Designing sustainable ICT platforms

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Abstract. The sustainability of ICT platforms is becoming increasingly important with a potential explosion of negative social and environmental impacts of new technologies. To analyse such impact, several frameworks exist; however, SusAF (Sustainability Awareness Framework) is the most widely applied. This paper reports on a multiple case study on the use of SusAF to evaluate existing ICT platforms. Identified sustainability issues create a basis for design suggestions for future versions of the platforms. The main findings include sustainability challenges and design suggestions for sustainable development of selected ICT platforms. Future work suggests the exploration of a variety of ICT platforms and the application of different sustainability approaches.

Keywords: Sustainability design · ICT platforms · SusAF · Design suggestions.

1 Introduction

Information and communication technology (ICT) platforms play an important role in ensuring all aspects of sustainability, including social, environmental, individual, technical, and economic sustainability. ICT have direct and indirect effects on software and hardware[12]. Direct effects, such as the energy consumption associated with the production, operation, and disposal of ICT systems, are referred to as "first-order effects"(immediate effects) [12]. These represent the immediate environmental consequences of ICT itself, regardless of how it is used in other sectors. Second-order effects (enabling effects) include the consequences of processes changing with the use of ICT, while third-order effects (systemic effects) are seen as long- and medium-term changes in behaviour, such as changes in consumption patterns and change in economic structures [12]. In the context of sustainable development, information systems and software development processes emerge as critical enablers for shaping a future where IT solutions are not only innovative but ethical and trustworthy. Today, software design and evaluation processes are primarily based on direct functionality, cost, and monetary value, with no sufficient focus on the wider social and environmental impact [13, 3]. Shifting the focus of software design and evaluation towards sustainable

development constitutes a major change, one that moves beyond traditional metrics such as functionality and cost to include broader societal and environmental considerations. As seen in [3], there are several approaches to evaluate and create awareness of sustainability. One of the approaches, known as the Sustainable Awareness Framework (SusAF), was originally developed by Becker et al. [5] and aims to structure the effects of software systems into five dimensions. Three of them have been used in several sustainability models since the 1980s: the economic (monetary), the environmental, and the social dimensions. To this end, individual and technical dimensions were added. In a review study of techniques to take sustainability into account in requirements engineering, SusAF is the most discussed approach, although the application of the framework appears to be limited [3]. However, sustainability design in ICT platforms usually has a limited focus on a specific dimension, for example environmental sustainability (e.g.,[11]) or social sustainability(e.g.,[16]).

To fill this gap, this work explores sustainability challenges across dimensions in ICT platforms and how these insights can inform the design of those platforms. During workshops, we apply SusAF on four ICT platforms for communication, coordination, and collaboration over the internet; 27 Crags, Instagram, Miro, and Strava. The contribution of this paper lies in the identification of sustainability issues in various ICT platforms and in corresponding design suggestions across dimensions.

The remainder of this paper introduces background work on sustainability and design, focusing on SusAF (Section 2). In Section 3, we elaborate on the method and introduce briefly the four ICT platforms. In Section 4 we discuss the results, based on sustainability analysis of the platforms. Design suggestions are presented in Section 5, in order to address critical issues raised during workshops. Section 6 discusses the main findings and limitations of the study, while Section 7 concludes the paper, pointing to future work.

2 Background

Sustainability in ICT design has gained increasing attention due to the environmental impact of digital technologies. Several frameworks—such as SusAF[9, 10], AMDiRE[15], and INSURE/ENSURE[17]—have been developed to support the integration of sustainability into software engineering. Specifically, SusAF framework is a well-known approach in sustainability design [9, **?**], while the Artifact Model for Domain-independent RE (AMDiRE) [15] is a reference artifact model for domain-independent requirements engineering, with applicability in many industrial cases. The framework INSURE/ENSURE (INcorporate SUstainability design in softwaRe Engineering life cycle) [17], is a meta-model for current and future sustainability requirements, captured in the viewpoints and business goals of stakeholders. These approaches enable practitioners to incorporate sustainability requirements into system design, while their evaluation has been predominantly conducted in academic contexts. The above approaches allow software engineers to embed sustainability requirements when developing

a software system. It is also common practice for researchers to evaluate their own developed sustainability approaches, which provides a likely biased perspective [3]. Furthermore, existing approaches and guidelines aim to incorporate sustainability principles into the practices of software designers, engineers, and other ICT professionals. Despite the growing availability of sustainability guidelines for ICT platforms, their practical integration into real world development environments remains limited [3]. Sustainability design in ICT platforms faces several challenges, including a lack of standardization in guidelines and metrics, limited integration with agile workflows, and the absence of tools for real-time sustainability assessment during development [7]. These structural and methodological gaps are further compounded by a conceptual limitation: many existing approaches adopt a single perspective on sustainability. Instead of addressing its multifaceted nature, they tend to focus narrowly on a single dimension—typically environmental (e.g., [11]) or social (e.g., [16])—rather than embracing a comprehensive, multidimensional framework.

Table 1. Description of selected ICT platforms.

	Characteristics		
	Aim	***Target group***	***Features***
27Crags	Platform for outdoor climbing	climbers who contribute and publish content in free or premium version	Users can create and share "topos"(topographical route maps), track personal achievements and collaborate with others
Instagram	social media platform	internet users who share photos and videos	Users can post content in various forms, e.g., a single-image post, a carousel-post, an "Instagram Reel", a live stream video, or a story.
Miro	collaborative platform for synchronous and asynchronous collaboration	teams who want to brainstorm, plan, and work together in a shared virtual space	Key tools include tagging teammates, tracking cursors, voting features, timers, and live reactions. Miro has an extensive template library and integrates with more than 160 tools, including Google Workspace, Slack, and GitHub.
Strava	social fitness platform	fitness enthusiasts	The app integrates with various fitness devices, enabling users to monitor their performance, join challenges, and interact with their own community or build new communities.

2.1 Sustainability Awareness Framework (SusAF)

Addressing sustainability in ICT requires multidimensional, systemic strategies that are embedded in existing practices and tools. The SusAF framework is a comprehensive model based on five interconnected dimensions: environmental, technical, individual, social, and economic[9, 10]. It incorporates a temporal perspective—immediate, enabling, and structural effects—and provides practical tools such as the Sustainability Awareness Diagram (SusAD) with guiding questions to support reflection during development. Immediate or direct effects involve the effects of the production and use of the ICT system [12]. The enabling effects refer to the outcomes of applying ICT, while systemic effects represent the long-term impacts of ICT, including behavioral changes and economic structural transformations [12].

SusAF framework is designed to help software developers and stakeholders consider the sustainability effects of IT products and services [2]. SusAF draws on previous sustainability models, particularly the three-dimensional model of the Brundtland Commission, which balances environmental, economic, and social sustainability [1]. The SusAF extends this model by adding two key dimensions: the individual and technical dimensions, which separately analyse the impact of digital solutions on individual users and the inherent sustainability of the technology as a viable technical artifact. Aspects within these dimensions are often interlinked, so that an effect in one area can have a positive or negative effect on another effect in the same or different dimension, possibly on another level, and these chain-of-effects are important to identify in a standard technique that has been developed for the usage of this framework.

3 Method

This paper reports on a multiple case study design in the context of exploratory research [4], aiming to explore sustainability challenges in ICT platforms (i.e., 27 Crags, Instagram, Miro, and Strava) and how these insights can inform platform design. Table 1 provides a brief overview of the key features of selected ICT platforms, which serves as a foundation for the subsequent sustainability analysis. This work applies SusAF in sustainability design in four cases. The case studies were conducted in the fall of 2024, during an MSc course project on sustainable development of IT systems. Four workshops were organised by MSc students in the course who invited 3-4 students to participate in a 2-hour workshop. A structured approach was applied across all workshops, where the ultimate goal was to explore and analyse sustainability issues in one predefined platform. Workshop participants were recruited through convenience sampling from MSc students' network. Participants were also students in the same university, with prior knowledge or experience related to the selected ICT platforms. Recruitment was based on voluntary participation and participants signed consent forms prior to the workshops. The SusAF framework was deployed in a collaborative setting, with participants undertaking three tasks in a printed version of the Sustainability Awareness Diagram (SusAD)[9]. First, participants identified

Table 2. Examples of sustainability issues in each case.

	Case studies			
	27 Crags	***Instagram***	***Miro***	***Strava***
Social	Community Interaction	Polarization	Workplace Interaction	Networking
Individual	Well-being	Online bullying	Inactivity	Sense of accomplishment
Economic	Subscription model	Ad revenue	Subscription model	Pressure to buy new gear
Environmental	Nature preservation	Environmental awareness	Storage / Server Resource Usage	Littering nature
Technical	Real-time information sharing	Security issues	Limited number of users	Hardware dependent

the sustainability issues of an ICT platform in a mapping exercise with SusAF and discussed these issues in five dimensions. Second, they classified the issues into levels of effects. Third, they identified the chain of effects within and across dimensions. Participants were delegated to different sustainability dimensions to work during the workshop, based on their background and interests, but were not limited in discussions to this dimension exclusively. Workshop participants were MSc students with previous experience or knowledge on the corresponding platform. Table 2 presents representative examples of sustainability issues that were identified during workshops.

4 Results

The findings suggest that economic and social sustainability is a common issue across cases. Economic sustainability in four platforms involves creating stable and diverse revenue streams for long-term financial health without compromising the user experience. Social sustainability encompasses issues related to community interactions and participation, as well as inclusion in digital platforms. Table 2 presents few examples of sustainability issues in each platform. In terms of economic sustainability, revenue models provide essential financial sustainability and allow these platforms to invest in innovation, improve user experience, and expand their services, contributing to their overall economic sustainability. For instance, 27Crags employs a freemium model, offering basic features for free while charging for premium content and advanced features. In addition, Instagram relies heavily on advertising, leveraging its user data to provide targeted ads, and has integrated shopping features that allow businesses to sell products directly on the platform. Strava generates revenue through subscription services like Strava Summit, offering advanced features for a fee, and through advertising partnerships and data monetization by selling aggregated activity data to interested organisations. Miro operates on a subscription-based model with dif-

ferent service tiers (free, starter, business, enterprise), offering to users and large enterprises customised solutions that include additional features.

In terms of social sustainability, community interactions, engagement, and inclusivity play a vital role in maintaining communication with the community. For instance, the climbing community grows and needs to share experiences and achievements with users. The social role of the platform was discussed as "a conversation starter". For climbers, 27 Crags provide a platform to share achievements, create discussions, and connect with friends, which could give a systemic increase in the community feeling. In addition, a common challenge in the climbing community is related to parking or trespassing on cultivated land. It has been customary for the local climbing community to make agreements with the land owners when new climbing areas are established. With 27 Crags, new agreements can be informed in real-time, as well as local custom. The group found an improved relationship between land owners and climbers as a possible systemic effect of online platforms like 27 Crags. Miro enables interaction and work-related workshop sessions for hybrid/ distributed teams, which mitigates the loss of community that non-physical work environments may lead to. Understanding the interconnected nature of various actions and their consequences is crucial for designing effective platforms. The following chain of effects are examples on such chains that were discussed during the workshops and illustrate how different platforms and features can lead to a series of outcomes, related with five dimensions of sustainability (Table 2): 1) Individual: health, mental health, and wellness, 2) Social: community and social dynamics, 3) Environmental, 4) Economic: business growth, and 5) Technical: user experience. Both positive and negative impacts are illustrated on each topic, while there exist overlaps in dimensions.

4.1 Individual sustainability issues

Individual sustainability issues in ICT platforms are closely tied to health and mental wellness. One example in health and wellness promotion refers to the 27 Crags' platform. Its premium subscription model (economic sustainability) facilitates the inclusion of premium crags, which are subject to quality control to ensure the enhancement of "topo" quality (technical sustainability). Enhanced "topo" quality could positively influence the quality (perhaps its frequency) of outdoor climbing activities, associated with numerous mental and physical health benefits, such as cardiovascular health, muscle strength, and flexibility (individual sustainability). The combination of these benefits promotes a healthier lifestyle within the climbing community and contributes to the overall well-being of individuals. Another example from the Strava platform explains a chain of effects at the individual level (Fig.1). Specifically, using Strava has the immediate effect of increasing training frequency among users, fostering a sense of achievement when individuals maintain a consistent and healthy training regime over an extended period. This leads to various systemic effects. On the positive side, regular physical activity is associated with health, strength, and fitness, as well as mental health benefits (e.g., reduced symptoms of depression and anxiety,

improved mood, and enhanced cognitive function). However, it is important to acknowledge the potential negative effects of excessive training. If the volume and intensity of training exceed healthy limits, individuals may experience physical burnout, overuse injuries, among other issues. Mental health issues also affect interaction with platforms. Two examples of mental health were discussed in relation to Instagram's effects. The first chain of effects illustrates the immediate effects of using Instagram, such as comparison and scrolling. For example, Instagram often facilitates users to compare their lives or bodies with others, which can negatively impact self-esteem and body image. One participant mentioned that *"I feel like many influencers on Instagram manipulate their photos."* This manipulation can result in unrealistic body image standards, further exacerbating negative self-perception, which can initially lead to mental health issues through the development of insecurities and addiction. The discussion also highlighted the issue of endless scrolling, which can contribute to social media addiction. These effects can lead to serious mental health challenges, such as anxiety and depression. This underscores a need for responsible use of social media and the implementation of measures to mitigate its negative impacts on mental health. Similarly, in the social-individual dimensions, workshop participants discussed the possible negative outcomes of communication on social networks. First, the immediate effect of endless scrolling on Instagram can lead to personal addiction. When combined with user communication, this behavior can create a "rabbit hole" effect, contributing to increased polarisation. This shows how individual behaviours can have broader social consequences. For example, individuals with similar views may cluster together, leading to a "rabbit

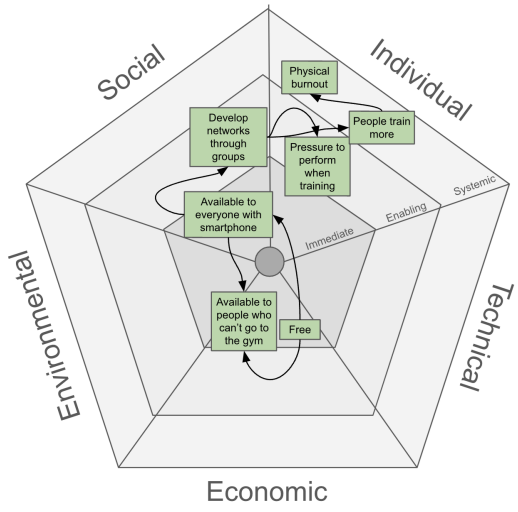

Fig. 1. Example for chain of effects in Strava platform.

hole" effect where users are repeatedly exposed to one-sided perspectives. This can reinforce existing biases and increase polarisation within the community.

4.2 Social sustainability issues

Examples of chain of effects on the Instagram and Miro platform explain community and social dynamics. In the social dimension, Instagram facilitates instant communication, which could enhance globalisation by connecting people across the globe at a structural level. In turn, this could promote travel and trade, both of which have a significant environmental impact on climate change. The immediate environmental effects of globalisation further cause activities, such as online shopping, increasing the demand for transportation and packaging, and the operation of data centres that consume substantial amounts of water, materials, and energy. These activities collectively contribute to Greenhouse Gas (GHG) and resource depletion, thereby accelerating climate change.

In the Miro platform, the real-time collaboration capabilities can lead to communication challenges, particularly in larger groups where maintaining conformity (e.g., to a common standard of use to avoid colliding features) becomes increasingly difficult. These communication issues can have various effects on individuals. As team sizes grow, it becomes challenging to monitor all participants in a session, leading to potential disengagement among some members, who may become inactive if they feel that their contributions are overlooked. On the other hand, certain individuals may play a dominant role that can skew group dynamics and create a feeling of "being unheard" to other members, affecting the dynamics of the individual and social team. Lastly, the presence of a dominant member can disrupt the balance of group interactions, leading to a less inclusive and collaborative environment. The interconnectedness of the above dimensions is evident and illustrates the complex interplay between social, individual, environmental, and economic factors.

4.3 Environmental sustainability issues

Environmental sustainability is illustrated within a diverse chain of effects in 27crags and Strava. Starting from the technical dimension, the implementation of GPS-tracked paths by 27crags has an immediate effect to provide climbers with paths. This adherence to established paths minimises environmental degradation by reducing the wear and tear on natural landscapes, enabling the preservation of nature, which is crucial to maintaining biodiversity and ecological balance. In addition, reduced environmental impact fosters a positive relationship with the local community and landowners, who are more likely to support climbing activities within responsible and sustainable practices. This positive relationship is essential for the long-term viability of the climbing community, as it encourages cooperation and mutual respect between climbers and local stakeholders.

In the second example of Strava, the chain of effects encompasses the various impacts may have on nature and the ecological system. Strava enables users to discover new routes and explore new locations. This can have a dual effect: on the

one hand, it can lead to a more even distribution of visitors across different areas, reducing the pressure on any single location. However, it can result in certain areas experiencing disproportionately high visitor numbers due to the sharing of popular routes on the platform. This phenomenon, known as overtourism, can lead to increased littering and environmental degradation in these areas. The economic consequences of such environmental damage include the loss of natural resources and the potential decline in tourism revenue. Additionally, increased littering necessitates greater costs by government authorities to clean up and maintain these natural areas.

4.4 Economic sustainability issues

The effects of business growth were also discussed on platforms like 27crags and Miro. The 27crags platform has an immediate effect of making climbing information readily accessible. This accessibility facilitates the expansion of the climbing community by providing newcomers with essential information. As the number of climbers increases, there is a corresponding increase in demand for climbing equipment and services, creating new business opportunities and economic growth within the climbing industry. The growth could be driven by consumers spending on climbing gear, training services, and related activities. In addition, expansion of the climbing community can stimulate innovation and competition within the industry, further contributing to its economic development.

On the Miro platform, the requirement for a subscription to access all features imposes a limitation on the number of users who can benefit from unlimited access. Consequently, ongoing processes and integrations within the platform may experience a delay in overall flow. This challenge is further compounded by the necessity to keep pace with the development of external tools, such as updates from Google, which can additionally impact the platform's performance. The continuous need to adapt to these external developments can create additional strain on the platform, potentially affecting the efficiency and user experience for both paying and nonpaying users.

4.5 Technical sustainability issues

Technical sustainability issues in ICT platforms encompass effects that have been already discussed in previous dimensions, such as energy consumption, environmental impact of data storage and processing infrastructure, but also issues such as software maintainability and hardware longevity. One example though that was highlighted was the rating system. Specifically, the star rating system on the 27crags platform relies on user input to provide a democratic measure of quality. During the workshop, a significant discussion focused on the potential manipulation opportunities inherent in the star rating system. However, when the number of user inputs is limited, the system can become influenced by a small number of users. This concentration of control can be exploited, making the system susceptible to manipulation for the benefit of specific individuals or

groups. Such manipulation undermines the integrity of the rating system, leading to biased and potentially misleading quality assessments. This highlights the challenges associated with democratic quality measurement systems, particularly in environments with low participation rates.

5 Design Suggestions

In an effort to develop more sustainable ICT platforms, the study concludes with design suggestions aiming to address critical issues, raised during the study.

5.1 Environmental protection

Adopt conscious resource usage practices The development of sustainable ICT platforms should focus on conscious resource usage, aiming to optimize energy consumption, reduce waste, and promote responsible use of digital and physical resources. Adopting environmentally responsible behaviors could be achieved in several ways, for instance, by leveraging data-driven insights, automation, and user engagement strategies. For example, Miro is designed to streamline collaboration and reduce emissions by digitizing processes, but it does not guarantee a reduction in emissions. The use of AI and the need for many processes to run synchronously in larger teams using Miro, can result in significant energy consumption. The large-scale storage and handling of data require substantial energy, and a potential risk is that a significant amount of data may be stored unnecessarily for prolonged periods. To minimise its environmental impact, Miro should ensure that the data centres in use are powered by renewable energy. This shift could help reduce its overall carbon footprint and promote more sustainable operations. Furthermore, the environmental effects of this case led to a discussion on the cost-benefit evaluation of the AI features implemented by Miro. AI is a hot topic in the current digital climate, and this has resulted in an explosion of AI tools on a variety of platforms However, AI consumes more energy than many other technical features Therefore, it may be worth considering whether Miro AI features provide enough benefits to be considered environmentally sustainable.

Focus on cultural preservation A sustainable ICT platform should focus on cultural preservation and incentives as a way to bridge the gap between technology, cultural heritage, and environmental protection through documenting, promoting, and incentivising sustainable cultural practices. For example, 27Crags' community of climbers have previously volunteered to maintain crags out of interest. The introduction of premium crags in 27Crags has changed community incentives by offering an opportunity to preserve nature and promote community-driven conservation efforts by rewarding individuals who actively contribute to cultural and environmental sustainability. This is also an opportunity to earn financial benefits by creating or posting new crags.

Protect vulnerable vegetation Vulnerable vegetation plays a crucial role in biodiversity, climate regulation, and ecosystem stability. A sustainable ICT platform could directly or indirectly protect endangered plant life, e.g., by providing data-driven solutions, supporting collaborative conservation efforts, and engaging communities in preservation initiatives. In the case of Strava, certain systemic effects related to overtourism, such as vulnerable vegetation and litter in nature, were identified. This platform has contributed to making certain areas and trails highly attractive, which will affect wildlife, local societies, and the natural environment. The popularity of different trails, running activities with off-road paths, and significant elevation changes - affects the trails. An example of a popular area is the Lofoten Skyrace, where the organisers had to change the trail route to let the original trails rest. This case raises the question of how Strava or similar IT platforms could contribute to protecting vulnerable vegetation.

5.2 Social well-being

Reduce addiction to social media A sustainable ICT platform should provide healthy digital habits, promote mindful use, and provide psychological support while ensuring data privacy and ethical use of AI. Social media addiction has become a growing concern, affecting mental health, productivity, and social well-being. Excessive use of social networks is linked to anxiety, depression, reduced attention span, and decreased social interactions in the real world. Instagram is a good example here, as one of the potential effects was how addiction to Instagram could increase mental health issues. To address this, Instagram can implement features that provide users with feedback when they have spent an extended amount of time on the app. Another suggestion is to implement a daily scrolling limit, such as allowing people to use Instagram for a maximum of three hours per day. These features can encourage healthier usage habits and promote digital well-being.

Reduce the social and performance pressure among users A sustainable ICT platform designed to promote social well-being and mental health should focus on reducing stress, encouraging balanced digital engagement. In the digital age, users often experience social and performance pressure due to comparison culture, unrealistic expectations, and the demand for constant productivity on social media, workplace platforms, and digital communities. The Strava case revealed that the platform can foster a culture of comparison, where users feel pressure on the performance metrics and the visibility of others' data, which can lead to unhealthy competition and stress. The default user settings allow sharing of various metrics, like distance, speed, and duration. Strava can address users' social and performance pressure by making privacy settings more accessible, allowing easier control over shared data. This can help to reduce the pressure of constant comparison. Similarly, to keep posts engaging even with limited data sharing, Strava could introduce fun features that add humour.

Take preventative action for increased polarisation A sustainable ICT platform designed to prevent polarisation and promote social well-being can help foster constructive dialogue, emotional resilience, and critical thinking, creating healthier online and offline interactions. Increased social and ideological polarization has significant impacts on mental health, community well-being, and social cohesion. Digital platforms and social media often amplify divisions through algorithm-driven echo chambers, misinformation, and hostility, leading to stress and anxiety. For example in the case of Instagram, during the workshop, discussed issues of polarisation and highlighted how communication and scrolling can contribute to increased polarisation. A mitigation strategy for Instagram can be to review its algorithms to ensure that users are exposed to various types of content, especially on political topics. This approach can promote a more balanced understanding of different perspectives. By prioritising content diversity, Instagram can help create a more inclusive and less polarised digital environment.

5.3 Accessible ICT platforms

Lower the technical competence threshold Digital accessibility and inclusivity are essential for creating sustainable ICT platforms that support equal participation, social engagement, and knowledge sharing. Many IT platforms require a high level of technical competence, which can exclude individuals, e.g., from marginalised groups, elderly populations, and people with disabilities. Lowering the technical competency threshold ensures that different users can interact, collaborate, and contribute in a healthy social environment. For instance, in the Miro case, several of the identified effects of the platform relate to how the tool impacts team dynamics, particularly on belonging and inclusion. One factor of exclusion is the technical threshold for moving workshops onto a digital platform with an increasing amount of features. The complexity demands a certain level of technical competence to participate in organised activities. As mitigation strategies could be include an explanatory introduction to the typical uses of Miro and to avoid distractions by minimising or customising the amount of features that are visible on the screen during a session.

5.4 Transparency and data accessibility

Increase transparency of data A sustainable ICT platform designed to increase transparency on data should focus on open access, verifiable reporting, secure sharing, and user-friendly visualisation tools. In an increasingly digital world, transparency and data accessibility are critical to ensuring accountability, informed decision making, and public trust. Many platforms supported by government, business, healthcare care, or else, require open and transparent data sharing mechanisms to promote fairness, security, and responsible data use.

The case of Instagram argues that by providing greater transparency through the release of detailed information regarding the environmental impacts of their data centre operations and Instagram use, Meta can strengthen the credibility

of their sustainability initiatives. This promotion of sustainable practices can, in turn, enhance global environmental engagement.

5.5 User experience and engagement

Build a reliable rating system Traditional star rating systems often lack depth, personalization, and contextual relevance, leading to biased reviews, fake ratings, and reduced user engagement. A sustainable ICT platform that builds a reliable star rating system can enhance user experience and engagement by making the ratings more interactive and valuable. For example 27crags has a star rating system which was identified to be unpredictable and easily manipulative. The current subscription model for posting premium crags encourages authors to increase clicks on their crags. Higher ratings result in more clicks, generating more income for the authors. Consequently, a user has to review additional information about the crag in order to determine the accuracy of a star rating, such as the number of climbers who have previously climbed it, comments, and possibly the author. The case suggests several solutions to limit the possibility of misusing ratings. One solution is to adjust the information in the star rating display by including the number of ratings next to the stars and excluding the author's own rating, as this may be biased.

6 Discussion

This study explores sustainability issues in four ICT platforms, and identified chain of effects that span multiple dimensions. The case studies of 27 Crags, Instagram, Miro, and Strava illustrate the diverse ways in which ICT platforms can impact sustainability. Despite their different purposes and user groups, these platforms share common challenges and opportunities related to sustainability. For instance, all platforms face issues related to energy consumption, data privacy, and user engagement, albeit in different contexts. There are notable similarities between platforms in terms of their impacts on sustainability. Economic sustainability is a common theme, and the four platforms employ various revenue models to ensure financial health and viability. These revenue models provide essential financial sustainability, allowing platforms to invest in innovation, improve user experience, and expand their services. Social sustainability is another shared aspect, with platforms that foster community interactions and participation. Specifically, maintaining communication with their respective communities, enhancing the sense of belonging, and inclusivity play a vital role in these platforms. In addition, environmental sustainability is addressed more directly in platforms related to activities in nature, like 27 Crags and Strava where the issue here is to focus on nature preservation and to minimise environmental degradation. Technical sustainability is evident in the platforms' efforts to maintain and evolve their systems, ensuring usability, security, and scalability. Lastly, individual sustainability is considered, with platforms addressing user well-being, privacy, and safety.

The identified chains of effects highlight the interconnected nature of actions and their consequences across these dimensions. Several examples of effects were found in six broad areas (health and wellness, mental health, community and social dynamics, environmental sustainability, business growth, and user experience). One observation is that health and mental health issues are the most discussed issues together with community and social dynamics. This suggests a significant concern for the well-being of individuals and the social fabric influenced by such platforms. The comparison of these platforms highlights the importance of context-specific strategies to improve sustainability. For example, while 27 Crags focuses on promoting responsible climbing practices and environmental stewardship, Instagram must address issues related to social media addiction and mental health. Miro's emphasis on collaborative work environments necessitates strategies for reducing energy consumption and enhancing data security, whereas Strava's focus on fitness and community engagement requires balancing user motivation with environmental preservation. This study also suggests how to adopt a holistic approach that considers all sustainability dimensions in platforms' sustainability design. For environmental protection, platforms can focus on conscious resource usage, optimizing energy consumption, reducing waste, and promoting responsible use of digital and physical resources. Additionally, platforms can adopt data-driven insights, automation, and user engagement strategies to promote environmentally responsible behaviors. Social well-being can be enhanced by reducing social media addiction and performance pressure, as seen in Instagram and Strava. Implementing features that provide feedback on usage time and promoting healthier usage habits can mitigate negative mental health impacts. Inclusiveness can be improved by lowering the technical competence threshold, making platforms more accessible to diverse users. Transparency and data accessibility can be increased by providing detailed information on environmental impacts, as suggested for Instagram. Lastly, user engagement can be improved by revamping rating systems to prevent manipulation and ensure reliable assessments, as proposed for 27 Crags.

Regarding the workshop approach, the SusAF framework with a five- dimensional view, provides a broad set of perspective that is crucial for developing sustainable ICT systems. Previous work applied SusAF in many cases in both academia and industry (e.g.[6, 14, 8]). The sustainability tool, SusAF, was developed using design science as a research methodology. We based our work on lessons learnt from previous studies, on the nature of sustainability and the need for efficiency in sustainability analysis [6, 8].

This study is subject to certain limitations. First, participants' familiarity with the SusAF tool can affect the study's outcomes; however, during class they were given an introduction to the tool and were provided with the assistance if needed. Second, the current study does not include enough cases to fully capture the commonalities and differences across ICT platforms. Therefore, there is a need for a larger sample size to better understand the patterns and variations across platforms. Third, study participants were students and there is a

need for a more diverse group of participants to highlight possible differences in sustainability views.

7 Conclusion

This study has explored the sustainability of ICT platforms by applying SusAF in multiple cases. The research evaluated 27 Crags, Instagram, Miro, and Strava, and highlighted how these platforms impact sustainability across dimensions. The findings reveal both common challenges and unique opportunities for integrating sustainability principles into platform design. A key insight from the analysis is the interconnected nature of sustainability effects. These cross-case findings underscore the importance of holistic sustainability strategies that balance multiple concerns rather than focus solely on isolated issues. The design suggestions of the study provide actionable recommendations for creating more sustainable ICT platforms. Key proposals include implementing resource-conscious practices, promoting cultural and environmental conservation, reducing digital addiction and social pressures, and improving transparency in data usage. Addressing these areas can help ICT platforms move beyond traditional revenue-driven models toward ethically and environmentally responsible design choices. Another point that this study highlights is how small changes to a platform can have a big impact. The long-term effects of seemingly minor features can be multifaceted and complex. Therefore, the SusAF framework is a valuable process that leads to a discussion of effects that might otherwise go unnoticed.

Although this research provides valuable information, it also highlights the need for further exploration. Expanding the study to more ICT platforms and diverse user groups would strengthen the generalisability of the findings. Future work could also examine the long-term systemic effects of digital platforms, integrating additional sustainability assessment tools alongside SusAF. Ultimately, when ICT platforms embed sustainability at the core of their development, the corresponding digital ecosystems could support well-being, inclusivity, and environmental stewardship in the long run.

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