruction** of value[3] when **partners** interact with each other. For example, when a provider cannot meet unrealistic expectations, when the benefits are unbalanced in a collaboration. Does the system enables this kind of **co-creation** or **co-destruction of value**? [ ] How can these changes in supply chain **impact the financial situation of the business and their partners?** [ ] Can it also impact the **financial situation** of their **customers** and **other people/institutions?** [3] In **B2B relationships**, **co-creation** happens due to the interaction between the business in the value chain. **Co-destruction** happens due to lack of trust, power imbalance, or inadequate communication/coordination/human capital. More info here. **GOVERNANCE AND PROCESS** [ ] Business make decision on who are the legitimate stakeholders, what are the business goals, which should the be business processes. Does the system affect **how** and **by whom such decisions are made**?	[ ] Extreme scenario: ● Imagine that many people worldwide are using this or similar system for many years or decades. ● Think about how one thing may lead to another. ● For example, if the system allows people allow people to be hired to perform small jobs, many people who are out of the official job market can start to make money and have buying power, which in turn can strengthen the local market. [ ] Looking at this list of key points you mentioned during the interview, can you think of a chain of effects for some of these key points in the extreme scenario above?

Figure 6. Question sheet 1/2 for the economic dimension (Interviewee version)

[ ] Does the system affect the **activities** or the **resources** of the business? [ ] Does the system affect the kind of **relationship** between the **business** and **people/institutions that may be affected** by it? [ ] What about the **means by which the relationships takes place** (the channels)? [ ] How can these changes in governance and process impact the **financial situation** of the **business** and their **partners?** [ ] Can it also impact the **financial situation** of their **customers** and **other people/institutions?**	**Turn sheet**
INNOVATION, RESEARCH & DEVELOPMENT (R&D) [ ] Does the system affect the **investment on research** & **development**? [ ] What about the **areas of R&D?** [ ] How can these changes in innovation and R&D impact the **financial situation** of the **business** and their **partners?** [ ] Can it also impact the **financial situation** of their **customers** and **other people/institutions?**	
Is there any **other issue** that is relevant to the **economy** that the system may affect?	

Figure 7. Question sheet 2/2 for the economic dimension (Interviewee version)

TECHNICAL DIMENSION (Interviewee copy)

For the technical dimensions, two scenarios exist:
- (a) conceptual idea. I.e. no technical solution has been designed or implemented
- (b) a software system exists (system evolution) or at least a technical design exists

Specific Questions	Final Questions
MAINTAINABILITY [ ] (a) (b) How long is the **system expected to be used for**? [ ] (b) In ten years time, how difficult would it be for a developer to **fix bugs** in the system? [ ] (a) (b) Are the **operating system** and **runtime environment** expect to change? [ ] (b) If so, what would be required from maintainers of this system? [ ] (a) (b) Can the correctness of the system be **affected by other systems**? [ ] (a) (b) Can this system **affect the correctness of others**?	[ ] Extreme scenario: ● Imagine that many people worldwide are using this or similar system for many years or decades. ● Think about how one thing may lead to another. ● For example, the greater the user base, the more complaints might be generated in the social media if there is a security breach, which can affect the image of the business and potentially the whole market. [ ] Looking at this list of key points you mentioned during the interview, can you think of a chain of effects for some of these key points in the extreme scenario above?
USABILITY [ ] (a) (b) **Who is expected to use** the system? [ ] (a) (b) How **used are they** to interact with systems like this? [ ] (a) (b) What can **ease / make more difficult the use** of the system? [ ] (b) Can **first-time users intuitively use** the system? [ ] (b) What are first-time, non-technical users likely to respond when asked if they **would like to use this system again**? [ ] (b) Can experienced users get their **job done efficiently**? Are they likely to bypass the system for any reason?	
EXTENSIBILITY AND ADAPTABILITY [ ] (a) (b) How easy would it be to add substantial **new features easier/more difficult**? [ ] (a) (b) How likely it is that someone will want to **use the system in another context**? [ ] (a) (b) What can make that easier/more difficult? [ ] (a) (b) Is the system required to adapt **itself** to fit new usage scenarios? [ ] (a) (b) What can make that easier/more difficult?	
SECURITY [ ] (a) (b) Which **assets controlled by this system would be desirable** to an attacker? [ ] (a) (b) What are the **risks** associated with these assets? E.g. financial information, people's whereabouts or preferences, purchase history, personal data, etc. [ ] (a) (b) What are the likely **vulnerabilities** of the system?	
SCALABILITY [ ] (a) (b) How likely is the system required to support **changes in workload**? [ ] (a) (b) What can make that easier/more difficult?	

Is there any **other issue** that is relevant to the **system itself** that may be affected?

Figure 8. Question sheet for the technical dimension (Interviewee version)

Topic	Key Points - Social Dimension
SENSE OF COMMUNITY	rent rooms ➔ personal contact ➔ start friendship ➔ better sense of community
	rating system ➔ welcome and helpful
	high use ➔ change house dynamics ➔ children affected
	high use ➔ door codes ➔ less personal contact
	structural changes to properties
	high use ➔ long-term renters forced out

Figure 9. Extract of the notes taking form