Mapping the Landscape of Digitally Mediated Circular Economy Practices

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Abstract. This paper investigates the method of landscape mapping in relation to digital platforms supporting Circular Economy (CE) practices in Ireland, with a particular focus on mobile applications. Through a systematic landscape mapping approach, we analyse how digital technologies mediate and enable circular practices at the community level. The research combines both academic and industry perspectives, stemming from the development of The Toy Library, a social enterprise project aimed at enabling toy sharing in local communities. Our methodology employs both bottom-up and top-down approaches to identify and analyse relevant mobile applications in the Irish market and completes the picture of the reuse sector in Ireland. A toolkit for the application of the method is also proposed. The work reveals insights about the usefulness of this approach to bridge academic and social enterprise research on the role of technology in promoting sustainable behaviours. This research contributes to the growing body of work on Sustainable Human Computer Interaction (SHCI) by providing specific insights into how digital platforms can support CE practices at the community level, while also offering practical implications for the discovery, design and implementation of future CE-focused digital initiatives.

Keywords: Landscape Mapping, Circular Economy, Digital Platforms, Social Enterprise.

1   Introduction

Sustainability is a growing concern in HCI, with a growing body of work exploring the potential of digital design to encourage and support sustainable behaviours and practices [39] and the need for systems to operate sustainably in terms of digital footprint and reusability of components [11]. The work reported in this paper connects a social enterprise and academic research focusing on designing digital support for Circular Economy (CE) practices in Ireland at the level of local communities, starting with a systematic investigation and landscape mapping of CE mobile applications in Ireland.

As of 2019, only 9% of the world's economy is circular according to the United Nations Framework Convention on Climate Change. The CE is gaining momentum both at the European level and in Ireland, which recently developed a Whole of Government Circular Economy Strategy [94]. The CE has started being promoted in the media, to help citizens and businesses become familiar with this new way of sharing resources. However, with a circular material use rate of just 2% in 2020 (relative to an EU average of 12.8%), Ireland has significant scope for progress, showing a deep circularity gap [17].

The Toy Library is a social enterprise project established in 2023, which aims at increasing the reuse of toys in the community, reducing plastic waste and consumption, by establishing sharing practices through a hyper-local, free digital platform. The design, deployment, adoption, and formative evaluation of The Toy Library platform are also part of an academic research project on sustainable HCI. Therefore, the methodology underpinning the project bridges academic and enterprise-based research, blending techniques that are widely used in industry contexts with theory-informed reflexive techniques to capture the academic contributions of the work. HCI work in social enterprises has occurred in relation to informing future platforms' design, particularly in developing economies and low-resource settings [62, 13, 77]. Despite an increase in interest and reflection on the non-profit sector [14], discussion of collaborations between non-profit enterprise and academia is still relatively limited in the field, where most academic-industry collaborations occur in the context of commercial product development.

In the initial phases of The Toy Library project (October 2023 to June 2024), defining the requirements and key features of the platform was informed by the first author's previous experience of many years in the UX industry and related research methods, including a mapping exercise to identify which tools and technologies are currently used by people in Ireland to engage in CE practices such as swapping and exchanging goods. The focus was mainly on mobile apps, a highly pervasive technology. Smartphone usage in Ireland is approaching 4 million users in 2023 [83]; as of 2021, Ireland's total population was 5.127 million. Mobile apps have the potential to promote large scale sustainable behaviours [99]. While the 2022 EPA report [35] mapping the reuse sector in Ireland covers a broad range of issues, it didn't go into the details of digital platforms available to citizens, and consolidated all options under a general "online" label that did not detail the most used systems and their features. With some evidence around how users of sustainability apps are more likely to translate their personal norm into pro-environmental behaviour in private and public settings [22], and

how users can interact with information and communication technologies (ICTs) to co-create new processes with the potential to enhance sustainability awareness in citizens [99], this study completes the picture, providing specific insights related to the circularity of the mobile apps with which citizens engage in Ireland.

To gather these insights, we therefore leveraged the technique of landscape mapping. Landscape mapping can be defined as the systematic scouting of a specific technology within a given domain [81]. A process typically leveraged in marketing supporting product design, development and positioning [7], scanning the competitive landscape of an industry based on their function can help identify broad competitors that provide services similar to each other [71]. In the case of The Toy Library, the landscape mapping was a first step in the design process, and it helped the first author, as researcher/designer, by providing orientation in the competitive landscape of CE mobile apps, helping identify a gap in the toys category and inspiring the design of features to be included in the first iteration of the digital toy sharing platform. This study was also the first step linking the work on The Toy Library as a social enterprise to the academic research in SHCI. Following this, further research studies informed the subsequent design and launch of the platform to the public in June 2024.

In the following sections we present a review of the literature on the circular economy and on sustainable practices in HCI, we then present the method of landscape mapping and illustrate how it was applied in the context of our project. Finally, we discuss the usefulness of this approach more broadly for ongoing HCI research on CE practices as well as other community-focused initiatives. We argue that the technique of landscape mapping can benefit HCI research beyond industry contexts and help unveil insights on user awareness and perception of circular economy practices at community level, allowing, for example, the creation of research informed awareness campaigns or informing future public funding opportunities. To enable other researchers who may be exploring new product opportunities or inform the design of other services and experiences, we propose a Toolkit for guiding the use of the technique to execute a comprehensive app landscape mapping, along with a checklist that can be used to conduct similar research in other contexts.

2   Literature Review

2.1   What is the Circular Economy?

The CE emerged as an alternative model to the linear model of Take-Make-Waste [93]. This model is associated with the concept of sustainable development explored in the Brundtland report [68] and is gaining momentum both at the European and State level, with multiple initiatives being coordinated and sponsored by national governments [63]. The scope of the CE is to prevent waste and pollution, keep resources in use for as long as possible and transform waste into resources that are reused and kept in a loop of production and usage, generating more value and for a longer period. The CE has a strong connection to the Sustainable Development Goals (SDGs), as it is relevant to

several goals related to pollution, resilience, inclusion, resource management and education [90]. The CE has the power to shrink global Greenhouse Gas (GHG) emissions by 39% and cut virgin resource use by 28% [17]. On a normative level, the CE sits within the sustainability paradigm [34], although the link between sustainability and the CE is still weak: a circular economy on its own is not enough, when overconsumption is at the root of sustainability challenges [92]. Moreover, industrial symbiosis (the process of re-using one industry's waste as a resource for another industry) can be sustainable but also contribute to locking-in unsustainable material systems (i.e. petrochemicals), perpetuating a need for fossil fuel extraction [97].

It is difficult to define exactly the boundaries between the CE and other sustainable economy paradigms such as collaborative consumption (CC) [50], the sharing economy (SE) [41], and the collaborative economy (CoE) [19]. A plethora of definitions are available in the literature, with the SE defined as the system through which users share with each other existing idle resources [53] while possibly getting a profit from it, with the important aspect of it happening on the internet [6], and enacting social rewards through the creation of a sense of community [5] coming together through sharing practices that promote social sustainability.

SE and CC are often used interchangeably; Hamari et. al [39, p 2047] define CC as "the peer-to-peer (P2P) based activity of obtaining, giving, or sharing the access to goods and services, coordinated through community-based online services." This is not remarkably different from the SE definition, as both SE and CC have in common a variety of activities encompassed by the sharing, renting, or giving of existing resources from users to other users, leveraging digital platforms, whether for profit or non-profit reasons. The CE itself is also subject to a variety of definitions, some of which are inconsistent with each other. Already in 2017, Kircherr et al [48] conducted an analysis of 114 definitions of the CE, showing the wide inconsistencies among definitions, with the CE concept sometimes mistaken as a combination of reduce, reuse and recycle activities, considered in isolation and without investigating the systemic shift needed to move away from the linear economy model.

Most scholars who analyse SE and CE business models have considered the SE to be a subset of the CE [41, 79], and in this research we embrace this view, as we conceptualise the CE as the main umbrella under which SE, CC, and CoE sit, as each of these forms of collaborative practice have one aspect in common: a use of existing resources within a community either through waste prevention or reuse, with a view to optimise the environmental, social and economic values throughout the life cycles of materials, components, and products [92]. When observing examples of CE practices, it is evident that sustainability is not as pervasive and easily demonstrable as one might think; for example, while reducing greenhouse gas emissions is a laudable goal, a more holistic and systematic analysis is needed to understand potential rebound effects from CE practices, for example shifting emissions from one part of the system to another [92]. It is also important to analyse the different types of sustainable outcomes of different CE practices: a CE model based on closed loop practices such as industrial symbiosis, creating energy from waste, is relatively easy to implement as it does not really require any dramatic change in the production lifecycle unlike another CE model with a strong emphasis on recycling and waste prevention, that however leaves consumption patterns

the same, or even a model that requires more radical socio-cultural changes that shifts consumption patterns more towards a growth model, but is much harder to implement without massive paradigm shifts [92].

For example, considering SE platforms and the interactions they enable (i.e. resource sharing), when looking at the end to end journey the downstream impact of these interactions is not always positive from an environmental and/or social perspective: in the case of Uber [38], for example, it has been proven that the environmental impact of increased use of ride sharing is in fact negative (i.e. traffic congestion and/or tailpipe emissions). In other cases, such as that of Airbnb [3], the reallocation of housing enabled by the platform decreased the supply of long-term rental units, creating a negative social impact on renting communities. These rebound effects can drive a detrimental socio-environmental impact, in contrast with the sustainability factor that is so deeply ingrained in these models [70]. In short: while ideally sharing and reusing is desirable, a whole system assessment is needed to carefully understand the downstream impacts of circular practices, and, subsequently of the infrastructures and systems that facilitate them.

2.2   Digital technology and Sustainable practices

Digital platforms present opportunities to enable citizens' circular practices and technology can help bridging the circularity gap: digital platforms can not only orchestrate interactions between various stakeholders in the circular economy [10] but also enable the normalisation certain behaviours as citizens form habits by interacting with them. Great hopes and expectations are placed on technology to be an enabler of the CE, or a remover of its barriers [96]. Digital connectivity is expected to enable citizens and industries to co-create new forms of value. But how exactly does digitalization enable circular practices, at a functional level? What aspects of digitalization are used to perform which actions?

The range of frameworks outlined in the literature to harness different CE strategies include the well-known and prevalent R3 Model (Reduce-Reuse-Recycle), other R models such as 4Rs, 5Rs, 9Rs and 10rs [74], and the more complex ReSolve framework [30]. In this research, we adopt the 9Rs model (Figure 1), an extension of the R3 model elaborated by Potting et.al [72] that maps each CE strategy to socio technical innovations. Liu et. al [54] use this framework as a base for mapping digital functions such as automation, data analysis and data collection to CE strategies.
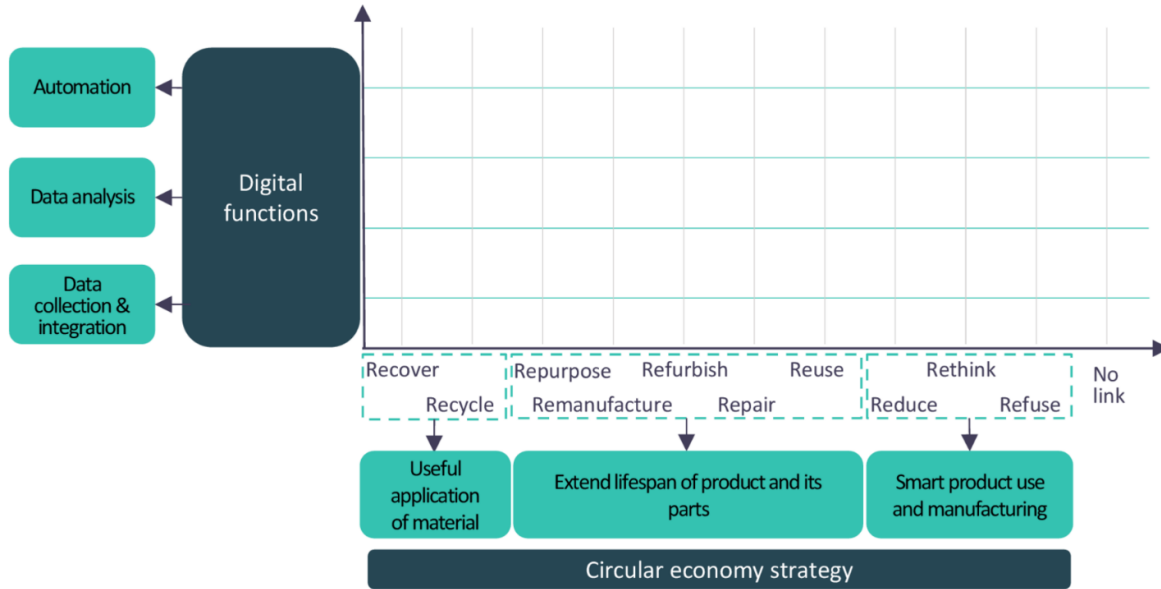
Fig. 1 R9 strategies and digital functions, from Liu et. al., 2021.

When looking at the R9 CE strategies, the technologies that enable them can be summarised as follows. First, within the function of data collection and integration sit IoT technologies, in which a physical product becomes "smart"; this enables data collection on product usage patterns, and allows the manufacturer to send maintenance when needed and inform the user on how to use the device more efficiently - this is the case of Homie [16] an initiative that developed a pay per wash model for their consumers. Another example of data collection and integration are sharing or re-commerce platforms, in which user data about idle resources is captured and shared with other users, who can avail of such resources and therefore extend their lifetime value.

Secondly, along with better data collection, within the function of data analysis, we see how in certain cases design can make the invisible visible: for example, by showing users transparent data about the usage or a certain product or service, and raising awareness around consumption, it can influence behaviours. This sits in the realm of HCI driving sustainable futures: an example of this are all those digital interactive technologies that aim to elicit behavioural changes: for example, a smart water meter that shows the user the amount of water consumed in the last shower, enabling better decision making - either through persuasive feedback or situational architecture [12], i.e. designing an "eco" mode that the user pre-select which sets a timer on the shower places the intervention "in the right place, at the right time" in relation to the consumer's everyday actions.

Finally, within the function of automation we see all those unsupervised activities that digital technologies can perform themselves, such as sorting and classifying activities, useful in smart recycling processes [75], as well as simple and repetitive tasks (such as sorting items by category). Automation can also help better capacity planning and forecasting of resource buying; for example, fruit and vegetables represent the largest source of waste in supermarkets (it's been estimated that they make up to 85% of waste in Swedish supermarkets [78]: with better automation leveraging big data, decision making around buying and pricing perishable items in supermarket can significantly reduce food waste [24].

Overall, we see that digital platforms are conceptualised in different ways, ranging from more to less technical definitions. In our research, we build on the definition of Koh and Fichman [49], which define digital platforms as two-sided networks, facilitating interactions between distinct but interdependent groups of users; we think of digital platforms for the CE in the same way, adding the condition that the group of users co-create value and drive positive social impact through their interactions. While mobile apps are only a type of digital platform (websites in which similar interactions take place would be included in the category) the scope of this research is mostly focused on these for two reasons: firstly, mobile apps exist within more clearly defined boundaries, residing in specific spaces such as the Google PlayStore for Android devices, or the Apple Appstore for iOS devices. Secondly, while the EPA report mapping the reuse sector in Ireland had breadth [35], it didn't go into the details of digital platforms available to citizens and consolidated all options under an "online" umbrella. With the evidence around how users of sustainability apps are more likely to translate their personal norm into pro-environmental behaviour in private and public settings [22], this research completes the picture. While we acknowledge the limitation of this focus, which potentially excludes websites leveraged for CE practices, we think that the narrower focus allows greater accuracy in assessing each application.

Due to their widespread adoption, digital platforms have an important role as mediators of the CE - digitalisation can make processes in organisations more efficient, helping to minimise waste and transaction costs [1]. While in their 2018 paper Sutherland and Jarrahi [84] summarise the roles of digital platforms specifically in relation to the SE, we believe some of those affordances, namely match-making, extending reach, trust building and facilitating collectivity, are equally applicable to the realm of the CE. For example, match-making which enables the matching of demand and offer is a common quality of marketplace-type applications; reach, on the other hand, is extended by the creation of wide networks where users co-create value, with the output of user generated content increasing proportionally with the growth of the user base, and vastly outperforms what a traditional firm could produce [21]. Digital platforms also enable the building of trust by providing rating or user review systems [42], encouraging the interaction amongst anonymous users who do not know each other. Finally, facilitating collectivity is also an important aspect of digital platforms for the CE: in different ways, these platforms bring users together working as communities of practices [94], sharing resources that would otherwise remain idle, mobilising them to connect with each other and leverage technology to build new, "real life" connections with like-minded users

in their community, with a natural consequence of establishing more sustainable behaviours. In the SantaCoin case study [86], the digital currency ideated for a festival seamlessly integrated with the participant's regular practices, allowing them to create an alternative, parallel economy.

3   Methodology

We conducted a study aimed to map the landscape of mobile apps enabling CE for citizens in Ireland; this was the first step in understanding the problem space for the creation of a peer-2-peer digital platform to enable toy sharing in Irish communities, The Toy Library. The scope of this study was to provide orientation to the researcher/designer, identifying the most common systems being used by citizens, and the functions offered by the existing mobile apps they use to practice circularity. This research also allowed the researcher/designer to identify a gap in the landscape of such mobile applications, which The Toy Library aimed to fill. At the time of final submission of this article (April 2025), The Toy Library had already become a well-established social enterprise counting 1596 users, with 297 toys being listed on the platform in several local communities in Ireland.

Landscape mapping is the systematic scouting of a specific technology within a given domain [81]. This method has been used in different disciplines to map mobile applications related to food [56, 59], health, and specifically pregnancy [57], oncology [91], and COVID [65, 64], as well as tourism [8]. In HCI, studies using landscape mapping focus on functional reviews of mobile apps, for example related to mindful eating [37] or on the issues of privacy policies [98] also in relation to period tracking apps [27]. The initial scanning of the digital landscape was conducted leveraging the top 200 ranked apps for Google Playstore and Apple Appstore. We defined inclusion and exclusion criteria to identify mobile apps relevant to our research scope.

To capture the landscape of mobile apps in Ireland, we leveraged both a "bottom up" approach - in which we first explored the top ranked mobile apps on the Irish market on a specific day, and identified the ones in which CE practices were taking place, and then a "top down" approach in which - through a selection of keyword based queries - we searched on the Google Play store and the Apple store for mobile apps that possessed the same criteria. Inclusion criteria: mobile apps designed with CE practices in mind, as per the R9 framework (for example enabling recycling, reusing, remanufacturing, etc.). This framework was used to gain a background understanding of CE practices and inform the landscape mapping in the scanning phase but was not part of the core research questions. Exclusion criteria: apps typically categorised under the sharing economy umbrella, such as "ride sharing" apps - as in the Irish market they are equivalent to taxi services - and "house sharing" apps - as apps like Airbnb have become equivalent to B&B business.

For the "bottom up" approach, we collected the data on three specific days (20th, 21st and 22nd of December 2023). Our data set was hosted on the Google Play Store (which hosts Android mobile apps) and the Apple store (for iOS mobile apps). To extract the data, we used the website data.ai intelligence (formerly known as the Annie

app), which is an analytics platform that extracts public facing information from Google Play and Apple stores. On the days specified, above, data was reviewed from the Google PlayStore and Appstore top ranked apps listing[1] and recorded in a spreadsheet, collecting the name of the app, ranking position, and a link to the app's page. The charts provided by data.ai show the relative popularity of each application on a specific market (in this case, Ireland), on a specific day. The data was securely stored on the university cloud based storage service, and being defined as "public data points", this information (mobile app ranking) is allowed for research and publication purposes by data.ai, according to their data usage policy [23].

For the "top down" approach, a list of keywords related to the CE was identified (sharing, share, freecycle, waste, sell, buy, swap, second hand, preloved) and used to search for applications on the two stores. These keywords were selected based on the most frequent occurrences through the author's organic discovery of second hand/preloved freecycling group in her local Facebook community. After having conducted the keyword-based search, results were collected on a spreadsheet, including the name of the app, and a link to its detail page. Following that, a quality check was conducted to assess the relevance of the app in the Irish market, as the apps that were produced by the queries were often not really "actively functioning" in the Irish market, even if they were publicly available (this is possibly due to the fact that developers can publish an app globally, and they take that chance even if the app is targeting a different market). Each relevant app detail page was scanned for quality checks to identify, for example, a foreign currency mentioned in the apps' screenshots, and if in further doubt, it was installed on the researcher's device and its functionality on the Irish market was personally checked. The different steps completed for both the bottom-up and top-down approach were captured and collated to formulate a toolkit for future landscape mappings.

This approach helped identify more mobile apps than possible using only one of the two analytical methods and paint a broader picture of mobile applications used for CE practices in Ireland. The quality control on the keyword-based query results ensured the identified apps were actually being used in Ireland. Landscape mapping provided a comprehensive picture of CE related mobile apps, as the criteria used to surface the top 200 ranked apps and the criteria used to surface apps following a keyword query are different: the first is influenced by popularity (i.e. user engagement with the app), while the second is heavily influenced by the relevance to the users' query.

4   Landscape Mapping Findings

More than one third (36.5%) of the top ranked 200 apps on the Google Playstore on the data collection day were games; on the Apple Appstore, games represented 15.5% of the top 200 ranked. Shopping was the second most popular category: it represented

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[1] For the Google Playstore, the data was collected on the 20th of December, Ireland, top 200 free apps for all Android devices, and the data was extracted at this link. For the Apple Appstore, the data was collected on the 21st of December, Ireland, top 200 free apps, for iPhone, extracted at this link.

9.50% of the top ranked 200 apps on Google Playstore, and 14.5% of the top ranked 200 apps on the Apple Appstore on the data collection day. In the top ranked 200 apps on the Google Playstore on the data collection day, only one was specifically designed with CE practices in mind: Too Good To Go - End food waste. However, it is common knowledge that CE practices also take place on social media apps (with the most well-known in Ireland being Facebook Groups). Social media apps on which CE practices take place that appeared in the top ranked 200 apps on the Google Playstore were: Facebook, Whatsapp, Telegram, Instagram, TikTok. In the top ranked 200 apps on the Apple Appstore on the data collection day only two were specifically designed with the CE in mind: Too Good to Go - End Food Waste and Depop - Buy and Sell Clothing. Overall, the bottom-up approach did not yield many results in terms of CE related apps: this may be because the results are "diluted" by the overwhelming presence of gaming and shopping apps in the top ranked charts. Or it could simply show a lack of awareness and engagement with existing CE apps.

The highest ranked shopping app on both the Google Playstore and the Apple Appstore was "Temu - Shop Like a Billionaire". Temu is a Chinese-owned online store that launched in the last year and has "taken over the internet" for its popular artificially cheap prices. Temu has achieved great popularity internationally but has been criticised for selling poor quality items and for its "crowdsourced marketing", using consumers to promote the app, providing them with credits to be spent on the online shop. Items are shipped from China everywhere in the world. Arguably, from an environmental perspective, Temu is the opposite of a CE app, as noted by several critics [36]: cheaply produced items shipped from China using cargo planes, making it practically and financially inconvenient to return a wrong item, increasing the chance that this would end up as waste.

Following the initial scanning of the landscape, we focused our research using keyword based queries on the Google Playstore and the Apple Appstore (sharing, share, freecycle, waste, sell, buy, swap, second hand, preloved). The keyword search produced more results, however having captured the data it was evident that many of the apps officially available on the Irish market did not have a real user base in Ireland and had been designed with other markets in mind: we screened those out of our search results. This approach resulted in seventeen mobile apps (Fig. 2) for giving or buying/selling items (with some apps allowing both options), across different categories: from general marketplace or general items to more specific categories such as food, fashion, sports, tech, and vehicles, with fashion being the category that produced more results across all categories.

Fashion apps for buying/selling second-hand designer clothes have the widest space in the market. This is important, as the fashion industry is one of the most unsustainable ones; already in 2018, it was responsible for 20% of global wastewater, with 85% of textiles ending up in landfill instead of being reused (United Nations Climate Change, 2018). While some organizations in the fashion industry have started adopting circular business models (for example, luxury brand Stella McCartney allowing the resale of used garments on their own platform), third party marketplace apps (like Depop) play an important role in the circular fashion economy, allowing users to buy and sell used clothes, with some apps specifically targeting the luxury fashion niche (Siopaella in

Ireland and Vestiaire Collective globally) - promoting trust building with their users by providing them with a validation of the authenticity of the luxury items put on sale on their marketplaces.

The only apps designed specifically for giving away unused resources were Olio, Trashnothing, and Go Zero Waste. These are citizen to citizen apps (or P2P). Within Olio, users can choose between food and non-food. The app is geolocated, so it encourages giving in local neighbourhoods. Certain features (such as an ad free experience and being able to see listings on a map) are reserved to "supporters" of the app, who can subscribe for €32.99 yearly. Olio also allows users to volunteer with supermarkets and redistribute leftover items within their community, to achieve giving goals (such as adding 7 listings in 7 days to get a special badge) and to reduce their carbon footprint through actions such as deleting unused photos from their phone (see Appendix 1). Trashnothing, on the other hand, only allows users to give items away to other users but is completely free to download and use.

Another notable app to prevent food waste is Too Good To Go: this is more centred on a business to citizen model, with businesses signing up to it and selling leftover items that would otherwise be discarded at discounted prices. Bakeries, restaurants and supermarkets create "surprise bags" and sell them to citizens for a fraction of the price, however citizens cannot choose contents, and agree to collect the bags at a specific time of the day (see Appendix 2).

While we did not focus our attention on a specific "R" in the R9 Framework (see Fig 2, adapted from Potting et. al. [72]) when scoping our research, the results show that all the Apps emerged from our landscape mapping refer to the R3: "reuse" strategy, with the only difference that some follow a P2P model, and others a B2C model (while others, like Olio, created a B2C2C model, in which a business - namely a supermarket - gives items away to a consumer - called "Food Waste Hero" -, who takes responsibility to redistribute them to other consumers). None of the available apps present a B2B model. (see Appendix 3).

Finally, as there is increasing evidence that commercial social networks are the go-to platform for giving/swapping/buying and selling in communities worldwide, Facebook was included in the selection of apps in our research. As of November 2023, there were 3.6 million Facebook users in Ireland, accounting for 71.4 percent of the country's population [82]. In the last decade, Facebook has
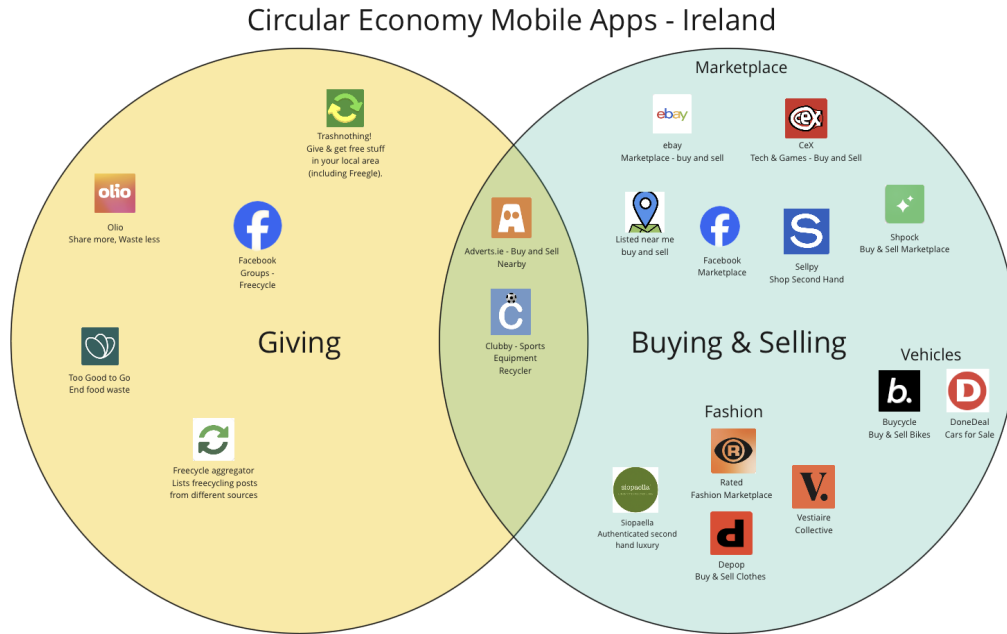
Fig. 2. Landscape of CE related mobile apps in Ireland

evolved from being a social network to becoming a global platform for online sociality [76]. The website circularliving.ie [18] consulted in December 2023, provided citizens with a directory of links to avoid waste and dispose (or acquire) items, listing several resources for freecycling, broken down by county. As of December 2023, most of those resources (excluding mentions of Olio, Freecycle.org and the app Go Zero Waste Dublin), were Facebook groups. The overwhelming presence of Facebook as a platform for circular economy practices is somewhat problematic and known as "the platform paradox" [76]: this illustrates how - despite Facebook being objectively misaligned with the core values and ethos of online solidarity groups, and despite its dubious data management practices - the social network is still the lowest effort/easier to adopt solution to facilitate at least some of the interactions in each group, due to some fundamental aspects such as its extensive market penetration.

5   Discussion: Towards a Landscape Mapping Toolkit

Overall, the study showed that CE platforms in Ireland remain scarce and poorly discoverable, with low rankings in App stores. Most of the platforms identified through

the landscape mapping operate for profit, with Olio being semi-nonprofit and Trash-nothing! being the only free item recirculation app. Other platforms like Facebook Freecycle and Too Good 2 Go monetize through user data or reduced-price sales, indicating opportunities for nonprofit CE solutions. Additionally, App store searches yielded irrelevant results, requiring time-consuming verification processes that may discourage users; better quality control of the apps made available to regional App stores would user experience for citizens who wish to practice circularity. From a social responsibility perspective, the only "government backed" mobile app emerged from our research was the "Waste Less" app (funded by Hong Kong's government), designed to help citizens locate recycling points; similar tools could be designed by local authorities to support reuse initiatives. Finally, Facebook's role as the main freecycling platform can be problematic from a data-privacy and user experience perspective.

Meanwhile, Temu's popularity as a fast-fashion retailer demonstrates the need for better consumer education about environmental impacts. Organizations like the EPA could have a more active role in informing citizens about the consequences of purchasing from apps that are located outside of the European Union, and that do not adhere to European regulations, data security practices, and have significant environmental impact [4], while also using dark patterns (deceptive or manipulative design techniques) in their user interface [74].

The deep dive in the world of mobile apps for CE practices unearthed a gap in the existing offerings tailored to peer to peer sharing of resources from citizens, and a scarcity of non-profit organizations providing such services, as most mobile apps are based on a for-profit model which ultimately requires user data monetization. It also showed a gap in relation to toys, the category we were investigating with The Toy Library, highlighting an opportunity to create a targeted web application to exclusively allow peer 2 peer sharing of toys. According to the SDG goal 12.5 [90], it is pivotal to "substantially reduce waste generation through prevention, reduction, recycling and reuse". Mobile apps provide opportunities for citizens to increase their sustainable behaviours, and for this reason, there should be free and not for profit platforms that allow citizens wide access to information and interactions that enable the reuse sector.

Conducting a landscape mapping exercise can be a good starting point for researchers who are exploring new product opportunities, as it can provide directional insights on existing gaps in the market, while also informing the design of future product or experiences based on the analysis of the existing applications and the functions they allow. For example, our in-depth exploration of Olio allowed us to discover the neighbourhood discovery function, which ended up being one of the most popular features in the proof of concept for The Toy Library, allowing users to discover items in the proximity of their own location, amplifying the sustainability impact of the platform.

5.1   Landscape Mapping Toolkit

The toolkit includes a visual representation of the steps of the technique to execute a comprehensive app landscape mapping - including both the bottom and up and top-

down approaches, along with a checklist that can be used to conduct similar research in another context or refined in case of additional requirements.
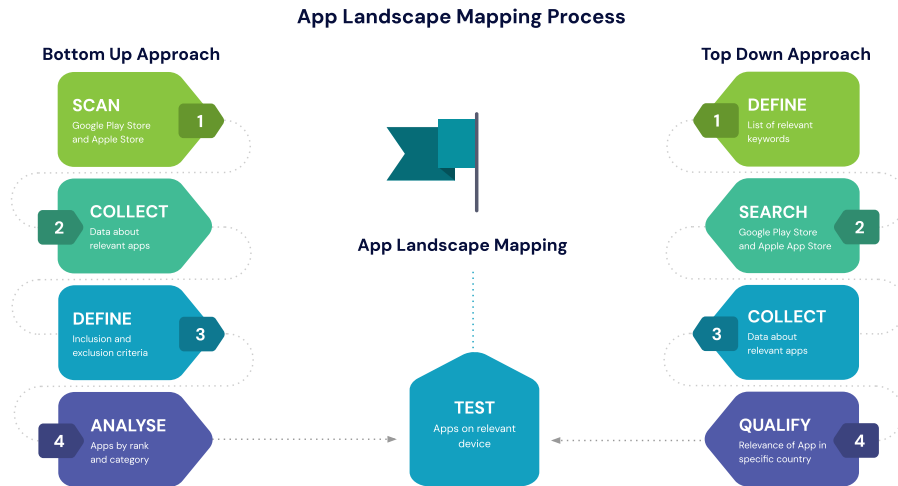

Fig. 3. Mobile app landscape mapping process

Researchers who wish to replicate this approach to map the landscape of mobile apps in the context of their work, can use the following checklist to inform the research design.

App Landscape Mapping - Checklist	
Phase 1 - Bottom-Up Approach	**Phase 2 - Top-Down Approach**
Scan - Google Play Store and Apple App Store for top 200 ranked Apps; it is possible to leverage third party tools such as data.ai intelligence (formerly known as the Annie app), an analytics platform that extracts public facing information from the Google Playstore and the Apple App store. Define a specific date range and stick to it.	**Define -** list of keywords relevant to your research questions. This can be an iterative process, with keywords being refined throughout (i.e. for Circular Economy Apps: sharing, share, freecycle, recycle, etc.)
Collect - data from the Google Play Store and App Store top ranked apps listing and record it using a method of	**Search -** Google Play Store and Apple App Store leveraging the keywords previously identified. Refine and iterate.

choice; record app name, ranking position, and a link to the app's page.	Which keywords work best and achieve results most relevant to research questions?
Define - inclusion and exclusion criteria for the analysis: these depend on your research questions (app category - i.e. mobility, food, or other - business model - i.e. b2b, b2c, p2p; platform type -i.e. marketplace vs freecycle).	**Collect** - data about relevant Apps. Record the same information as in phase 1 to ensure consistency.
Analyse - apps by rank and category: which category has the biggest presence in the top ranked apps (i.e. games vs shopping, etc.)	**Qualify & Test** - are the selected Apps not simply available but truly functioning in the relevant country? (hints to look out for: currency, language, etc.). Test functioning of Apps in relevant devices (iOS, Android). Does the App have a significant user base (i.e. are there many user generated entries, listings, etc.)

Table 1. Checklist for mobile app landscape mapping

6   Summary of Contributions and Conclusions

This study offers several contributions to HCI research and practice bridging academic and non-academic contexts. Firstly, it shows the value of an industry-based research method for product design across contexts: one of the challenges of Sustainable HCI is the disconnect with industry fields of interaction (and industrial) design – which DiSalvo et. [26] argue is systemic throughout HCI. HCI prototypes often fail to succeed due to poor usefulness in their real-world application – aspect that is often disregarded in favour of understandability and usability [45]; additionally, it has been a repeated concern that HCI innovations rarely develop into commercial products [43]. An industry-based approach that enables the researcher to identify the existing applications and potential gaps / unmet needs in the existing market is an advantage in informing the decision to move from discovery to design. In our specific case, as of the 23rd April 2025, The Toy Library counts 1596 users in the whole Republic of Ireland, with 297 toys being shared between families in the same community. This is evidence that the platform addresses real user needs and a gap in the existing mobile/web apps offering in relation to toy sharing.

Secondly, the study completes the picture of the reuse sector in Ireland. The analysis aims to connect the dots between the CE and mobile apps currently used by citizens to practice a specific function (circularity) in a specific area (Ireland). To the best of our knowledge, no other studies focused on this specific intersection between the CE and mobile apps; the 2022 EPA report [35] addressed the reuse sector but grouped all the resources identified under an "online" umbrella. Our study completes the picture focusing on mobile apps and unearths additional platforms with "atypical" business models (i.e. Olio and their B2C2C model). Finally, it has been distilled into a re-applicable model (toolkit) that academic researchers can leverage when exploring product design, to make sense of the landscape of mobile apps enabling specific relevant functions. This is useful when in the discovery phase of product design, to quickly identify existing functions in a specific problem space and can even be used to conduct market research and ideate solutions that are currently unaddressed in the market.

We also acknowledge certain limitations. The research captures the results of a specific moment in time (December 2023) – results which could vary significantly by the introduction of new mobile apps in the relevant area (i.e. since then, Vinted – the most famous second-hand marketplace for clothes in Europe, has launched in the Irish market). Furthermore, for the top-down approach, the keywords-based research was based on the first author's own organic discovery of existing resources for CE in Ireland, but this selection of keyword does not pretend to be comprehensive or even unbiased, therefore the researchers' own subjective experience has influenced the queries that produced the results further analysed. Finally, we acknowledge that the only publicly available data is the ranking of the apps released by Google Playstore and Apple Appstore, and it is not clear how reliable and valid the data is.

In conclusion, this paper presented a study applying the method of landscape mapping, which is an established approach to product design and development in industry, to The Toy Library, a project bridging research in academic and social enterprise contexts to develop a Circular Economy community platform. We have shown how this technique can be useful for the growing professional practice of Sustainable HCI, and we proposed a reusable toolkit that can be used by stakeholders engaged in this field and wishing to either understand and/or add to the existing landscape of digital platforms fostering CE practices in a particular area. With the hope that SHCI research will increasingly translate in tools that are adopted and used by relevant communities, methods that hail from product and UX design can make a positive contribution to the process and also benefit social enterprises and other not-for-profit initiatives taking part in research.
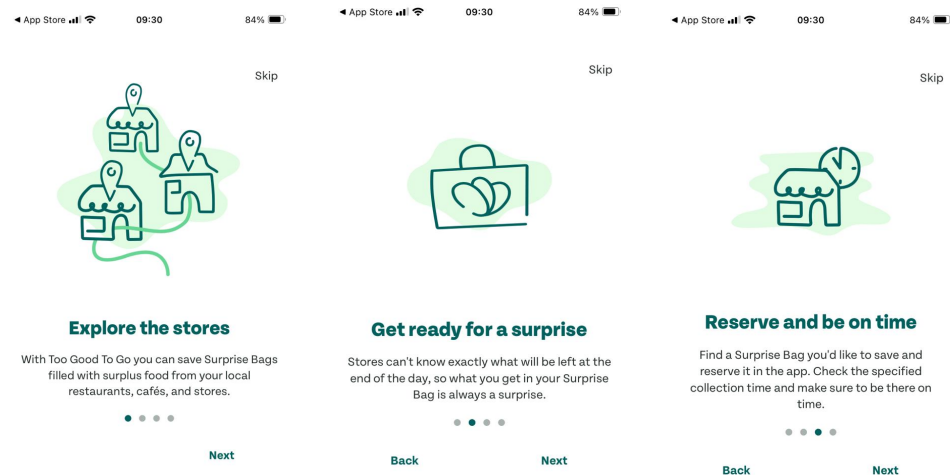
7 Appendices

7.1 Appendix 1 – Olio
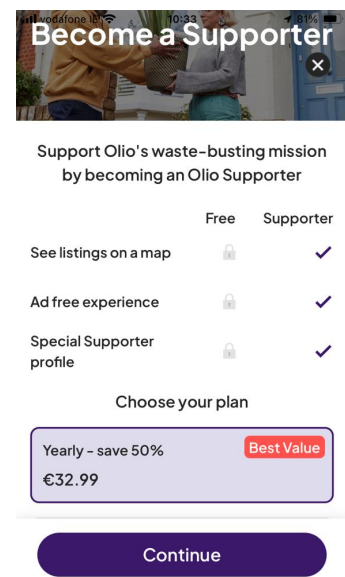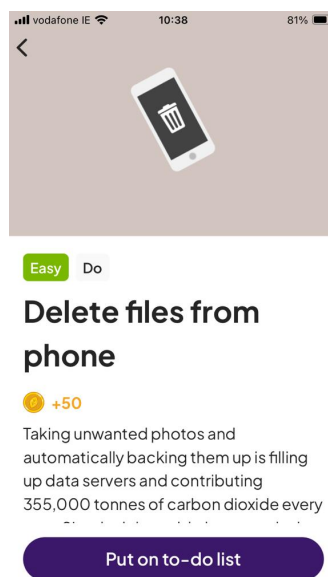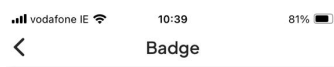
7.2   Appendix 2 – Too Good To Go

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