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Review

Risks and Requirements in Sustainable App Development—A Review

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Abstract: Apps are a part of the everyday lives of many people around the world. Digital applications support many areas, including the private sphere and the working world. To strengthen social sustainability in app development, it is necessary to consider users' needs. The aim of this paper is to identify users' requirements and to explore possible concerns. Furthermore, we aim to investigate how sustainability can be integrated into app development. For this purpose, 25 studies were analyzed, in which users were interviewed. The papers were qualitatively evaluated. Our results reveal three main findings. First, specific requirements, such as value for monetary aspects, security, and privacy, play a crucial role for users. Second, users expressed concerns about the attractiveness, motivation, and accuracy of apps. Third, an absolute research gap was revealed in the integration of sustainability in app development. Based on the findings, the Sustainable App Development Model (SADM) was then developed. This model incorporates the most fundamental aspects of social, economic, and environmental sustainability and is characterized by a circular approach to app development.

Keywords: app development; users' requirements; sustainability integration; social sustainability

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1. Introduction

Sustainability and digital transformation represent two important trends that interact with one another in multiple ways [1]. There is a huge amount of potential for the development of sustainability on the one hand; on the other hand, many trade-offs, dilemmas, or rebound effects can occur [2]. Computer programs, such as software and apps designed to perform specific tasks, are related to sustainability in various ways. First, software is an important tool for achieving sustainability as it can be used to monitor and analyze data related to sustainable development. It can support the implementation of strategies for reducing environmental impacts; the management, tracing, and tracking of sustainable supply chains; the reporting of sustainability performance; the development of sustainable business models. Specifically, application software for smartphones and tablets, also known as smartphone or tablet applications (apps), is gaining wide acceptance and popularity [3]. Apps are a type of software designed for mobile devices or the web, having a specific focus or goal and optimized for touch-based interaction. App development involves software applications that, unlike web applications, do not run in a browser. Instead, they must be downloaded from platform-specific app stores and installed on users' devices [4]. Apps can provide quick information for making environmentally conscious decisions. Second, software and apps need to be designed sustainably, e.g., by using eco-friendly technologies and processes. As data processing and digital devices have an immense environmental impact, their production and usage need energy-efficient data centers and recycling programs for electronic devices [2].

There are several areas where sustainability requirements can be integrated into the software environment: software systems, software products, web applications, data centers,

etc. [5]. This is because, as the authors of [6] note, software plays an important role, both as contributing to climate change and as part of its solution. This is further demonstrated by the fact that digital technologies, and software applications in particular, can help to achieve Sustainable Development Goals (SDGs) [7]. Software products that are labeled as green or sustainable software should, in principle, be as sustainable as possible [8]. Economic, social, and environmental impacts should be as minimal as possible, as should be the impacts on the user that occur during use throughout the product's life cycle.

App development and use not only represent a growth market with diverse business model options, they are equally accompanied by numerous risks in production and use, such as addiction, user rights, overconsumption, privacy, security, and other concerns [9–12]. It is important for app users to be aware of these risks and the related sustainability impact.

In view of the continuing boom in the app industry, it is important to take a closer look at economic, ecological, and social sustainability. We aim to investigate how sustainability can be further integrated into app development. The two central research questions are as follows:

1. Which requirements and risks in dealing with apps are demanded or perceived by users?
2. How can sustainability be recognized and integrated in app development?

2. State-of-the-Art

The study of risks associated with software development has had a relatively long and varied evolution compared to the study of risks associated with app development. One of the first works is the research in [13] (see Appendix A). The authors identified ten risks in the area of software risk management that are personnel shortfalls: unrealistic schedules and budgets; developing the wrong functions and properties; developing the wrong user interface; gold-plating; continuing stream of requirement changes; shortfalls in externally furnished components; shortfalls in externally performed tasks; real-time performance shortfalls; strained computer science capabilities. For instance, ref. [14] notes that these risks were created through an informal process. Further, these risks reflect the risks of the software development at the beginning of the 1990s. Since then, the complexity, extent, and variety of software has increased continuously. These ten risks are no longer representative 30 years later [13]. The current literature (see Appendix A) shows a variety of methods for handling risks in software development and app development. The methodology of risk identification differs greatly. Surveys, reviews, and Delphi surveys are some of the methods used. Furthermore, surveys are generally limited to providers and developers [15–22]. As shown in the Appendix A, in the previous research, the focus was mainly on the implementation of software projects and their risks. Users, on the other hand, were rarely included in studies.

Based on the literature, there is a varying number of risks in software development [19–25] (see Appendix A). Since the work in [13], the number of risks has steadily increased, which is likely to do with the complexity of software. However, the different number of risks involved is also related to the different subject areas. As users have not been the focus of research thus far, it is appropriate to examine the risks associated with them more closely. The analysis of risks in app development has played a subordinate role so far. Only the authors of [4,26] have surveyed users (see Appendix A). Various user behaviors were analyzed in [4]; however, risks were not a focus of the study [4]. There are various reasons for users to install or uninstall applications [26]. Five factors influence users to select a particular app [4]. These are price, features of the app, description of the app, reviews from other users, and the developers of the app. Furthermore, there are various reasons for discontinuing use. These include better alternatives, boredom of use, and invasion of privacy. Other negative influencing factors include intrusive advertising, poor user interfaces, and instability [26].

The work in [4,26] provides an initial insight into possible risks that can arise for both app developers and users if these issues are not considered. The needs and concerns with regard to successfully establishing an app in the market require focusing on the user's experience. Since users have been under-represented in both software development and

app development, it is important to bring them to the forefront through a review paper. This is accomplished by analyzing studies in which users are surveyed regarding their concerns, requirements, and perceptions when dealing with apps. This will help to ensure both the economic and social sustainability of the apps. Economic sustainability could be achieved through longer-term establishment of apps due to loyal users. Social sustainability of apps could be achieved through better consideration of users' needs.

The development of software models with integrated sustainability has made greater initial contributions compared to those of app development. The dimensions of sustainability are integrated in seven different software models as identified in [27]. Applicable content for app development was used in four of the seven models for the Sustainable App Development Model (SADM) [6,28–30]. In summary, it is clear that sustainability has played a subordinate role in both software development and app development. Risks that could influence sustainability have not yet been investigated, though these risks are of great concern, as the following explanations make clear.

From an economic perspective, the increasing sales and number of apps are also accompanied by higher employment levels. In 2007, employment in the United States (U.S.) as a result of apps was almost zero, whereas by 2012, it accounted for 460,000 jobs [31]. Since the iPhone established itself in the market in 2007, apps have created tremendous economic value and provided jobs at an astonishing rate. In Europe, app development is becoming increasingly important, offering the potential to create sustainable jobs. In 2017, app development was associated with over 145,500 jobs in Scandinavian countries, with employment in the field continuing to grow. Within the European Union (EU), the Scandinavian countries are considered to be pioneers in app development. Therefore, there is an opportunity for the Nordic countries to benefit from the digital transformation and create additional job opportunities in the future. Scandinavian developers are also almost on par with US developers, representing strong competition [32]. The three most popular app stores in 2022 included "Google Play", with approximately 3.5 million apps, the "Apple App Store", with 1.6 million apps, and the "Amazon Appstore", with approximately 500,000 apps [33]. The generated revenues of these app stores are continuously increasing. In 2016, the gross revenue of the Google Play Store was USD 15 billion, and the Apple App Store saw USD 28.6 billion in revenue. By 2021, these revenues had nearly tripled for both app stores. In 2021, the gross revenue of the Google App Store was USD 47.9 billion, and the Apple App Store saw USD 85.1 billion in revenue [34]. In terms of economic sustainability, the question is: how long the apps will be used by users? If an app is at its peak in the life cycle, whether it can retain a large proportion of users is critical to its continued positioning in the market. The post-peak phase of the lifecycle can be described using the concept of half-life. It is important to pay increased attention to user retention and users' needs in order to avoid early deactivations of apps [35].

From a social perspective, apps can be addictive, induce social stress, or interfere with daily life and negatively impact mental and physical health [36]. Conflicting consumer rights often occur with regard to in-app purchases [11], which are not transparent from the first usage onward, but are linked to premium features or virtual items that are needed for progress. These extras are expensive and can lead to unexpected charges. False or misleading information by apps, e.g., in news or health categories, can be harmful, as this information can cause misinformed decisions or an impact on democracy [37]. Security and privacy risks relate to (hidden) data collection, data misuse, the stealing of sensitive information, and spreading malware or viruses [10]. Overconsumption can lead to battery draining, as some apps consume a great deal of battery power [12]. The consumption of large amounts of data can also lead to a slowed down network performance. The difference between privacy and security in this paper is as follows: privacy involves the protection of personal information, while security involves protection against malware designed to obtain user data.

The research gap identified within this paper is the lack of attention paid to users' requirements with regard to sustainable apps. This research gap results from the lack

of user analysis in the existing literature. In order to expand the existing literature, we present an analysis of quantitative studies that survey app users. The methodology used is explained in the next section.

3. Materials and Methods

The aim of this research is to identify the requirements and risks that users face when using apps. To answer the research questions, a systematic literature review with qualitative analysis was conducted. For this purpose, targeted search terms were entered in the scientific databases, Scopus and Web of Science (Wos). These were selected to cover the wide range of topics involved. As can be seen in Figure 1, the search terms fall into two categories. The first category includes keywords addressing the concerns of the users. These include requirements, interests, and barriers. In the second category, the keywords cover the area of app development, as well as software engineering. Both categories were connected with each other by the Boolean operator "AND". This was to ensure that topic-specific articles were found. The query was performed on 14 March 2022 and generated 1866 articles. After deleting 136 duplicates, the total number was reduced to 1730 articles.

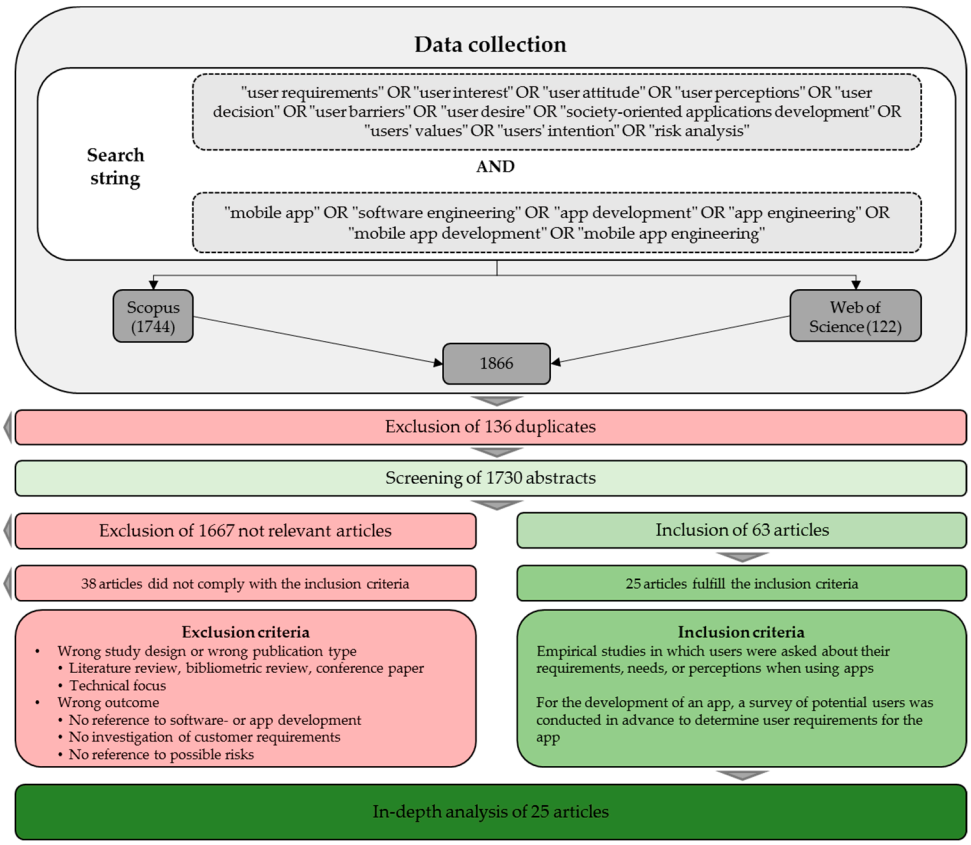

Figure 1. Data collection process.

The focus of the literature analysis was empirical studies in order to specifically survey users with regard to their requirements for apps and how they feel during use. In order to filter out this type of study, the screening process was refined using additional criteria. The exclusion criteria and the inclusion criteria are listed in Figure 2. After applying these criteria, 1667 articles were excluded. This resulted in 63 articles. When the full texts were analyzed, an additional 38 articles were excluded from the literature analysis using the criteria in Figure 2. At the end of the collection process, 25 articles remained for the actual analysis (see Table 1). All 25 articles contained empirical research in which app users were interviewed. These 25 articles were analyzed using structured content analysis according to the authors of [38]. Within the analysis, the focus was on the users. An iterative process

was used to systematically search for commonalities within the studies. Categories were identified in accordance with [38]. During the screening of selected studies, they were filtered for frequently occurring keywords; these keywords reflect the categories within the results. The results of the analysis are discussed in the following section.

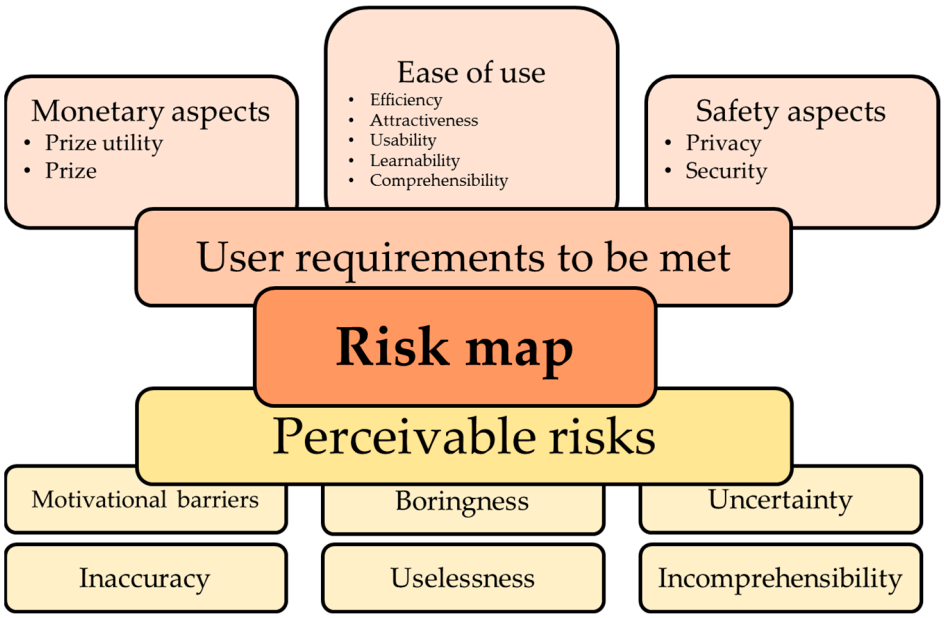

Figure 2. Risk map.

Table 1. Resulting list of articles.

Ref.	Authors	Date	Journal	Title
[39]	Al-Natour, S.; Cavusoglu, H.; Benbasat, I.; Aleem, U.	2020	*Information Systems Research*	An Empirical Investigation of the Antecedents and Consequences of Privacy Uncertainty in the Context of Mobile Apps
[40]	Alqahtani, F.; Winn, A.; Orji, R.	2021	*JMIR Formative Research*	Co-Designing a Mobile App to Improve Mental Health and Well-Being: Focus Group Study
[41]	Anagnostopoulos, G.G.; Deriaz, M.; Gaspoz, J.-M.; Konstantas, D.; Guessous, I.	2017	*Information Science Institute, GSEM/CUI, University of Geneva, Geneva, Switzerland*	Navigational needs and requirements of hospital staff: Geneva University Hospitals case study
[42]	Balapour, A.; Nikkhah, H.R.; Sabherwal, R.	2019	*International Journal of Information Management*	Mobile application security: Role of perceived privacy as the predictor of security perceptions
[43]	Ceccato, M.; Marchetto, A.; Perini, A.; Susi, A.	2014	*IEEE 4th International Workshop on Empirical Requirements Engineering (EmpiRE)*	How Smartphone Users Assess the Value/Risk Trade-Off of Apps: An Observational Study
[44]	Elsantil, Y.	2020	*International Journal of E-Services and Mobile Applications*	User Perceptions of the Security of Mobile Applications
[45]	Hong, W.; Thong, J.Y.L.; Lewis C. C.; Dhillon, G.	2015	*Journal of Management Information Systems*	User Acceptance of Agile Information Systems: A Model and Empirical Test
[46]	Hsiao, K.-L.; Lin, K.-Y.; Wang, Y.-T.; Lee, C.-H.; Zhang, Z.-M.	2019	*The Electronic Library*	Continued use intention of lifestyle mobile applications: the Starbucks app in Taiwan

Table 1. *Cont.*

Ref.	Authors	Date	Journal	Title
[47]	Hsu, C.-L.; Chuan-Chuan Lin, J.	2016	*Technological Forecasting & Social Change*	Effect of perceived value and social influences on mobile app stickiness and in-app purchase intention
[48]	Hussain, A.; Mkpojiogu, E.O.C.; Musa, J.; Mortada, S.	2017	*The 2nd International Conference on Applied Science and Technology*	A user experience evaluation of Amazon Kindle mobile application
[49]	Inal, Y.; Hacaloglu, T.	2019	*Digital Transformation for a Sustainable Society in the 21st Century*	Users' Behavioral Strategies Toward Mobile App Problems: Fight or Flight
[50]	Kairy, D.; Mostafavi, M.A.; Blanchette-Dallaire, C.; Belanger, E.; Corbeil, A.; Kandiah, M.; Wu, T.Q.; Mazer, B.	2021	*International Journal of Environmental Research and Public Health*	A Mobile App to Optimize Social Participation for Individuals with Physical Disabilities: Content Validation and Usability Testing
[51]	Kamboj, S.; Rana, S.; Drave, V.A.	2020	*Journal of Electronic Commerce in Organizations*	Factors Driving Consumer Engagement and Intentions with Gamification of Mobile Apps
[52]	Kim, S.; Baek, T.H.; Kim, Y.-K.; Yoo, K.	2016	*Journal of Research in Interactive Marketing*	Factors affecting stickiness and word of mouth in mobile applications
[53]	Lin, T.C.; Chen, Y.H.; Su, Y.-S.; Lee, H.-P; Yang, E.H.; Chang, Y.-J.	2021	*CHI Conference on Human Factors in Computing Systems*	"Put it on the Top, I'll Read it Later": Investigating Users' Desired Display Order for Smartphone Notifications
[54]	Mirkovic, J.; Kaufman, D.R.; Ruland, C.M.	2014	*MIR Mhealth and Uhealth*	Supporting Cancer Patients in Illness Management: Usability Evaluation of a Mobile App
[55]	Peng, W.; Kanthawala, S.; Yuan, S.; Hussain, S.A.	2016	*BMC Public Health*	A qualitative study of user perceptions of mobile health apps
[56]	Raza, A.; Capretz, L.F.; Ahmed, F.	2015	*International Journal of Open Source Software and Processes*	An empirical study of Open Source software usability: the industrial perspective
[57]	Schneider, T.; Baum, L.; Ami, A.; Marisa, C.	2019	*Health Informatics Journal*	I have most of my asthma under control and I know how my asthma acts: Users' perceptions of asthma self-management mobile app tailored for adolescents
[58]	Shah, M.U.; Rehman, U.; Iqbal, F.; Wahid, F.; Hussain, M.; Arsalan, A.	2020	*2020 International Conference on Communications, Computing, Cybersecurity, and Informatics (CCCI)*	Access Permissions for Apple Watch Applications: A Study on Users' Perceptions
[59]	Shehzaib, U.; Ferzund, J.; Aisf, M.	2018	*International Journal of Information Technology and Web Engineering*	Mobile Apps Acceptability: A Meta-Analysis Model for Google Play
[60]	Shupei Y.; Wenjuan M.; Shaheen, K.; Peng, W.	2015	*Telemedicine and e-Health*	Keep Using My Health Apps: Discover Users' Perception of Health and Fitness Apps with the UTAUT2 Model

Table 1. *Cont.*

Ref.	Authors	Date	Journal	Title
[61]	Wu, D.; Moody, G.D.; Zhang, J.; Lowry, P.B.	2019	*Information and Management*	Effects of the Design of Mobile Security Notifications and Mobile App Usability on Users' Security Perceptions and Continued-Use Intention
[62]	Yu-Yin, W.; Hsin-Hui, L.; Yi-Shun W.; Ying-Wie, S.; Ssu-Ting, W.	2017	*Internet Research*	What Drives Users' Intentions to Purchase a GPS Navigation App: The Moderating Role of Perceived Availability of Free Substitutes
[63]	Zhou, L.; Jie B.; Watzlaf, V.; Parmanto, B.	2019	*JMIR Mhealth Uhealth*	Barriers to and Facilitators of the Use of Mobile Health Apps From a Security Perspective: Mixed-Methods Study

4. Results

Analysis of the scientific articles revealed various requirements, as well as doubts and concerns of the app users, which are described for the two categories of requirements and risk perception. Users' requirements and risks are summarized in Figure 2.

4.1. Users' Requirements to Be Met

4.1.1. Monetary Aspects

Prize Utility

The price benefit of an app from the user's perspective is associated with a certain appeal. This influences both the overall perception of the app and the purchase intentions for paid apps [62]. As noted in [59], the price of a paid app has a direct positive effect on the rating of the app in question. In addition, the price of an app has a direct positive effect on its size. Accordingly, it can be concluded that free apps are usually smaller and smarter, which leads to a greater appeal from users. This is because users often install smart apps because they have limited storage space on their smartphones. For a paid app to be installed, it must provide some benefit to the user and have a significant appeal [59].

Prize

The authors of the study in [62] found that the price has a positive impact on the overall perception of an app. Prices especially affect the size as well as the rating of an app [62]. The higher the perceived price is, the higher the value of an app is from the user's perspective. Furthermore, the price of an app has been described as a functional value that plays a role in a user's decision to use an app [60]. In [59], it was also shown that a lower price of an app leads to an increased number of installations. Apps that have been downloaded many times receive a higher number of ratings due to the greater number of users [59].

4.1.2. Ease of Use

Efficiency

Though the studies in [40,48,55] did not explicitly examine the efficiency of an app, relevant conclusions about risk mitigation can be drawn from their results. The efficiency of an app is significant for its long-term success. If users spend too much time on an app before their goals are achieved, these users will perceive the app as less beneficial. The more efficient an app is, the more satisfying it is for users. Furthermore, efficiency influences users' satisfaction in using an app, and thus, affects loyalty to the app [48]. The study in [55] showed that it is necessary to develop apps as efficient as possible for the users to ensure

their comfort with the platform. In addition, the users surveyed in [40] communicated the importance of an having a clear purpose and how this can be realized.

Attractiveness

Several studies were found on the attractiveness of apps. Respondents in a study [53] mentioned their feelings towards self-explanatory notifications, which they considered to be unnecessary and negatively influenced subjective attractiveness. Perceived attractiveness improves user satisfaction and promotes their loyalty to an app. It leads users to be positive about and attracted to an app and to have a sense of enjoyment when using it. Satisfying customers' needs leads to positive attitudes of users towards an app and increases product loyalty. This was the finding in [48]. Respondents in [54] indicated that they would prefer a larger font size and more detailed information. Existing deficiencies in design and visibility had a negative impact on attractiveness from the respondents' point of view. Respondents in the study in [57] pointed to individual design options that could positively influence attractiveness. Furthermore, the regular updating of content increases the attractiveness of an app [40]. Respondents in the study in [49] complained about aesthetic deficiencies, such as incorrect color contrast, the size and orientation of images, and the choice of font as affecting the readability of text. According to the respondents, the shortcomings led to a lower attractiveness of the app in question. However, attractiveness alone is not sufficient for success, as the app should remain usable and have a functional value [56].

Usability

In previously conducted research, notifications through an app were sometimes seen as reminders. According to the respondents, these notifications should be ordered in terms of priority. This is important because too many notifications through an app are perceived as annoying by users, and a lack of order could lead to crucial notifications being overlooked [53]. In order to be able to use apps in the best possible way, it was important to the respondents in [41] that apps do not have Internet access as a prerequisite for use. This is also confirmed in [57]. Apps should therefore be able to function offline. Required Internet access and a password login were identified as external barriers to use in these studies. Furthermore, simple and comprehensible usability has a positive influence on user friendliness [56]; as the study in [48] showed, apps that are difficult to use involve an increased risk of frustration among users. This may lead users to switch to an alternative app, which are plentiful in today's market. Therefore, it is important that the app is easy to use and understandable [48]. This was also found in the research in [40]. Simple and user-friendly apps are preferred according to the respondents. In particular, information that could be found quickly and good organization of the app were of particular importance to users [40].

Learnability

An app can only be learnable if the developers understand and consider the needs and limitations of the users. Making an app highly learnable could lead to the app being accepted and used more quickly [56]. In the research in [54], respondents indicated that they needed time to learn how to use an app. This time provides the basis for the long-term use of the app. According to research, different age groups have different preferences and desires in terms of the technical nature of an app. Older users are often put off by complicated apps, whereas younger users generally have no problems using a more complex app [54].

Comprehensibility

Various elements play a role in the comprehensibility of an app from the user's point of view. According to the results in [53], the notifications of an app must be clearly visible, and the user must be informed as to where they are stored. In addition, users can be overwhelmed by complex systems with a large number of functions, which could impair

further use [45]. Thus, simple understandability promotes the use of an app, as the authors of [56] confirmed. This is because understandability is positively related to usability. Furthermore, the study in [58] showed that users prefer easy access to apps, while not compromising security. Visibility is another important aspect of the comprehensibility of an app. Users should be able to recognize the individual functions and features of an app. This was confirmed in [48]. A fuzzy or unclear user interface frustrates users, wastes their time, and interferes with them achieving their goals. Poor comprehensibility leaves users with a level of dissatisfaction that could eventually lead to deleting the app. Too many functions within an app, e.g., in the form of icons, messages, etc., can additionally impair the comprehensibility of an app and prevent the clear conveyance of information [54].

4.1.3. Safety Aspects

Privacy

Only a limited number of empirical studies currently exist that address the topic of privacy in apps. As the results in [39] show, privacy uncertainty has a significant influence on the intention to use an app. Furthermore, privacy is an influential factor in the users' decision to download an app. To reduce users' concerns, it is necessary to reduce the perceived information issues. As the results of the study show, providing relevant security-specific information can help to eliminate information asymmetries [39]. Users' concerns also include worries about what their personal information will be used for and whether their information will be misused. As users note in the survey in [41], guaranteed protection of their privacy is particularly important.

Security

The study in [63] found that users want to know why their data are being collected. In addition, users do not want their data to be collected. Users want to be shown the privacy functions within an app by the provider. A large number of respondents in the study in [58] felt that development companies would misuse their data. Further, age seems to have a negative impact on users' perceived security, as evidenced by the results in [42]. Accordingly, app security perception decreases with user age. Since age indicates lived experience, older people may have experienced more security incidents and are therefore less optimistic about app security. Overall, the results in [42] show that users' concerns about the perceived safety of apps affect usage and recommendation.

4.2. Perceivable Risks

4.2.1. Comprehensibility

The perceived user-friendliness and comprehensibility are prone to the same issues as discussed in the previous section. In general, if an app is simple, easy to understand, and user-friendly, usability and comprehensibility are fulfilled. For users, the design, the texts displayed, and the clarity of the app are particularly important. Individual optimizations or adjustments to the design within an app are important elements of usability, as reported in [50].

4.2.2. Pleasure

The perceived pleasure of the users in the study in [62] represented a positive influence on the value of the app studied. Perceived pleasure, as noted in the study in [48], improves user satisfaction and promotes their loyalty towards an app. It leads users to be positive towards an app and to find the app attractive. Satisfying needs leads to users' positive attitude toward an app and their willingness to make a positive recommendation [48]. This is because the feeling of fun has a positive effect on the use of an app [51]. Furthermore, an outdated design will lead lack appeal for users [57]. The study in [46] found that user satisfaction with mobile apps has a positive effect on users' intention to continue using the app. When users can effectively fulfill their needs through the functions provided by the app, their satisfaction is increased. Thus, their intention to continue using the app is strengthened.

4.2.3. Benefit

The subjective perceived benefit of an app can include various aspects from the user's point of view. Since the perceived benefit can vary from user to user, only rough conclusions about the actual benefit of an app can be drawn from the results obtained in the studies. Although many apps are free, this does not mean that users will use them in the long term, especially if they do not offer any added value. On the other hand, users may be willing to pay for an app if they perceive it to have a significant value [60]. Benefits play an important role in motivating users to use an app. This is because a positive and meaningful benefit of an app has a positive effect on user satisfaction. In particular, the quality of an app influences the perceived benefit. However, this depends heavily on the context of the app in question [46,51,52]. Furthermore, for potential users, satisfaction has a direct effect on purchase intention, while attitude toward an app has no significant effect on purchase intention, but it does significantly influence satisfaction. Potential users' expectations are usually based on the opinions of others or information disseminated through mass media. If potential users feel a benefit when using an app, they will use the app more often and for longer periods of time [47]. If users have the impression that the risk of using an app is higher than its benefit, they tend to perceive the app as less useful [42].

4.2.4. Motivation

The results from the study in [52] show that both intrinsic and extrinsic motivational factors play an important mediating role in establishing the links between apps and user behavior. Positive motivation to use an app generally leads to more long-term app use than its use when motivation is negative [40,60].

4.2.5. Security

In the study in [61], it was found that both the usability of an app user interface and the design influence the security as perceived by users. This, in turn, has a positive influence on the intention to continue using the app. Furthermore, users in the study in [43] stated that they are sometimes fearful when using apps. Apps could, in their view, disclose or misuse personal data. This was one reason in the decision to install an app or not. To protect and preserve the confidentiality of their data, users consider the permissions requested by an app. Furthermore, it was found that users must have reached a certain level of maturity to search for apps independently and curiously [43]. The best places for downloads are provided by app stores designed for this purpose. Users in the study of [44] believed that user safety should be the responsibility of app stores. They also believed app stores were revenue-driven and pushed security onto users [44]. To address users' concerns and reduce their uncertainty, app developers and vendors need to reduce perceived information asymmetry. As the results in [39] show, providing security-specific information can help reduce user concerns. The perceived security of an app and its utility are closely related. When doubts arise in the perceived security of an app, it negatively affects the utility of the app [46].

4.2.6. Accuracy

The interviewed participants in the study in [57] attached great importance to the fact that the reminders were conveyed by the app at the right time. In particular, it was important to them not to receive too many messages, but instead to be notified at appropriate intervals. A flood of messages would be perceived by users as irritating rather than helpful [57]. Regarding the amount and relevance of information in the app, mixed opinions were expressed in the research in [50], suggesting that it is important to find a balance between the two states to satisfy the majority of potential users. However, the right balance of information in an app is a subjective concept. Many of the participants expressed interest in additional information in the app, while others suggested that the app should be limited to relevant information [50].

The results of the analysis culminated in the risk map consisting of two domains (see Figure 2). The users' requirements for price–benefit ratio, ease of use, and privacy and protection represent the first (upper) part of this map. These concern users in particular. On the other hand, the perceived risks of incomprehensibility, boringness, uselessness, motivation barriers, uncertainty, and inaccuracy represent the second (lower) part of the map. These are considered to be risks for developers in the absence of consideration of user perceptions. This figure serves as an illustrative answer to the first research question, which is addressed in the next section.

5. Discussion

5.1. Users' Requirements and Risks in App Development

With reference to the first research question in Section 1, the data collection shows the underrepresentation of the empirical analysis of users' requirements for apps. Only 25 of 1730 articles addressed the requirements of users in their interaction with apps. This illustrates how inadequately the topic is covered in research, considering that the importance of apps has grown significantly in recent years. The first research question can be answered by the generated results as follows: For users, three aggregated requirements are of crucial importance. These are the price–benefit ratio, user-friendliness, and privacy and protection of their data (see also Figure 2). The requirements for the price utility and the price of an app are summarized under the heading of price. Five requirements are summarized under the heading of ease of use. Privacy and security are interconnected; therefore, these two requirements are combined in one section in the risk map.

Users' requirements and perceived risks include the aspect of safety. The assurance of privacy combined with the protection of user data is a fundamental requirement for users of an app. In contrast, users also perceive security in a subjective way while using apps; this perception is strongest when users think that an app they are using has deficiencies in security.

Within the studies, it was clear that there was no specific questioning around the risks users face when using apps. However, users expressed concerns or perceived risks that could arise when using apps. Six perceivable risks were identified from the users' perspective. These arise when the perceived risks of the users are not sufficiently taken into account by the developers. Therefore, the risks in the risk map differ from the perceived risks outlined in Sections 4.2.1–4.2.6. These risks include incomprehensibility, boringness, uselessness, motivational barriers, uncertainty, and inaccuracy (see Figure 2). While these perceivable risks do not negatively impact users, they could contribute to the early deletion of an app. Thus, from the customer's point of view, the perceivable risks also represent a risk for the app developers if they are not sufficiently considered. This would lead to an impairment of economic sustainability in app development. In order to develop a successful app, the requirements mentioned as important by the users must be considered and concerns must be addressed and, if possible, eliminated, especially in the case of security issues. The following hypotheses therefore need to be explored in further research:

H1. *When the users' requirements of apps are given more consideration, then an app will be more successful on the market.*

H2. *The more social sustainability features that are included in app development, the more user-friendly an app is.*

H3. *If apps are labeled as sustainable, then potential users will prefer these apps compared to unlabeled apps.*

5.2. Sustainable App Development Model

With regard to the second research question stated in Section 1, it is clear from the literature analysis that sustainability has played a little or no role so far, both among users and app developers. Within the surveys, sustainability was not considered. Thus, there

is a clear neglect of all three dimensions of sustainability. Only privacy and protection of personal data played a role for users. This requirement can be assigned to the social dimension of sustainability. With regard to the identification of sustainability in app development, an absolute research gap could be uncovered within the scope of the previous empirical surveys. Typical sustainability criteria were rarely, if at all, included in the survey of users. Yet, many of these criteria that play a crucial role for both users and developers. The previous models are linear in orientation [6,28–30], and the concept of circularity was not considered. Therefore, the SADM was further developed in light of sustainability and circularity capability. The extended SADM includes the three dimensions of sustainability and shows them along the three value creation stages of app programming, app usage, and end of life/circularity (see Figure 3).

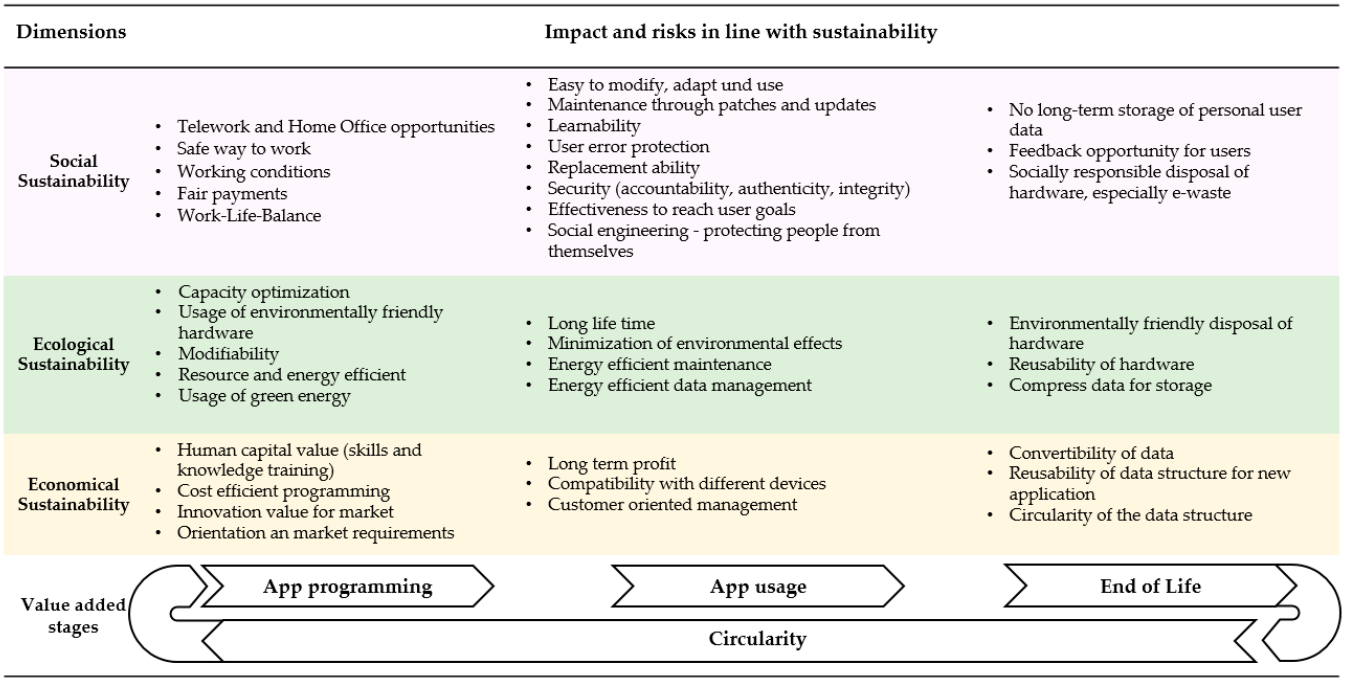

Figure 3. Sustainable App Development Model.

Care was taken to integrate the users' requirements identified in this paper. These are particularly evident in the social sustainability category as part of the usage phase in the SADM. In the following sections, we show how the criteria of sustainability could be integrated into app development based on the SADM. For future research, it is important to consider various aspects in terms of users' requirements and concerns, as well as the integration of sustainability in app development. The focus of research should be on the risks that arise with the use of apps from the user's perspective. Furthermore, it should be explored why sustainability has not played a prominent role within the users' requirements so far. The SADM should be tested in practice in order to expand it with further criteria. In addition, developers should consulted about whether the SADM is suitable as a guideline. In order to implement SADM in practice, the respective business models must be taken into account. In particular, smaller development companies such as startups should be in focus [64].

6. Conclusions

The continuing expansion of apps in many areas of everyday life calls for the consideration of users' requirements and sustainability. Users' requirements for apps and the integration of sustainability currently play a subordinate role. Not many studies have focused on this topic. Only two articles placed users at the center of their research. This paper

extends the previous research by highlighting that users have their own interests when they choose apps. Perceived risks are another factor in the decision-making process when downloading an app. The requirements and the risks need to be considered, especially in order to ensure social and economic sustainability. The app industry, despite its novelty, now generates large revenues and an increased number of employees in different regions.

In addition, the app industry has the potential to develop new business models through an SADM. Practical implications could be introduced in human resource management in particular. This includes the continuous training and further qualification of employees. Sensitivity is necessary to understand users' requirements and to address any perceivable risks at an early stage to ensure the long-term success and social sustainability of an app.

In the future, it will be necessary to analyze the developments in the growing market of apps in order to sufficiently consider the needs of customers and developers. The SADM should be implemented and tested by developers.

Several different aspects limit the generalizability of the results. Students and users with an increased affinity for apps participated in the analyzed studies. Other user groups with less know-how about apps are under-represented, and general conclusions are limited. This is reinforced by the relatively small number of respondents within studies. Furthermore, studies took place in different countries and regions, which means that cultural differences in terms of the respondent's limit generalizability. Data collection is limited to a single date, 14 March 2022; later published studies were not considered in this paper. In addition, data collection occurred in two databases for papers published in English. Published studies that are not available in these databases were therefore not considered. The results of this review serve to answer the research questions stated in Section 1. The requirements of apps in research question 1 include monetary aspects, ease of use, and security aspects. User risks are motivational barriers, boringness, uncertainty, inaccuracy, uselessness, and incomprehensibility. These risks occur when developers ignore the needs of users. In order to answer research question 2 and to integrate sustainability into app development, the SADM is a suitable approach. In this integration, it is necessary to consider the three dimensions of sustainability along the life cycle of an app. In order to save resources and to ensure an efficient life cycle, a circular approach is necessary. On the developer side, the focus should be on the working conditions of the developers and their training opportunities. On the user side, the requirements of users, as well as their security, should be taken into account. The SADM illustrates the difference from existing linear models in software development.

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Appendix A

Table A1. Relevant literature using a snowballing approach.

Ref.	Author (by Year)	Method	Research Subject	Risk Categories	Risks	Topic
[13]	Boehm (1991)	unknown	unknown	0	10	software risk management
[20]	Longstaff et al., (2000)	unknown	unknown	7	32	risks of information technology
[21]	Barki et al., (2001)	survey	120 software projects	5	23	software project risks
[22]	Houston et al., (2001)	review	unknown	0	29	software development risks
[15]	Schmidt et al., (2001)	Delphi survey	43 project managers	14	53	software project risks
[23]	Chiang and Starren (2002)	interviews	16 project team members	3	12	software engineering risks
[16]	Wallace and Keil (2004)	interviews	507 project managers	4	53	software project risks
[14]	Huang and Han (2008)	survey	97 projects	6	27	software project duration and risk exposure
[17]	Nakatsu and Iacovou (2009)	Delphi survey	32 project managers	0	25	risk factors of outsourced software development
[18]	Reed and Knight (2011)	survey	107 project managers	0	3	virtual project risks
[19]	Moorthy et al., (2014)	survey	330 software developers	5	42	software usability risks
[4]	Lim et al., (2015)	survey	4824 participants	0	0	app user behavior across 15 countries
[26]	Ickin et al., (2017)	survey	121 users	0	16	installation and deletion of apps
[24]	Menezes et al., (2018)	review	41 articles	0	148	risk factors in software development projects
[25]	Salam and Khan (2018)	survey/review	54 articles/ 108 experts	0	14	risks in green and sustainable software development

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