# Towards Tool-support for Sustainability Profiling

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***Abstract*—The demand for sustainable software is increasing, as the understanding of the importance of sustainability aspects is developing in the software engineering community. The most effective decisions related to sustainability of software can be made in the early stages of software development. To support these decisions, we introduce Sustainability Profiling for Software (SuSoftPro) tool that can assist in analysing sustainability requirements. In this paper, we analyse the core features of SuSoftPro in comparison with two other approaches, which utilise Multi-Criteria Decision Analysis. We also present a case study we conducted using SuSoftPro: analysis of sustainability aspects of a Skin Cancer Information System.**

## I. Introduction

The impact of software systems on social and economic activities increases each year, which makes the analysis of sustainability requirements of the software systems more and more important. Becker et al. [1] highlighted the point that software systems are a major driver of social and economic activity, which demands a paradigm shift in the software engineering mind-set to take sustainability into account. The key point for this is in requirements engineering activities, which should consider sustainability design principles.

Requirements engineers still have a narrow understanding of sustainability; they focus on one or two dimensions of sustainability such as environmental and economic sustainability, or on the non-functional requirements for technical sustainability such as maintainability and reusability requirements. Requirements engineers should take into account sustainability requirements, which implies additional analysis in the early stages of software development to maximise the positive impact and to minimise the negative impact of all sustainability dimensions. To support these activities a tool is required.

The tool has to be easy-to-use and allow involvement of stakeholders from diverse groups in the process of software development, as empowering more participants with a diversity of perspectives leads to more sustainable systems [2].

There are many requirements engineering (RE) tools to elicit, analyse, model, trace, document, manage, as well as verify and validate software requirements. Some of these tools are web-based, which allows collaborative access to resources. However, none of them has the ability to analyse sustainability requirements by involving stakeholders. Thus, the goal of our ongoing work is to evaluate Sustainability Profiling for Software (SuSoftPro) for analysis of sustainability requirements. More precisely, we are aiming to analyse the SuSoftPro method in-depth and evaluate the tool-support through comparison and rating the requirements of a real-life project with sustainability dimensions to analyse the overall sustainability of the system. This would provide researchers with insights into SuSoftPro, and allow requirements engineers to explore how to take into account sustainability aspects and how to determine which software requirements should be implemented to maximise positive and to minimise negative impacts of the long-living software.

In our previous work, we introduced a methodology with supported tool to analyse sustainability requirements for long-living software systems [3]. This methodology provides a software sustainability profiling that involves a Fuzzy Rating Scale (FRS, cf. [4]), and uses the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS, cf. [5]). Our new tool presents sustainability as a five-star rating label, a visualisation for the degree of the five sustainability dimensions, and a bar graph which illustrates the overall sustainability level for each requirement. The tool enables requirements engineers to defining stakeholder groups allotted to one or more of the five sustainability dimensions, building a fuzzy rating scale-questionnaire with regard to a sustainability dimension, specifying the high-level requirements and assign them to created groups, assigning stakeholders and allow them to rating requirements, analysing sustainability, and generating software sustainability profiling [6]. We discussed the core steps of the SuSoftPro process in [6] to answer "What is SuSoftPro?". While this work is to answer: *What are the differences between SuSoftPro and RE approaches using MCDA in sustainability context?* and *How can SuSoftPro be applied?*

**Contributions:** In this paper, we analyse the core features of SuSoftPro (abbreviated from *Sustainable Software Profiling*) in comparison with two approaches which employ Multi-Criteria Decision Analysis (MCDA) in requirements engineering. We consider a case study of a Skin Cancer Information System (SCIS), which is a clinical software to store patient health records, to optimise SuSoftPro and to increase its usability.

**Outline:** The rest of this paper is organised as follows. In Section II, we analyse and evaluate the core features of SuSoftPro by comparing against two RE approaches which a different methodology using MCDA. Section III illustrates the work flow using a case study from the eHealth domain. Further discussion of the SuSoftPro features is presented in Section IV. Section V covers related works. Finally, Section VI summarises the paper and outlines the directions of our future work.

TABLE I
COMPARISONS OF EMPLOYING MULTI-CRITERIA DECISION ANALYSIS IN REQUIREMENTS ENGINEERING DOMAIN

| Examines Criteria | sureCM [5] | ReproTizer [7] | SuSoftPro |
|---|---|---|---|
| **Framework focus** | Requirement analysis: resolve conflict | Requirement analysis: prioritisation | Requirement analysis: sustainability |
| **Collection method** | Various methods | Online questionnaire | Online questionnaire |
| **Weight scale** | "natural numbers" (several scales are used) | "natural numbers" (scale from 1 to 5) | "rational numbers" (fuzzy rating scale) |
| **Analysis method** | TOPSIS | WADM | TOPSIS |
| **Participants** | Some stakeholders | All stakeholders | All stakeholders |
| **Rank update** | Not defined | Yes | Yes |
| **Tool support** | No | Yes | Yes |
| **Manual computations involved** | Yes | No | No |
| **Number of criteria for analysis** | Two criteria | Multi-criteria | *1st round:* Five criteria, and *2nd round:* Multi-criteria |

## II. COMPARATIVE EVALUATION

To analyse and evaluate our methodology and the SuSoftPro tool, we compared the SuSoftPro against two approaches that developed a methodology using MCDA and used for requirements engineering domain. Below, we address the procedure, analysis, and result of the comparative evaluation.

### A. Procedure

To perform comparative evaluation against SuSoftPro, we defined three criteria for selecting frameworks from literature studies as follow:

- **Scope**: Developed for requirements engineering context,
- **Process**: Involved MCDA and stakeholders, and
- **Objective**: Analysed sustainability.

Because there was no study meet the three criteria, we removed the objective criteria (analysing sustainability) because no MCDA technique has been used to analyse sustainability within RE as well as sustainability is a new growing topic in RE. Thus, only two frameworks were found: ReproTizer and sureCM.

Then, we specified 9 sub-criteria to analyse the three frameworks (SuSoftPro, ReproTizer and sureCM) including the purpose of the methodology, collection method, weight scale, analysis method which is one type of the MCDA, participant, rank updates that the methodology can instantly re-compute results, supported tool, computational complexity, error-proneness, prevent imprecision inherent in human responses, number of criteria.

### B. Analysis of selected studies

We analysed SuSoftPro's core process and features with regard to two other frameworks for requirement analysis: ReproTizer and sureCM.

*1) SuSoftPro:* SuSoftPro[1] is a methodology and tool-support to analyse sustainability requirements within sustainability dimensions having individual, social, economic and environmental dimensions. The general idea of the SuSoftPro process is presented in Figure 1 and discussed in [3], [6]. There are 7 core steps allow requirements engineers to:

- *Define stakeholder groups*: through creating stakeholder group based on stakeholders' role or expert, and then assign this group to one or more of the five sustainability dimensions, so the group will be allotted to stakeholders and requirements;
- *Define questions*: that will be generated automatically as five instructions with regard to a sustainability dimension for FRS questionnaire;
- *Define requirements*: via the specifications of the high-level requirements and allotting them to related groups affected stakeholders and requirement ownership;
- *Assign stakeholders*: to related groups based on stakeholders' role in the system and their areas of expertise after defining them;
- *Rate requirements*: through enable stakeholders to use ratio quantity approach as FRS responses;
- *Analyse sustainability*: with MCDA using TOPSIS approach to determine the level of sustainability dimensions and sustainability requirements measurements; and
- *Generate software sustainability profiling*: including a five-star sustainability rating label, visualisation of sustainability dimension levels, and bar-chart graph for each sustainability requirements level.

Sustainability profiling provides insight and identifies the predictability of sustainability to enable requirements engineers and stakeholders to analyse and break true requirements-dependencies, and the interaction and overlapping of sustainability dimensions by predicting the outcome value before developing software systems.

*2) ReproTizer:* ReproTizer was elaborated by Achimugu et al. [7]. It allows requirements prioritisation via capturing stakeholders' requirement ranks through numeric weight scale that are valued between 1 and 5, the prioritised requirements are then analysed using a Weighted Average Decision Matrix (WADM). ReproTizer framework has five steps as following:

- *Define requirements* Requirements engineers specify requirements list;
- *Add stakeholder*: Requirements engineers add stakeholder and assign them to requirements;
- *Score requirements*: Stakeholders score each requirements using a Likert scale from 1 to 5;
- *Compute requirements prioritisation*: Requirements prioritisation automatically are determined using WADM, after scoring requirements by stakeholders; and

[1]Link of the tool-support: https://www.SuSoftPro.ahmedalharthi.net

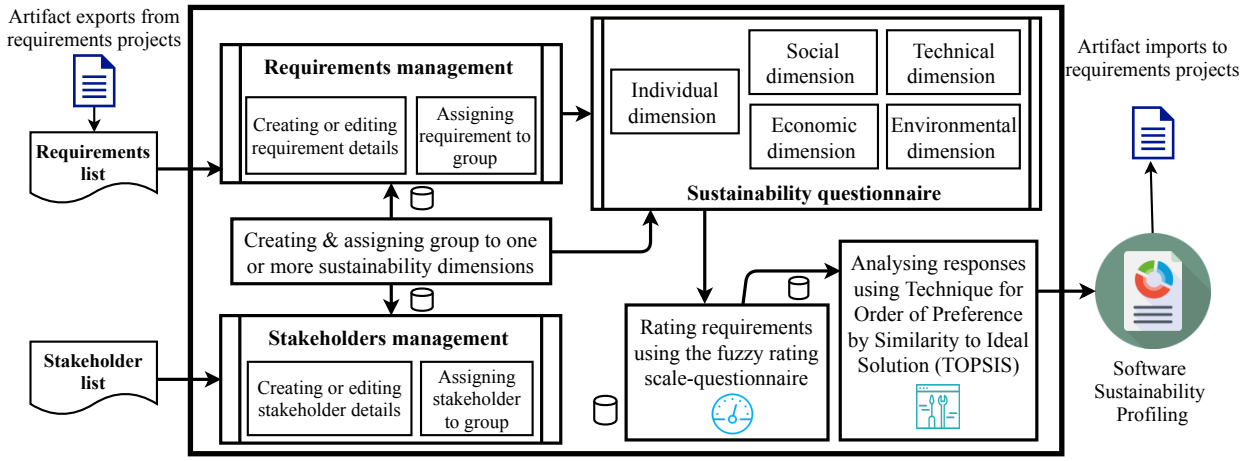


Fig. 1. SuSoftPro: Process Model

- *Generate requirements prioritisation list*: Weight of each requirement prioritisation is presented in ordered list.

*3) sureCM:* sureCM was introduced by Mairiza et al. [5], focusing on resolving non-functional requirements (NFR) such as security-usability conflicts. Like SuSoftPro, it also applies the TOPSIS method to analyse the collected data, but unlike SuSoftPro the sureCM framework does not have any tool support. sureCM framework has four steps including:

- *Identify NFRs conflict*: via conflict relationship digram, requirements engineers need to identify if NFRs have conflict;
- *Rank characterize conflict*: through recognising parameters of alternative functionality, metrics, or measures;
- *Analysing solution*: via TOPSIS the best alternative solution and the worst solution are calculated; and
- *Present selected solution*: Alternative solutions list is presented from the highest to the lowest rank.

### C. Result

As shown in Table I, both SuSoftPro and ReproTizer work with more than two criteria for analysis, and are supported by a tool, providing a fully systematic computation to prevent errors. The sureCM framework is based on a semi-automatic computation and data collection (requirements rating), which are more error-proneness than a fully automated solution. Another advantage of SuSoftPro is utilising the FRS, which allows better precision of requirements' rating. Although the FRS application provides more accurate scale than Likert scale to capture real-valued responses, the FRS is not fully friendly-to-use scale [4]. With minor orientation and guidances will be enough to use the FRS for responding.

Neither ReproTizer nor sureCM support the sustainability context whereas SuSoftPro supports and utilises a fully systematic and comprehensive discovery methodology to analyse sustainability requirements.

The core results of the comparison are summarised in Table I.

## III. Case Study

To illustrate how SuSoftPro can be applied, we used a case study from the eHealth domain, based on a real-life project, a Skin Cancer Information System (SCIS), cf. [8]. SCIS is a web-based software system to register the diagnoses of skin cancer along with the treatments. SCIS has five stakeholder roles:

1) Physicians,
2) Nurses,
3) Receptionists,
4) Administrators and Managers, and
5) Developers and IT Support.

### A. Defining Stakeholder Groups

Requirements engineers have selected 14 stakeholders (two physicians, two nurses, four receptionists, three administrators and managers, and three developers and IT supports). Five groups (corresponding to the stakeholder roles) are created and assigned to sustainability dimensions, cf. Table II. Groups are used not only to group stakeholders with related sustainability dimensions but also to associate requirements with related stakeholder groups. For instance, nurse group is assigned to individual and social sustainability dimensions as well as each requirements affecting or related to nurses are assigned to nurse group.

### B. Defining Questions

SuSoftPro generates questions/instructions according to the following format:

"*Rate the influence of the requirement on the X sustainability*",

where *X* is replaced in a concrete case by the corresponding sustainability dimension: *individual*, *social*, *technical*, *economic*, and *environmental*. There is an option to adjust each question, but we decided to continue with the generated questions for our case.

TABLE II
ASSIGNED SUSTAINABILITY DIMENSIONS TO STAKEHOLDER GROUPS

| Group | Sustainability Dimensions | | | | |
|---|---|---|---|---|---|
| | Individual | Social | Technical | Economic | Environmental |
| Physician | ✓ | ✓ | | ✓ | |
| Nurse | ✓ | ✓ | | | |
| Receptionist | ✓ | ✓ | | ✓ | |
| Administrator & Manager | | ✓ | ✓ | ✓ | ✓ |
| Developer & IT Support | ✓ | | ✓ | ✓ | ✓ |

### C. Defining Requirements

A 23 high-level requirements specification of the system in [8] are imported from a Comma Separated Values (CSV) file and assigned to related groups, cf. Table III. Each requirement is assigned to one or more groups only when the requirement will impact or belong to the associated stakeholders in the group. For example, Req. 2 *"Create a new record"* is allocated to the physician, nurse, and developer and IT support groups because they will utilise this requirement and it may affect them.

### D. Assigning Stakeholders

The user profiles for the stakeholders are created and then assigned to the groups, as shown in Figure 2. Therefore, each group is assigned to related sustainability dimensions, requirements and stakeholders. In other word, stakeholders are grouped and designated to related sustainability dimensions and requirements. Adjusting stakeholder details are automatically prevented when stakeholders start responding to the questionnaire. For example, a nurse begins answering the questionnaire, the change of the group and other related details are frozen.

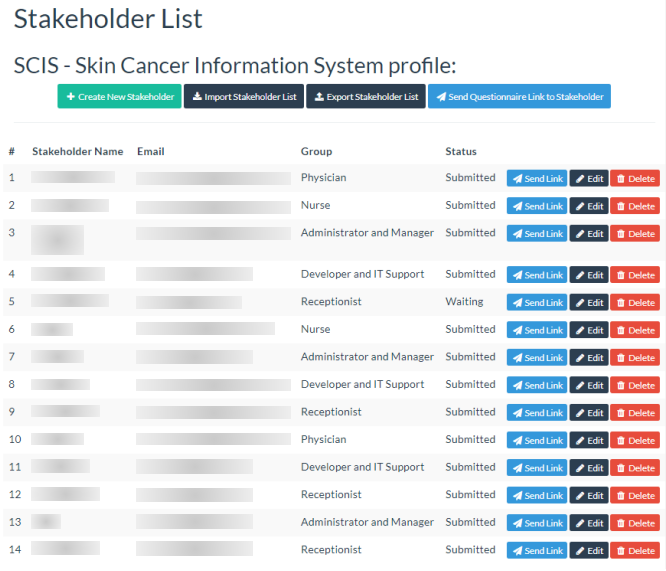


Fig. 2. SuSoftPro: Stakeholder Management (example, the names and the email addresses are blacked-out)

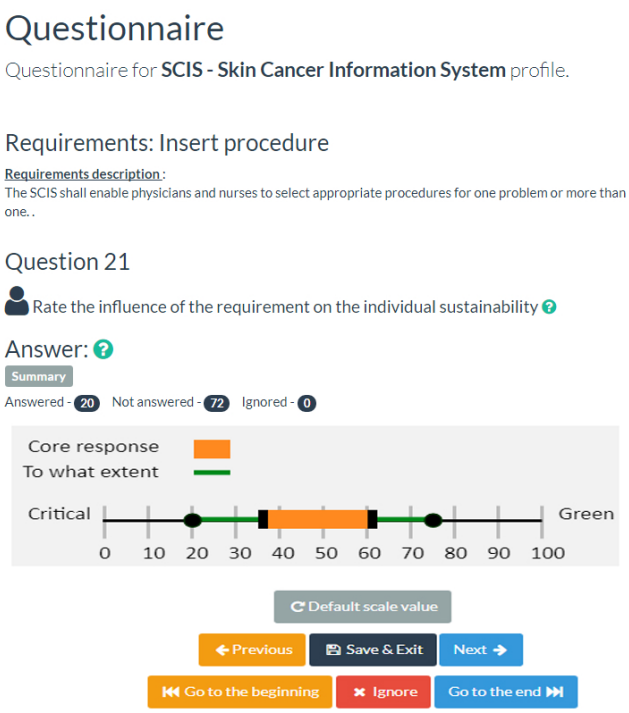


Fig. 3. SuSoftPro: An example of rating one requirement's impact on individual sustainability

### E. Rating Requirements

After building the questionnaire, generating and sending auto-sign-in link to the stakeholders to access the questionnaire, the status of all the stakeholders in the project becomes *waiting*, until they begin to respond to the questionnaire. For each high-level requirement to be rated, the stakeholder can rate its influence on the sustainability dimensions using interface presented on Figure 3. In SCIS case to illustrate the flexibility of the tool, nurses have 30 questions to answer, where

- 15 questions are on the individual sustainability perspective for the 15 allotted requirements to physician and nurse group in the SCIS, and
- 15 questions for the social perspective of the same requirements.

Physicians have 45 questions:

- 30 questions are the same as for the nurse group,
- additional 10 questions on the economic perspective of the same requirements.

TABLE III
SCIS REQUIREMENTS WITH SUSTAINABILITY RATING WHERE 1 IS THE HIGHEST AND 0 THE LOWEST POSSIBLE RATING

| # | Requirement Name | Description | Assigned Group | Sustainability |
|---|---|---|---|---|
| 1 | Login system | The SCIS shall provide system access having suitable security services. This access will have various levels that depend on user authorization. | Physician<br>Nurse<br>Receptionist<br>Administrator and Manager<br>Developer and IT Support | 0.618686 |
| 2 | Create new record | The SCIS shall provide physicians and nurses with the ability to create a new record for patients for the first time. | Physician<br>Nurse<br>Developer and IT Support | 0.495698 |
| 3 | Create new problems | The SCIS shall provide physicians and nurses with the ability to create a problem in a patients' record. When patients have a problem, the problem will be described and diagnosed. | Physician<br>Nurse<br>Developer and IT Support | 0.611013 |
| 4 | Create visit | The SCIS shall enable physicians and nurses to record each visit that may have various problems and different procedures. | Physician<br>Nurse<br>Developer and IT Support | 0.55784 |
| 5 | Edit record | The SCIS shall enable physicians and nurses to edit records by updating or adding more information. | Physician<br>Nurse<br>Developer and IT Support | 0.542436 |
| 6 | Insert procedure | The SCIS shall enable physicians and nurses to select appropriate procedures for one problem or more than one. | Physician<br>Nurse<br>Developer and IT Support | 0.410874 |
| 7 | Finalise procedure | The SCIS shall enable physicians and nurses to complete record and finalise the procedure. | Physician<br>Nurse<br>Developer and IT Support | 0.613918 |
| 8 | Access patients' record | The SCIS shall enable physicians and nurses to view record and previous problems with their procedures and any previous history that was recorded. | Physician<br>Nurse<br>Developer and IT Support | 0.473612 |
| 9 | Allocate pathology report to procedure | The SCIS shall enable physicians and nurses to allocate any pathology report to its procedure in a patients' record. | Physician<br>Nurse<br>Developer and IT Support | 0.406329 |
| 10 | Upload documents and image | The SCIS shall enable physicians and nurses to upload documents and images to a patients' record. | Physician<br>Nurse<br>Developer and IT Support | 0.489118 |
| 11 | Generate and print form | The SCIS shall enable physicians and nurses to generate forms such as, taking a test and printing it. | Physician<br>Nurse<br>Developer and IT Support | 0.432951 |
| 12 | Generate bill | The SCIS shall enable physicians and nurses to generate bills and print them. | Receptionist<br>Administrator and Manager<br>Developer and IT Support | 0.525928 |
| 13 | Hold or un-hold bill | The SCIS shall enable physicians and nurses to hold bills until the result appear, then un-hold them to continue the process. | Physician<br>Receptionist<br>Administrator and Manager<br>Developer and IT Support | 0.467628 |
| 14 | Print bill | The SCIS shall enable physicians, nurses and receptionist to print bills. | Nurse<br>Receptionist<br>Administrator and Manager<br>Developer and IT Support | 0.418866 |
| 15 | Create patients' information | The SCIS shall enable physicians, nurses and receptionist to create patients' information. | Physician<br>Nurse<br>Receptionist<br>Administrator and Manager<br>Developer and IT Support | 0.638787 |
| 16 | Edit patients' details | The SCIS shall enable physicians, nurses and receptionist to update patients' information. | Physician<br>Nurse<br>Receptionist<br>Administrator and Manager<br>Developer and IT Support | 0.624384 |
| 17 | Search feature | The SCIS shall enable all users who have authorisation to look at different information via a search feature, including patient and staff information. | Physician<br>Nurse<br>Receptionist<br>Administrator and Manager<br>Developer and IT Support | 0.49455 |
| 18 | Generate and print Financial and business reports | The SCIS shall enable administrators and managers to print various reports. | Administrator and Manager<br>Developer and IT Support | 0.565542 |
| 19 | Generate and print Financial and business reports | The SCIS shall enable administrators and managers to print various reports. | Administrator and Manager<br>Developer and IT Support | 0.487618 |
| 20 | Create new staff account | The SCIS shall enable administrators and managers to create new staff account and enter their details. | Administrator and Manager<br>Developer and IT Support | 0.5329 |
| 21 | Edit staff's details | The SCIS shall enable administrators and managers to update staff details. | Administrator and Manager<br>Developer and IT Support | 0.532949 |
| 22 | Administrator Manage role | The SCIS shall enable administrators to locate staff authorization | Administrator and Manager<br>Developer and IT Support | 0.552101 |
| 23 | Create centre's information | The shall enable administrators to establish the centre's information and entering important details such as connecting details. | Administrator and Manager<br>Developer and IT Support | 0.430374 |

There are 24 questions covering the individual, social, and economic perspective for requirements related to receptionists. Administrators and managers are assigned 52 questions to answer for administration and managements requirements covering the following perspectives (13 questions each): economic, technical, social, and environmental perspectives. Developers and IT people have 92 questions for all the requirements covering 23 questions on each individual, technical, economic, and environmental sustainability perspective, see Table III.

Guidance on how to use the FRS is provided for stakeholders, so stakeholders such as nurses or physicians, who have not seen or used the FRS before, will be easily guided. They also had

the ability to save their responses and return back to continue. An option for skipping any question for certain requirements within particular sustainability dimension is implemented. For example, a physician was asked to rate the influence of Req. 6 *"Insert procedure"* on economic sustainability; the physician was able to skip this question. However, the question has a probability to be answered by other stakeholders such as other physicians and developers who are assigned to rate Req. 6, for the economic dimension.

### *F. Analysing Sustainability*

As the next step, SuSoftPro applies the TOPSIS method and creates the sustainability profiling of the system. A systematic computation of TOPSIS is performed and recalculated when each stakeholder submits their response. Also, rated requirements with its questions are automatically locked when any stakeholder begins to rate it, so engineers can not amend them.

### *G. Generating Software Sustainability Profiling*

The created profiling presents in the dashboard in Figure 4. Based on the simulated responses we used to illustrate the example (where only 13 out of 14 stakeholders submitted their responses), the overall sustainability of the SCIS has ★★★ three-star rating (3 out of 5). The five sustainability dimensions are presented by a bar chart:

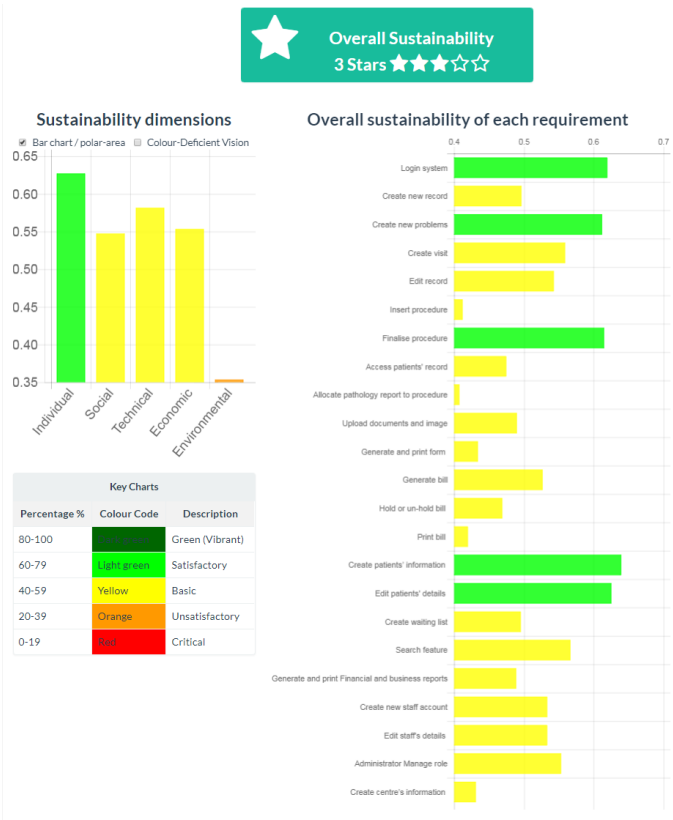


Fig. 4. The SuSoftPro Dashboard for the SCIS profile

- Only the individual dimension is in a *satisfactory range* which is more than 0.60 (the corresponding bar in the chart is *light green*).
- The technical, social and economic dimensions are between 0.54 and 0.58 (the corresponding bars in the chart are *yellow*).
- The environmental dimensions is in an *unsatisfactory range* which is around 0.35 (the corresponding bars in the chart are *orange*).

The sustainability value of each requirement is indicated in Table III. The value in the result is between 0-1 where in the TOPSIS method 0 represents the worst ideal solution and 1 is the best ideal solution [9].

## IV. Discussion

SuSoftPro is an automated solution in the sustainability context to analyse sustainability requirements based on questionnaire, in which quantity data gathers via FRS questionnaire and analyses using TOPSIS. The result presents as sustainability profiling for software having a five-star rating label, visualisation of the degree of sustainability dimensions, and bar graph of overall sustainability level for each requirement.

From the comparative evaluation result, both SuSoftPro and ReproTizer approaches are based on individuals perspective. The perspective is important to change sustainability of software when users' opinions are addressed and taken into account. Scholars of social practice theory believed that practices and perspectives of individuals in the performance of daily tasks stimulate social, economic and environmental changes [10]. The SuSoftPro tool aggregated all stakeholders' requirements. This enables the recognition of diverse visions and voices into decisions that are needed to develop sustainable software. Thus, the point of sustainability perspective while analysing requirements could be the main force in providing sustainable software in the early stages.

Besides, providing FRS in SuSoftPro to capture individuals views was necessary to prevent imprecision. However, there is the need for reconciling plurality through supporting stakeholders with the diversity of points of view that ensure sustainability [2].

As the case study demonstrated, practitioners were supplied with information related to sustainability aspects. The sustainability profiling presented sustainability scores for each requirements and sustainability dimensions. These scores will improve the sustainability attention and allow practitioners to provide sustainable software. For example, the lowest sustainability scores in SCIS was Req. 9 *"Allocate pathology report to procedure"*, so practitioners could give more attention to improve this requirements and acceptance as well as increase users satisfaction which lead to sustainability [11].

Additionally, the tool allows requirements engineers to create groups with regard to stakeholders diversity or role. For example, groups in SCIS profiling were divided into user role. Grouping stakeholders and requirements are not only to reduce the number of questions but also to express their opinion about what is related to them. Also, there are two ways to

invite stakeholders either with a public link to accommodate more stakeholders with self-registration or being registered by the engineers.

Two different colours are provided for practitioners with colour-deficient vision in the tool. The red colour is replaced with blue when the colour-deficient vision is opted. This option ensures better accessibility and equally user experience to read sustainability profile because one in every 12 people has colour vision deficiency [12].

Intuitive design is taken into account during designing the tool. For practitioners, the tool divided into logic sections including a dashboard, questionnaire, requirements, stakeholders, and profiling. A systematic computation of stakeholders responses after submitting is implemented to prevent error. Icons and colours also are provided for an effortless understanding of the tool. However, stakeholders may face difficulty to understand the FRS when they start to respond [4]). A guidance with example is developed to accomplish rating and increase the usability.

The tool also allow integration with commonly used requirements engineering tools such as ReqMan and Rational DOORS: Its export and import features allows the exchange of requirement specifications using the CSV format.

SuSoftPro has emerged to:

- Capture more individuals perspective with the diversity and accurate impression,
- Analyse software requirements in sustainability context, and
- Present the result as a sustainability profiling.

However, a few limitations need to be taken into account. There is need to provide a standards for sustainability five-star rating label to specify the minimum level of sustainability performance that software should meet before they can be developed. Also, when the number of requirements is increased and a group has assigned more than two sustainability dimensions, the number of question will be large either double or treble requirements. This large number could lead to take a long time for responding to a questionnaire, so stakeholders might feel more annoying. An initial optimised solution, requirements engineers can divide a group that allotted to more than two sustainability dimensions into two groups and then assign them to one or two different sustainability dimensions. Another solution is to leverage machine learning to assign stakeholders and divide questions between one group. We did optimise the number of questions in the tool through establishing a group and assign stakeholders and requirements to it. This solution assists to reduce the number of questions about 20-50% in some cases.

## V. Related Work

Some works on embedding sustainability in the software development process, e.g. [13], are focusing on environmental aspects. In SuSoftPro, contrary to them, we cover individual, social, economic, technical and environmental dimensions.

Porras et al. [14] proposed a manually model-based analysis to evaluate the ICT projects wrt. sustainability effect. Although the model covers sustainability dimension and impacts, the model is not simple and systematic approach to measure sustainability during software developments and usages. There is limited of stakeholders involving to provide sustainability perceptions, so this limitation will lead to a lack of sustainability perceptions.

Mahaux [2] suggested that additional analysis activities need to have support from participants who are involved as stakeholders in the process of software developments. Hence, involving supported participants will ensure sustainable software. This argument emerges the need of a tool involving supported participants easily, and the SuSoftPro is developed to involve supported participants vis providing their perspective as support.

Al Hinai [15] introduced a number of metrics and an accompanying method for analysing social sustainability requirements of software systems. The method is not systematic and easy to elicit the values because of the variety of translating value, and the potential of conflicting value types.

Chitchyan et al. [16] presented the results of a qualitative study, which goal was to explore perceptions and attitudes towards sustainability, of requirements engineering practitioners. The lack of methodological support was one of the identified barriers to the engagement with sustainability design in RE practice. The SuSoftPro is a solution to overcome this barrier through engaging practitioners and stakeholders to analyse sustainability.

Becker et al. [1] compared two projects to illustrate the software development within and without sustainability design, so they stated that requirements engineering is the key to sustainability through following interdisciplinary, stakeholder-focused approach, and systems-oriented as well as supporting by higher management and executives. Their analysis approach is to visualise the systems' potential impacts as immediate, enabling, and structural impacts within the five sustainability dimensions. While SuSoftPro visualises the sustainability level of software and requirements within the five sustainability dimensions. Both practices could assist to understand the sustainability of software systems and their impact on sustainability aspects.

A number of requirements engineering tools with general or specific features for eliciting, analysing, modelling, tracing, documenting, managing, and verifying and validating requirements [17]. Some of these tools are begin to facilitate web-based solution in order to allow collaborative access to resources, while others particularly dominated tools are becoming more complex and difficult to use. However, none of them has the ability to analyse sustainability requirements by involving stakeholders with regard to the sustainability dimensions. Hence SuSoftPro was developed to enable the analysis of sustainability through extensive questionnaires on requirements which cover the sustainability context of the software and can include a wide range of stakeholders.

## VI. Conclusions

We evaluated SuSoftPro with two approaches that developed a methodology using Multi-Criteria Decision Analysis (MCDA) and used for requirements engineering domain. The evaluation demonstrated a number of advantages of SuSoftPro for the sustainability analysis: such as tool support, FRS to allow better impression of requirements' rating, and last but not least a systematic methodology to analyse the sustainability of the system under development.

Also, we explored the viability and demonstrated the usability and feasibility of SuSoftPro by conducting a case study from the eHealth domain, based on a real-life project: a Skin Cancer Information System to store patient health records.

**Future work:** We are conducting an empirical assessment of SuSoftPro. The evaluation methodology is designed to capture the views of professional practice experts in sustainability requirements through qualitative approach, using qualitative methods [18]. The data is collected via online questionnaire. Then, these data will be analysed using predefined themes such as the usefulness of the framework and developed tool, and the potential of adapting the framework and tool. Furthermore, we are currently conducting two other case SuSoftPro studies from education domain, having two different eLearning systems and large number of participants in higher education institution from two countries.

## Acknowledgements

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