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Exploring the Risks of Green Crowdsourcing in South Africa: The Case of Dilivari

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Abstract: Green crowdsourcing mobile applications provide an appropriate supply chain coordination mechanism for deliveries, harnessing benefits for people, profits and the environment. Despite the benefits, the risks and challenges associated with green crowdsourcing undermine the social, economic and sustainability benefits of last mile logistics. We undertook an exploration of the risks of using the green crowdsourcing Dilivari mobile application (App) innovation in South Africa. The study used an exploratory research case study research design. The study included 54 respondents with rich, in-depth knowledge, 49 participants for focus group discussions (FGDs) and five key informant interviews. Our study established security, legal, human and connectivity risks associated with this app. We focused on the risks and challenges in the literature including critical emergent risks in a developing country context, compatibility of technology, load shedding, mobile penetration, and data costs. Furthermore, we highlighted the security risks posed by theft, robberies and terrorism.

Keywords: green crowdsourcing; risks; security; human; legal and connectivity risks

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1. Introduction

Logistics are critical for social and economic development in Africa and beyond. The growth of crowdsourcing logistics has provided several options for improvements in social benefits such as resource sharing and community support [1] and economic benefits such as faster delivery, flexibility, and low-cost distribution. Several scholars have dealt extensively with the benefits of green crowdsourcing [2–4]. Green crowdsourcing applications benefit people and the economy [2] and address environmental problems [4]. Specifically, several scholars have emphasised the significance of crowdsourcing for peoples' livelihoods [5], profit [6,7] and environment. Inadequate understanding of the risks associated with green crowdsourcing can erode these benefits, however.

The previous literature covers the risks inherent in structured crowdsourcing in applications such as Piggy Baggy, Uber and Bolt, which have formalised mechanisms for risk management [8–13]. Researchers have highlighted the risks of theft, loss and damage [10], risks to personal privacy, and vulnerability to criminal activity [8], and risks to standards of delivery and of loss or theft during delivery [9]. However, the crowdsourcing applications Uber, Bolt and Piggy Baggy have developed appropriate risk management strategies to ensure security from theft, robbery, and threats to privacy [8]. Rougès and Montreuil [11] stress the point that structured crowdsourcing applications have developed appropriate techniques for minimising risks. These include rigorous selection processes, feedback systems, personal web pages or spaces, secure messaging systems, secure online payment systems and insurance. Paloheimo et al. [13] confirmed that Piggy Baggy had successfully pre-tested security features designed to address these risks. Techniques such as 'cyber manhunt' [14], 'human flesh search' [15] and 'cyber crowdsourcing' [16] have proved successful in combating risks associated with crowdsourcing applications. Furthermore,

Mwaura [17] argues that formalised mechanisms for vetting participant drivers are effective in minimising the risks of crowdsourcing.

In this paper, we define green crowdsourcing as 'unstructured information connectivity enabled marketplace concept that matches supply and demand, contributing to environment sustainability. Green crowdsourcing is dynamic and flexible' [8,9,13,18,19]. These applications optimise and exercise flexibility by using pre-existing travel routines [9], commuting trips [11] or delivery locations near the user's own destination [18], maximising car occupancy [20], utilisation of unexploited space [10], shared freight transportation [21], use of energy-saving transportation such as bicycles [22], with the objective of harnessing logistic efficiency and reducing carbon emissions [8]. Structured crowdsourcing applications such as the Uber and Bolt applications designate part of the crowd to drivers and other users during registration [17], as opposed to unstructured green crowdsourcing. These applications encourage shared occupancy, shared freight, the use of pre-existing routes, and delivery by drivers close to delivery locations. In addition, green crowdsourcing uses energy-saving transport such as velomobiles, bicycles, motorised bicycles, electric scooters, electric vehicles, solar cars and non-motorised forms of transport for deliveries.

In order to assess the risks connected to green crowdsourcing, we piloted the Dilivari green crowdsourcing application in South Africa. This application was developed using a quantitative computer program as guided by decision science methodology [23]. The mobile application (App) provides an innovative solution to a multi-embedded grocery supply chain coordination by maximising car occupancy and shared freight for environmental sustainability. The "Dilivari app" was developed with green crowdsourcing principles: dynamic and flexible capabilities different from structured crowdsourcing existing apps like Uber and Bolt in dedicated trips. In this way the application is more environmentally friendly as the number of vehicles on the road can be reduced, resulting in less carbon emissions. Green crowdsourcing applications reduce carbon emissions as opposed to traditional crowdsourcing applications. Traditional crowdsourcing apps such as Uber, and Bolt complete one delivery before an additional delivery is made available to them for execution [17]. The environmental perspective of the Dilivari App is the reduction of carbon emissions through flexibility as opposed to traditional apps like Uber and Bolt that mainly focus on profitability and people. We conducted Focus Group Discussions (FGDs) with 49 participants and Key Informant Interviews of participants on the risks involved in the use of the new green crowdsourcing digital conceptual prototype. An exploratory study embedded in the case study was used to understand the potential risks of green crowdsourcing. Understanding the risks involved in the use of a prototype application is critical in making improvements to it. Furthermore, this study helps to strengthen green crowdsourcing applications by balancing people, profit and the environment.

In our study, security, legal and human risks, previously appropriately managed under traditionally structured crowdsourcing, re-emerged. Risks related to structured crowdsourcing have been explored in earlier studies and solutions have been found but there are scant studies of green crowdsourcing risks. Green crowdsourcing is dynamic and flexible; in addition to legal, security, and human risks, there are connectivity risks associated with internet access, load shedding, smartphone penetration and data costs. This study stresses the critical importance of connectivity in the context of developing countries, especially in townships and rural areas.

The following section provides a critical review of the specific risks inherent in green crowdsourcing applications.

2. The Literature Review

A comprehensive review of the literature reveals five major categories of risk in green crowdsourcing: security, legal, human, quality of service and connectivity risks.

2.1. Security Risks

The current literature identifies the security risks in crowdsourcing as risks to privacy and physical risks [24,25]. The first form of security risk examined in the literature is privacy of information. Howe [26] initially described crowdsourcing as anonymous and without privacy concerns but the emergent literature has highlighted privacy breaches [27–29]. In their study, Wang et al. [30] highlighted scenarios where online platform users regretted the sharing of sensitive, personal and private information. Furthermore, Wang et al. [28] documented cases of participants in crowdsourcing environments who complained that they had been profiled and tracked. The likelihood of personal, sensitive and private information falling into the wrong hands raises concerns about privacy and personal security [31]. Despite the benefits of innovative problem solving [32] offered by crowdsourcing, consideration must be given to the protection of privacy [27]. Abrams [24] argues that the privacy of information demands much greater attention owing to frequent cases of in-house data breaches. Privacy is of great concern to participants on online platforms [25]. Traditional crowdsourcing applications such as Piggy Baggy, Uber and Bolt have developed 'cyber crowdsourcing', using applications mainly with distinctive security features to protect privacy [16].

Academic literature privacy risks in the use of green crowdsourcing have increased significantly and are a result of the dishonesty of some participants, both drivers and clients. Chen et al. [33] proposed a crowd delivery application based on unstructured crowds in the city of Hangzhou to reduce environmental pollution. Despite the benefits, there were privacy risks that increased leaks in location [34], travel time [35], personal information [36], and personal information hacking [37]. Hallgren et al. [38] developed a model for controlling information leakage to trusted sources, but the task of balancing trusted and untrusted sources proved daunting [37]. In a bid to balance profit, people and the environment, green crowdsourcing applications make use of pre-existing travel routes, community trips, delivery locations near the user's own destination, maximisation of occupancy, and shared freight [19], which indirectly exacerbates risks to personal privacy.

In addition, research highlights physical threats to security: theft, robbery and attacks by rival drivers [39]. Mpofu et al. [40] reported that robberies are common in South Africa in e-hailing Uber and Bolt vehicles. In their study, Bhana [41] observed the theft of parcels as a critical risk to delivery in the crowdsourcing environment. Crimes include techniques by criminals who knowingly use innocent crowdsourcing participants to unwittingly undertake deliveries to facilitate criminal activity [42]. Mutandiro [43] mentions an incident involving the late-night hijacking and murder of a Bolt driver. Various crime networks in which criminal enterprises outsource tasks and defraud unsuspecting crowd participants have also been recorded [44]. The crowdsourcing appflications Piggy Baggy, Uber and Bolt have significantly reduced theft and robberies [8]. These applications are traditionally used in Europe where approaches such as cyber manhunt [14] and human flesh search [15] are used to combat crime. However, the need for security measures increases in green crowdfunding where there are limited vetting and regulatory mechanisms. In addition, green crowdsourcing's flexibility in the use of ride-sharing, community trips, delivery location near own destination, maximisation of occupancy and shared freight [13] complicates strategies to protect clients. Green crowdsourcing applications have encountered security threats [45–47]. Khan et al. [48] highlighted increases in security risks in their green crowdsourcing applications that facilitate ride-sharing. Chaudhry et al. [45] highlighted increased harassment, assault and theft. In addition, Feeney [47] also observed that legitimate security risks: violence, theft and robberies increase with flexible platforms. Ding et al. [34] observed that there was a legitimate concern that unstructured crowd participants deliberately shared user information resulting in security risks: assault, harassment, hijacking and theft [49]. Security measures like distress alarms should be made available with ride-sharing applications [46], and have integrated facial recognition modules [47].

In addition, attacks by rival driver groups on green crowdsourcing drivers and customers were highlighted [50–52]. Solomon and Kosaka [51] argued that the use of applica-

tions exposed some foreigners to xenophobic attacks as drivers and passengers. Mutengwe et al. [50] found that discrimination in crowdsourcing applications is a form of xenophobia and sabotage by rival competitors. Adebayo [53] found that xenophobia was also involved in the targeting of foreign drivers using the applications. Drivers using crowdsourcing applications face opposition mainly from metered taxi drivers and criminal gangs [50]. In fact, there are criminal gangs that target crowdsourcing drivers and customers specifically. In his study, Mwaura [17] documented several crowdsourcing drivers in Kenya who had been assaulted by criminal gangs and rival drivers.

2.2. Legal Risks

The second type of risk examined in the literature concerns the legal risks associated with crowdsourcing [54–57]. Yadin [54] explored the legal risks of green crowdsourcing in developing countries. Legal risks may emerge in an environment that is not conducive to regulation, monitoring or the enforcement of contracts during crowdsourcing. Furthermore, in a virtual environment, it is difficult to promote public participation, transparency, administrative efficiency, and effective administration of contracts. Dimov [55] emphasised the importance of establishing appropriate legal, policy and regulatory mechanisms for the management of risks of contract breach in a crowdsourcing environment. He observed that Bloomberg reports 90 million disputes annually in the virtual environment. Legal risks have also been identified in relation to employment law [56], patent inventorship [57], data security [58] and copyright ownership [59]. A critical assessment of the literature revealed that crowdsourcing applications such as Uber and Bolt have rigorous legal frameworks for the regulation, monitoring and enforcement of contracts [50], but these legal frameworks are directed more at Europe. The extent to which current regulatory frameworks for developing countries with limited technological advancement exist leaves a lot to be desired. Furthermore, these policy and regulatory frameworks are not specific to green crowdsourcing. Paloheimo et al. [13] noted the unique features of green crowdsourcing applications that emphasise flexibility: pre-existing travel routes, community trips, delivery location near own destination, maximisation of occupancy, and shared freight.

The literature advocates the strengthening of risk management by streamlining legislation, policy and regulatory frameworks [54,60,61]. Ben-David [60] stressed the critical need to pay attention to regulatory frameworks during crowdsourcing application development. In an earlier study, he called for the streamlining of policy to address liabilities and contract breaches in crowdsourcing [61]. This is supported by Yadin [54] in his paper that focuses on the solving of crimes that emerge during crowdsourcing. Ben-David [60], on the other hand, notes the need for the development of appropriate legislation that adequately addresses the liabilities and roles of the various parties in a crowdsourcing undertaking. Earlier, Anat-Beck [62] supported the use of political campaigns as the best strategy for addressing legal risks in crowdsourcing. Policy and regulatory frameworks should incorporate aspects of pre-existing travel routes, community trips, delivery location near own destination, maximisation of occupancy, and shared freight [13]. Emerging dynamics complicate regulatory and policy frameworks in unstructured green crowdsourcing.

Despite the success of green crowdsourcing in the environment and social cohesion [63], green crowdsourcing applications aggravate legal risks. Sundararajan [64] highlights the emergence of a new crowdsourcing paradigm requires policy choices and regulatory mechanisms for self-regulatory organizations, and labor law. In addition, the emergent paradigm requires a change in the regulatory framework for the maintenance of social and economic transactions. Crespo [65] highlighted the green crowdsourcing platforms and that the legal system was not intended to regulate relationships in a technologically-driven shared environment. In addition, laws were designed to regulate relationships in a competitive economy, not a collaborative one. Emergent legal risks in the green crowdsourcing environment need to be dealt with by the legal system and city regulators: employment law [56], patent inventor ship [57]), data security [58] and copyright ownership [59], insurance, safety [66], and driver liability [47]. Unstructured crowds' major focus is connecting

clients through a smartphone app [66], but instead, they suck financial value out of interactions and the value out of your daily interactions [67]. The sharing economy are criticized for "nullification of federal law" [68]. Ride-sharing vehicles were seen as less regulated, and due to this, taxi drivers demanded that ride-sharing be subject to the same regulations [69].

Li et al. [70] proposed the law that ride-sharing vehicles would need intermediation business licenses and would be subject to regulation by the Commercial Vehicles Licensing Board. In addition, unstructured ride-sharing applications with the Singapore Land Transport Authority (LTA) increased their focus on more regulation and transparency.

2.3. Human Risks

Scholars have mainly highlighted the following human risks in crowdsourcing: negligence, accidents, and trust [71–75]. Participation of individuals in the crowdsourcing environment is mentioned as it is critical to the establishment of optimal outputs, to reliable and relevant labelling [76,77], and to quality assurance [78]. Some scholars have, however, observed limited trust and random behaviour among participants in the crowdsourcing environment [79,80].

Kazai et al. [71] found that negligence on the part of some participants in this environment presented a major human risk. Telima et al. [72] cited traffic accidents as a major challenge in crowdsourcing environments in Egypt. Green crowdsourcing applications with with ride-sharing capabilities result in negligence [70] as green crowdsourcing unstructured apps result in the rise of non-professional and non-regulated workers. Malhotra and Van Alstyne [81] argued that the green crowdsourcing platforms mainly facilitate matching drivers with passengers thus bearing no legal responsibilities for property damage or injuries caused by the drivers. Some, however, argue that ride-sharing companies enjoy profits but offload risks onto others [81]. Feeney [47] observed that deaths result from accidents due to negligence by green crowdsourcing platforms. Wolter [82] highlighted the human risks and complications of green crowdsourcing platforms with ride-sharing capabilities in the USA. In addition, there was a case of an accident in Singapore due to the negligence of Uber and Grab drivers following this initial accident [83]. Despite this, there are studies that identify the use of intelligence software and Internet of Things (IoT) for managing risks [73–75]. Yang et al. [73] argued that the use of crowdsourcing applications with intelligence abilities facilitates the collection of comprehensive and coherent traffic-related data, used to avoid accidents. Zhang et al. [74] advocates for the use of IoT to systematically manage traffic for the reduction of accidents. On the other hand, Le et al. [79] called for the development of traffic incident management systems.

A number of scholars have identified the importance of human trust in the use of crowdsourcing for deliveries [8,10,11] and agree that successful green crowdsourcing depends on trust. Despite the people [5], profit [6,7] and environment [4], the trust risk limits participation [84,85]. The contradiction is partly due lack of trust in working with strangers [85]; the low willingness for ride-sharing with strangers signifies that many of the existing ride opportunities are unacceptable for a certain person [86] because of a lack of trust due to safety and comfort [87]. Dubernet et al. [88] argued that behavioural factors are the most limiting factors of ride-sharing, which strongly substantiates the significance of our work. Brereton et al. [89] also emphasised the necessity of involving social networks in ride-sharing based on their technological review. Furuhata et al. [90] framework space sharing: dynamic real-time ride-sharing, carpooling, long-distance ride-match, one-shot ride-match, bulletin-board, and flexible carpooling, with dynamic real sharing for short-term matching or even en-route matching in Atlanta [91]; however, trust risks are critical in green crowdsourcing applications [84]. Yet even with such a substantial number of benefits to various transportation stakeholders, trust [86] is imperative, therefore, green crowdsourcing apps need to build participant trust [92]. Ride-sharing is leveraged on social contacts [93]. In order to address the risk of a lack of trust, appropriate reward and compensation mechanisms should be developed to strengthen trust in crowdsourcing environments [8,10]. These incentives and mechanisms require risk management of the

trust among participants in the crowdsourcing. Mckinnon [22] observed in his study that crowdsourcing applications have streamlined mechanisms for reducing human risks, such as driver ratings, matching vehicle information and reporting reckless drivers [10], but that these have limited success in green crowdsourcing, which is unstructured and has limited vetting.

2.4. Quality Service Risks

The literature provides extensive discussion of the human risk of quality service in crowdsourcing. In a study by Al Sohibani et al. [94], it was established that quality assurance and management were challenging in crowdsourcing deliveries. Scholars have emphasised the need for delivery management [95], human engagement [96], and human requirement management [97], and knowledge curation [98]. Huang et al. [99] argued that risks to human participants from crowdsourcing may arise as a result of the need for unique critical skills for handling perishables and delicate items, which may be lacking in green crowdsourcing participants. Zhang et al. [98] identified the risks emerging as the result of discrepancies in the quality of human engagement that affect customer satisfaction. Furthermore, the participants in crowdsourcing may lack the critical skills needed for the management of human relations, in contrast to a dedicated courier company with its core focus on undertaking deliveries. Huang et al. [96] argued that improvement in understanding the customer during the delivery process may enhance service quality in the pure green crowdsourcing environment. There is the risk that there may be difficulty in understanding that human requirements are unique to certain circumstances [95]. On the other hand, Huang et al. [99] noted the risks that may emerge from a lack of knowledge curation, or the inability of the business entity to effectively manage different business segments. These scholars argue that the process of selecting appropriate sub-sets of information for different groups of customers is difficult in a crowdsourcing environment. Finally, Zhang et al. [98] found that good service delivery requires knowledge curation in the sense of how green crowdsourcing incorporates knowledge management systems to harness customer experience in a crowd.

The literature documents methods used by traditional crowdsourcing applications Piggy Baggy, Uber and Bolt to improve service quality through vetting, training and recruitment [95–97,99]. This approach is commendable but increases risks in green crowdsourcing environments. Jiang et al. [100] proposed ride-sharing to address the shortfall during the Chinese Spring Festival travel season but service quality remained a major risk. Seng et al. [37] showed that green crowdsourcing encounters complications due to user preferences, skills, and reliability of intelligent distribution. In order to improve service quality, Li and Chung [101] proposed cluster-first-route-second approach to handle large-scale scenarios, Kong et al. [102] considered the use of administrators and Ma et al. [103] proposed a cloud-based approach for real-time city-scale taxi ride-sharing. Despite this, the proposal service depends on the perceptions of the crowdsourcing participants [84]. Seng et al. [37] argued that green crowdsourcing has limitations in navigating across different social levels especially older ones and persons with disabilities. In order to balance profit and people, green crowdsourcing emphasises the use of an unstructured crowd. Building capacity among volunteers to undertake deliveries using flexible approaches such as pre-existing travel routes, delivery locations near and maximisation of occupancy exacerbates the risk to service quality.

2.5. Connectivity Risks

Finally, the literature underscores the impact of internet and cyber security risks on the success of crowdsourcing. Lynn [104] and Markoff [105] observed that security gaps in existing technology provide opportunities for cybercrime and internet insecurity. Shiffman and Gupta [106] found that adversaries and hackers may attempt to maliciously gain access to the entire crowdsourcing application, obscuring the target and undermining the performance of the entire application [107]. The cyber-attacker may be able to access

crowdsourcing participants' private and sensitive personal information. No wonder that Chen and Kapravelos [108] found that browser extension security attacks require the prioritisation of monitoring and modifying data. Kim et al. [109] noted the importance of the installation of malware to control the user, while Eskandarian et al. [110] advocated the use of off-the-shelf risk management. Chief among the risk management strategies adopted by previous scholars is the prioritisation of addressing potential security and privacy risks [105] caused by frequent in-house data breaches [24]. Chen and Kapravelos [108] argue that a front protection approach is the best strategy for addressing internet security risks. This approach has proved useful in developed countries but its application in South Africa with its limited internet is difficult.

Internet access poses risks in the use of a green crowdsourcing application [111]. It undermines adaptability to the environment in aspects like flexibility and scalability [1]. Afuah and Tucci [112] argued that crowdsourcing technology must be flexible and scalable to meet the requirements of consumers. Internet access presents a major challenge in developing economies with limited internet connectivity [113]. This is supported by earlier studies that have stressed the importance of internet access for the effective performance of crowdsourcing applications [1,32]. Brabham [32] argued that internet access is necessary for connecting crowd participants and, therefore, imperative for crowdsourcing; the inability to access the internet has a negative impact on the success of crowdsourcing. Prpic and Shukla [1] agreed that the internet has revolutionised the concept of crowdsourcing and that a lack of access to the internet becomes a critical risk to its success. Previous studies of the crowdsourcing applications Piggy Baggy, Uber and Bolt by Buldeo et al. [8] made the assumption that the internet is always available; this is not the case in developing countries. Cheng et al. [114] developed a green crowdsourcing application focusing on underutilized vehicle capacity for implementing the city-wide package distribution but connectivity risks were impeding performance. In addition, Makin and Molkenthin [115] investigated the role of the network topology for on-demand ride-sharing systems establishing unique risks in service quality. Wu et al. [116] introduced a WiFi sensing mechanism that promotes quality connection and network for users by assisting others in connecting to the improved WiFi hotspots. However, the mechanism did not improve connectivity but aided the evaluation of trustworthiness within the network [37]. In addition, there are other connectivity risks in developing countries such as technology incompatibility, load shedding, mobile phone penetration and high data costs.

In conclusion, green crowdsourcing applications have unique techniques and approaches well suited for harnessing, profit, people and the planet but come with diverse emergent risks [37]. Table 1 below provides a simplified and contextualised summary of the literature review on green crowdsourcing risks.

Table 1. Contextualisation of risks in the literature.

		Security Risks					Legal Risks						Human Risks			Service Quality				Connectivity		
Categorisation	**Year & Author**	**Personal Privacy**	**Theft**	**Robbery**	**Terrorism**	**Rivalry**	**Policy**	**Legal**	**Regulation**	**Administration**	**Copyright & Patents**	**Employment Law**	**Negligence**	**Accidents**	**Trust**	**Delivery Management**	**Human Engagement**	**Requirement Management**	**Knowledge Curation**	**Internet Security**	**Cyber Security**	**Internet Access**
Security Risks	[27,73]	x																				
	[44]		x																			
	[41,44]			x																		
	[39,44]				x																	
	[50]					x																
Legal Risks	[54]						x															
	[55]						x	x	x													
	[56]											x										
	[57]										x											
	[59]										x											
Human Risks	[71]												x									
	[72]													x								
	[11]														x							
Service Quality Risks	[95]															x						
	[96,99]																x					
	[74,97]																		x			
Technology and Connectivity Risks	[104]																			x	x	
	[105]																			x	x	
	[108]																				x	
	[32]																					x

x shows the occurrence of the literature.

3. Materials and Methods

3.1. Research Design

This research study was grounded in interpretative qualitative providing a deep insight into "the complex world of lived experience from the point of view of those who live it" [117], reality is socially constructed [118–121], consistent with the construction of the social world by interaction between the researcher and the participants [122]. Our task was to unearth the green crowdsourcing risks in a developing country context experienced by "Dilivari App" participants.

We used exploratory case study research design to explore the risks in a green crowdsourcing environment. In particular, a single case study approach for exploring the risks of green crowdsourcing in South Africa. This approach combined two perspectives, exploration and a case study. The exploratory aspect was critical when dealing with the new phenomenon of green crowdsourcing in South Africa. Singh [123] argues that an exploratory research design is appropriate when studying emerging phenomena with limited understanding. Owing to the exploratory nature of the project, we used case study research to allow for greater flexibility to adapt to the circumstances of the use of the new application for green crowdsourcing (Dilivari application) and the terminology used in the context [124]. The case study is "an empirical inquiry that investigates a contemporary phenomenon within its real-life context" [124], for comprehending processes in a previously little-studied area [125,126] for a holistic understanding [127,128] of phenomena.

Exploratory case studies are critical for in-depth understanding [124], flexibility [121], contextualization [118], discovery [129], theory development, rich data, practical implications [130], interactive learning [131]. In addition, Yin [132] argues that case studies have been stereotyped on weak generalizability [133], and subjectivity [134] and complexity [127] and yet offer rich and distinct knowledge appropriate for green crowdsourcing applications in different unique and dynamic environments.

In addition, our study is premised on the interpretive phenomenology appropriate for understanding subjective world views. The research design was critical in assessing risks in the new innovation, unique context of developing countries, pilot study and preliminary theory of risk in green crowdsourcing in developing countries. In our study, critical theoretical and practical risks have emerged for advancement of theory and practice. Theoretically, risks earlier mitigated with green crowdsourcing applications re-emerged in developing countries. In practice, the Dilivari Application in South Africa has to develop strategies for improvements along the critical domains of security, legal, human, and connectivity. Developers can refine green crowdsourcing to manage the identified risks. In accordance with earlier scholars, exploratory case studies have been used for improvement of software development for a specific unique context [130,135] and, development of theory [125,132,136,137].

An unstructured application for green crowdsourcing developed in South Africa was selected for the study to allow it to be replicated and the findings compared [128] and to improve external validity and prevent observer bias [138]. The Dilivari application is unstructured crowdsourcing with flexibility enabling information connectivity enabled marketplace concept that matches supply and demand contributing to environment sustainability. Risk has been examined in structured crowdsourcing [9,10,12,22], but the risks in unstructured crowdsourcing have not been addressed. The case study approach taken in this study of the Dilivari application contributes to an understanding of the risks involved in green crowdsourcing. This study is critical to strengthening the success of crowdsourcing applications with an emphasis on benefitting people, profits and the environment. Furthermore, it helps towards sustainability goals of economic growth—Goal 8, industry innovation and infrastructure and Goal 9, the promotion of inclusive sustainable economic growth in the context of environmental sustainability [139]. It therefore resonates with United Nations (UN) Goal 13 for the promotion of inclusive and sustainable economic growth [140].

3.2. Sample and Data Collection

The purpose of our study was the assessment of risks associated with a green crowdsourcing application. The exploratory study, therefore, accessed 54 respondents with rich and in-depth knowledge of current transport logistics in South Africa. The study also used a sample of 49 participants for the FGD and five key informant interviews.

In the first part of the study, we interviewed five e-grocery retailers to explore the risks and suggest possible risk management strategies in the use of a green crowdsourcing application. The second part of the study involved conducting FGDs to gain insight into the context and perspective of participants in green crowdsourcing, as we recognised that interviewees participated in both traditional and green crowdsourcing for the delivery of their groceries. The sample of 49 participants was drawn from industry, government and the community. They attended a workshop and took part in a panel discussion and agreed to participate in the study. The FGD was critical in contextualising the existing and emerging risks in green crowdsourcing in South Africa.

We purposively selected interviewees and participants for the FGDs who would support the contextualisation of risk in green crowdsourcing. The participants for the key informant interviews and FGDs had insight into green crowdsourcing in South Africa. Despite the limitations in purposive sampling of bias and subjectivity, this was strengthened by triangulation, data saturation and transparency [137]. In addition, the study research objectives were clearly defined and validated of the findings through triangulation. The interviews were recorded, and transcriptions were made. In certain instances, notes were taken to capture the critical contextual risks in green crowdsourcing. The focus of the interviews and FGDs was on gaining an understanding of participants' views of the risks associated with green crowdsourcing. We conducted our study by adhering to highest level of ethical considerations throughout the phases of the study [141]. First, we obtained ethical clearance from the University Research and Ethics Committee to strengthen responsibility, respect respondent rights, and minimise harm. Data collection was undertaken while upholding the ethical considerations: informed consent, no-harm, confidentiality, anonymity, privacy, honesty and transparency. In addition, trustworthiness and rigour were critical during the research process and were harnessed through reflexivity and bracketing. This was critical for strengthening credibility, dependability, transferability and conformability. Finally, the choices and sequencing of key informant interviews and FGDs were critical for the triangulation to harness the quality of our study.

3.3. Data Analysis

All interviews and FGDs were recorded on mobile or laptop audio instruments and were later transcribed, coded and analysed using MAXQDA. MAXDA is a computer-aided qualitative data analysis purposefully built for analysing qualitative data analysis [142]. The qualitative software has the ability to create themes and sub-themes for the entire project management, data management, searching and mapping data, analysis, sharing and outputs. The software was critical categorization of risks into major and minor categories by use of thematic analysis: themes and sub-themes as provided in Figure 1. With the use of MAXQDA, the processes for qualitative data analysis were followed: familiarisation, reflection, open coding, selective coding, axial coding and evaluation of codes for thematic analysis. In accordance, ethical clearance and due diligence were undertaken during the analysis using the ethical considerations of confidentiality, anonymity, privacy, honesty and transparency. In addition, bracketing and reflexivity was used during the analysis right from familiarisation, coding and theory development.

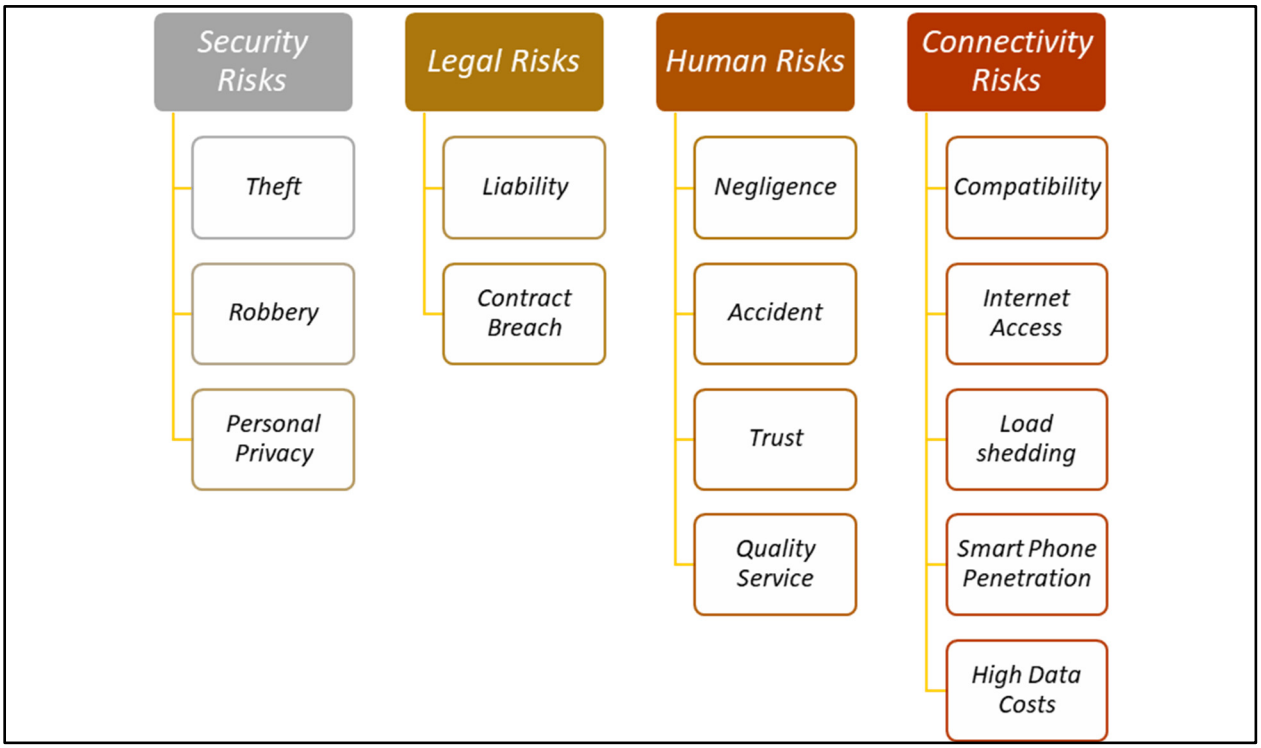

Figure 1. Illustration of risks associated with green crowdsourcing (Dilivari application).

In accordance with Glaser [136], familiarisation and reflection were the first steps in the data analysis. This was followed by the uploading of the transcripts to the MAXQDA qualitative data analysis software for cataloguing the concepts, using the processes of open coding, axial coding, selective coding, linking and re-evaluation [142]. Open coding captured critical aspects in the transcripts, focusing on risks and risk management. Borgatti et al. [143] observed that open coding is the first step in identifying, naming, categorising and describing phenomena found in a text. This was followed by axial coding that related the identified texts to different forms of risks in crowdsourcing. Axial coding is the process of relating codes of categories and properties to each other by the use of various inductive and deductive mechanisms [144].

The next step involved selective coding, placing holistic risks into distinct categories. Easterby-Smith et al. [142] explained that selective coding involves identifying a single theme that encompasses all other stories. The categorisation of risks using selective coding included the mapping of security risks with sub-categories such as theft, robbery, and personal privacy.

The next phase involved re-coding and linking concepts [142]. We undertook re-coding interactively by going back to the initial data and comparing incidents to identify particular properties and realign codes. This was followed by linking assessment risks in terms of appropriateness to integrated risks. According to Charmaz [145], assessment of how substantive codes may relate to each other is critical for development of theory. Re-coding and linkage facilitated a re-alignment of some codes, such as personal privacy, which was initially sub-coded under legal risks but re-categorised under security risks.

Finally, re-evaluation of the codes was undertaken to assess whether the codes and sub-codes in the contextualisation of risks in crowdsourcing. The assessment of the various hierarchies created maps of the different categories of risks, that is security, human, legal and connectivity risks [146]. The assessment highlighted the credibility of the sub-codes for security risks: theft, robbery, and personal information security. Subsequently, the concepts of conformability and transferability were assessed and aided the process of interpretation and analysis of the results [147]. The audio recordings and transcripts provided insights for the final evaluation of the codes developed in the analysis. Yin's [118] study guided the

approach for the development of appropriate and relevant mechanisms for convergence and supporting constructs presented in the findings and discussion.

The findings in relation to risks associated with green crowdsourcing in South Africa are presented in the following section.

4. Results

This study used MAXQDA 24 for the analysis of the interviews and FGD data to explore the risks involved in green crowdsourcing in South Africa. Green crowdsourcing is unstructured in that it is flexible, dynamic and unique in its operation, as opposed to structured crowdsourcing. Flexibility in green crowdsourcing encompasses shared occupancy, shared freight, use of pre-existing routes, and delivery locations by drivers to nearby locations. This study established four critical risks facing green crowdsourcing in South Africa: security risks, legal risks, human risks, and connectivity risks.

4.1. Security Risk

Green crowdsourcing undertakes the delivery of groceries using any member of the crowd, and this poses security risks. The FGD and interviews highlighted the following security risks: theft, robbery, and personal privacy. Security risk management requires alignment with government policy and regulatory implementation with the establishment of guidelines for effective management.

Firstly, the risk exists of the theft of parcels and the contents of parcels during deliveries in a crowdsourcing environment. One of the participants in the key informant interview said that "the risk of using applications in the crowd, which allows everyone in the crowd to delivery is the risks like theft of parcels or contents in the parcels. There have been cases of theft where parcels have been stolen or misplaced with the normal couriers". Appropriate strategies for the protection of parcels and their contents must be developed in green crowdsourcing applications. The main difficulty is the flexibility in the application that allows various people to carry out the deliveries.

The second risk is that of robberies targeting e-hailing services, something that has become widespread in South Africa today. One of the participants in the study highlighted that robberies have become common and a great risk to green crowdsourcing. In his own words, he pointed out that "the criminals have changed their game by targeting drivers using crowdsourcing applications to rob the cars. There are so many cases of robbery now where the people will order for a ride and rob the driver of the car. There are several cases reported in Gauteng Region". Developers of the application should endeavour to strengthen the application and take appropriate action to guard against robberies. The participants suggested the need to work with the government to address the challenge posed by crime, especially robberies during crowdsourcing. The participant stated that, "There is a need for collaboration with the government to develop appropriate policy and manage the criminal aspects like robberies which have become rampant in South Africa". In order to strengthen the application, existing legislation must be strengthened to protect participants in crowdsourcing against robbery.

Finally, the security of personal privacy is a critical risk in green crowdsourcing applications. One of the participants in the FGD highlighted the risk of infringement of people's privacy and asked "How do we enhance information security of the members participating in the crowdsourcing application? There's personal information being shared in terms of where the parcel needs to be delivered to. The person's address is going to be made available to a crowd member that needs to affect the delivery". Information security can be strengthened by ensuring that the development of the application is streamlined in accordance with the existing Information Act, which provides mechanisms for the protection of personal information and the promotion of privacy. One of the respondents emphasised the approach for the protection of information and remarked that 'We do have the Protection of Personal Information Act 2013 together with the Constitution. This is critical in ensuring that the privacy is harnessed'. This was supported by another respondent who noted

that ethical requirements for the development of an application promote the privacy of information, arguing that 'There are guidelines that have to be followed by the developer of mobile applications to uphold ethics and follow through during the development of the application and harness privacy. The developers of applications have a responsibility of ensuring people's privacy; for instance, you can't really track someone's location without them giving you permission, or you can't really do that without getting permission from the actual user to actually use their data'. The green crowdsourcing application has mainstreamed the mechanisms for the protection of people's privacy and rights as provided in the *Constitution and Information Protection Act 2013* which provides mechanisms for the protection of privacy.

4.2. Legal Risks

The green crowdsourcing application is exposed to legal risks that require appropriate management: liability, contract breach and negligence. As opposed to structured crowdsourcing applications such as Uber and Bolt that register users to undertake deliveries. The green crowdsourcing applications are flexible bringing these different people from the passengers, therefore, the legal risks are appropriately managed by the company in conjunction with the government. The FGD highlighted mechanisms for the management of legal risks in crowdsourcing.

Firstly, the risk of liability when a participant in the crowd undertakes deliveries based on convenience. The green crowdsourcing application must provide appropriate responsibility to the parties involved in the delivery at the point of registration to avoid liability. The Dilivari application must ensure that participants exposed to the risks inherent in the mobile application are protected by appropriate mechanisms for demand management. One of the participants in the FGD asked the questions "You know, who bears the liability of things going wrong across this process? Who is the one that is going to be answerable in a court of law if it ever does come to that? What type of evidence can be secured across the transactions that we can now use to stand up in a court of law? You know, what is the liability that is incurred by the person owning this parcel? What is the liability of the person who is transporting this parcel? Who's simply just doing the delivery and may not even know what the content of the parcel is? What is the liability that arises in terms of the person that had now all the people who owns this app that has, you know, linked the business to the person doing the delivery?".

These liability issues must be addressed by the technical designers of the application before uploading it to the Google store. One of the respondents observed that "If I were to break it down, every application has some form of governing body or any decision that it must report to ensure compliance to established ethical standards. And there are guidelines in which you have to write your application to be ethical in a sense. So even if, like, you were to deploy your application to the AppStore or Google Play or Android whatsoever". Liability is incorporated into the different participants of the crowdsourcing execution. There should be a review of policy to strengthen legislation against fraud committed by any of the parties involved in the process of the delivery of goods.

Secondly, the risk of contract breach in the process of green crowdsourcing delivery of groceries has to be appropriately managed, in particular the loose nature of the relationship between the drivers and recipients of the deliveries. The critical aspect of a breach of contract was raised during the FGD, highlighting this possible risk in green crowdsourcing. One of the participants mentioned the issue of the management of a contract breach in the green crowdsourcing environment. She pointed to the risk that "The responsibilities of the different key players in the crowdsourcing are not very clear especially in view of the parties involved likely leading to breach of the contract. How do we trust driver who is on his own to undertake a delivery when his initial motive was travel to work or undertaking his errands? Trust is a very important element that should not be underestimated. Business dealings, they often work on trust as much as we have contracts and legal obligations that arises that are monitored in terms of these contracts in place". In

order to appropriately manage contract breaches in the process of participating in green crowdsourcing, streamlined guidelines and policy frameworks for involvement in such crowdsourcing are required. In addition, one of the respondents emphasised the approach taken for information security and stated that "responsibilities and breach of agreement as responsibilities are not clear in terms of development of a green crowdsourcing application to appropriately address risk management". In order to appropriately address the challenge of contract breaches, there must be guidelines for the liabilities to be apportioned to the different players right from the initiation of the request, to acceptance and delivery. The person requesting, the deliverer and the developer must be made aware of the applicable responsibilities and liabilities in the case of failure.

4.3. Human Risks

Risks to humans can emerge from human error, negligence, motivation and human behaviour involved in green crowdsourcing. Most of the participants in the FGDs observed that the human factor was critical in the entire process of delivery right from initiation to completion of the order.

Firstly, negligence is one of the dangers in the process of the delivery of groceries in a crowdsourcing environment. A green crowdsourcing application must provide appropriate mechanisms for the effective management of negligence. One of the participants in the FGD opined that "Negligence, and wrongfulness is one of the risks which have to be considered across this process of undertaking deliveries of groceries. Negligence could occur as a result of having different actors from different backgrounds". In order to manage the negligence risk effectively, the capacity of the players in a crowdsourcing environment must be strengthened so that negligence is limited. One of the participants in the FGD called for an appropriate assessment of the processes undertaken in crowdsourcing for effective risk management. He said that "An in-depth research can facilitate the process of developing an application and a system to effectively address negligence". The argument was that in-depth research would ensure that users are made aware that risks are mitigated upfront as far as possible; this is critical in addressing the risk of negligence. Furthermore, it was suggested that a holistic approach that captures government policy, consumer education and manufacturing would be critical in ensuring that negligence in the process of green crowdsourcing could be appropriately managed. In her own words, this respondent argued that "Human capacity is critical in the management of negligence risk, which requires support by government policy consumer education, and manufacturing are critical in addressing the negligence risk". The negligence risk requires appropriate studies to understand the threat across the green crowdsourcing life cycle and how to involve various stakeholders in dealing with negligence.

Secondly, accidents in the delivery process could undermine green crowdsourcing. The Dilivari application should ensure that exposure to accidents during deliveries is appropriately managed and addressed. One of the participants in the FGD highlighted the risk of accidents and said that "We are now using a crowd who are not necessarily trained in what they need to do in terms of delivering this parcel, until there's many different things that can happen and that can go wrong along the way. Accidents happen, there's congestion that can cause delays". The issue of mechanisms for the avoidance and management of accidents in the green crowdsourcing environment during deliveries must be addressed. A possible review of policy to strengthen legislation against fraud by any of the parties involved in the process of delivery of goods is recommended.

Thirdly, trust in the process of using crowdsourcing in South Africa raises risks. The participants of the FGDs observed this risk in the face of the current insecurity in South Africa and the high incidence of robbery and theft. A participant highlighted the risk, stating that "Trust, therefore, is crucial. Trust in terms of the community that may be participating in terms of being the crowd during the delivery or the community where the parcel is being delivered to as well". Green crowdsourcing applications must strengthen trust by eliminating areas where trust can be breached during crowdsourcing. One of the

participants suggested a strategy for the management of crowdsourcing: "Trust has to be appropriately underpinned in the entire application and the entire process in mobile application. It's important to understand, how we are able to build this trust, how we can manage trust between different role players involved in the process. And also how, you know, we can mitigate risks that can arise as a result of lack of trust". Developers of the mobile application should devise strategies for building trust among the stakeholders in South Africa.

Poor service quality poses another risk for green crowdsourcing, resulting from inadequate knowledge in the handling of deliveries. One of the participants of the FGDs noted that "We use participants to deliver groceries who are not necessarily trained in what they need to do in terms of delivering this parcel. This compromises the quality of the service being provided". The involvement of several stakeholders as part of a crowd with dynamic roles and responsibilities can systematically undermine the quality of the service. In order to efficiently manage the risk of a limited understanding of roles in the process of green crowdsourcing, it is imperative to equip the various key players with knowledge and skills for effective management across the entire crowdsourcing environment.

Finally, unethical behaviour by the people involved in green crowdsourcing constitutes a risk that requires attention during the development of the application. One of the participants argued that "You know the dilemma that we have with technology is not on the technical side. It is on whether or not humans can actually be ethical; can we trust humans working side by side with machines. So, we do design these technologies to work very well, but they can be misused by humans. So that is the aspect that is really a dilemma". In order to appropriately address ethical dilemmas, the processes for the development of technological applications that have been stipulated must be followed through. Furthermore, another the participant of a FGD argued that "There are guidelines in there that have to be ethical, and you need to follow through. And if your application does not meet those particular standards, like for instance, you can't really track someone's location without them giving you permission, or you can't really do that without getting permission from the actual user to actually use their data. And you need to get some form of consent from that standpoint". It is important that the developers of the Dillivari application understand the code of ethical conduct to be adhered to in the process of developing technologies for human use. This is critical in addressing risks that emerge from using this kind of application.

4.4. Connectivity Risks

The study established that connectivity risks pose a significant challenge to the advancement of green crowdsourcing in South Africa. Data from the FGDs and the interviews highlighted the following security risks: compatibility, internet access, load shedding, mobile phone penetration and high data costs.

Firstly, the risk associated with application compatibility is a critical aspect of connectivity in view of emerging townships and rural areas in South Africa. Townships and rural communities still bear the burden of poverty and people may not be able to afford smartphones or access the network. The FGDs highlighted the need for the development of a prototype to match market requirements. One participant stated that "One of the challenges of some applications is incompatibility with existing norms in rural and townships. The crowdsourcing applications developed need to be cognizant of the indigenous knowledge. There is a need to align the mobile applications with the local practices and norms as this will make them compatible with the existing practices in townships and rural areas in South Africa". The application should be piloted to enable the integration of unique aspects of green crowdsourcing applications that suit the dynamics in South Africa. The respondent highlighted that 'There is a need to integrate the current technology with the unique requirements in rural areas in Africa without different challenges like high data costs and connectivity. Furthermore, the suggested holistic approach which captures the government policy, consumer education, manufacturing is critical in ensuring that

negligence in the process of green crowdsourcing will be appropriately managed'. Piloting the application is critical in the integration of user experience and user interface to meet the unique market conditions in Africa. One of the technical experts involved in the FGDs emphasised the importance of focused piloting of integration: 'From a technical standpoint, we have the concept of UX UI, which is the user experience and the user interface. So, depending on the type of application that one is trying to deliver, it's critical to be able to understand what the app does, and how does it function. So, from a standpoint of being able to deliver we've got technological frameworks like PWA, which is Progressive Web Applications that are more aligned with the Fourth Industrial Revolution'. Incorporating the unique conditions of South African townships and rural communities is crucial in last-mile technology improvements in green crowdsourcing.

Internet access in townships and rural communities constitutes a major risk to South African green crowdsourcing. One of the participants of the FGDs explained 'I'm involved in retail aggregation of groceries especially in townships and the great question of network and connectivity is a challenge and that's where actually this type of app will make a huge impact so the problem is a huge challenge in townships mainly because of connectivity'. The appropriate strategy for connectivity risk management requires building collaborations and partnerships with the various role players in government, the private sector and with non-government actors. Partnerships and collaborations are critical in improving connectivity in townships and rural areas. One of the participants suggested a strategy for the management of crowdsourcing by suggesting that 'As one of the key players involved in townships and rural areas I believe partnerships between the different stakeholders is critical in improving connectivity and so forth . . . because there is a huge challenge in townships for instance we can't do deliveries mainly because of [poor] connectivity, security and so forth we undo deliveries and so forth'. The risk of unpredictable connectivity could be addressed by streamlining the mechanisms for the green crowdsourcing application to work offline.

In addition, frequent load shedding in South Africa is a risk that undermines the effective performance of the green crowdsourcing application. Most of the participants in the FGDs mentioned the risk to connectivity posed by power cuts. One participant in an FGD highlighted the impact of electricity cuts, saying that 'The major challenge in load shedding which has become rampant by Eskom times makes connectivity difficult. Furthermore, the participants will have challenges to operate during the load shedding periods especially in townships and rural areas'. Stakeholders suggested several strategies to address power cuts. The first group argued that building offline capability in the green crowdsourcing application is critical for the risk management of electricity cuts in South Africa. A participant argued that 'The suggestion of making the application to operate offline is a major strategy for improvement of the connectivity to meet the required conditions'. The participants were pessimistic about using the application offline if this involved the use of satellite, which would be equally expensive. One participant remarked 'The gentleman mentioned something about using the software offline. And is that going to be possible? Because if we're going to be using the normal network that everyone uses, I think it's going to be difficult when there is load shedding. So, are we going to be connected into a satellite network, which I think will be more expensive and it might exclude other people who might not afford the services and that can also please get clarity on that?'. There was an argument about collaboration as an approach to addressing the risks posed by power cuts. Partnership and collaboration between the various key players such as internet providers, government, Eskom and academia could find appropriate solutions for the effective management of the provision of electricity such as generators. A partnership between such stakeholders would be vital in bringing people together to improve green crowdsourcing.

The delivery of a green crowdsourcing application could face enormous challenges in solving the Last-Mile Logistics in South Africa because of issues with smartphone penetration. This was highlighted during the FGDs. A participant argued that 'Smart

phone penetration, it's a problem in Africa and South Africa so the last mile mainly in what I have experienced because my stores are in township last mile those guys don't have access to smart phones'. A lack of mobile phones makes the last-mile penetration of the supply chain very difficult when using green crowdsourcing applications. A concerted effort is needed to improve smartphone access in rural communities and townships. Furthermore, this participant suggested that in order to improve the performance of last-mile logistics in these rural areas, various key players in the industry would have to combine their efforts to increase mobile phone penetration: 'Emphasis has to be put in place on partnership and collaboration with the different industry players and stakeholders in improving access of mobile phones. I think it's a good initiative but I think it will need collaborating effort from all industries especially in that [it] has to do with impact and more impact will be in line with our township economy and so forth'. This would be critical in ensuring that people in townships and rural areas are in a position to use crowdsourcing applications.

The study also established that high data costs affect the success of green crowdsourcing in South Africa. The participants in the FGDs identified high data costs as impeding participation in crowdsourcing by community members. Participation in crowdsourcing requires internet connectivity but costs prohibit individuals from participating in it, especially in townships and rural areas. One of the participants in an FGD challenged the researchers by questioning the logic of a project that required the use of the internet, yet with prohibitive data costs. The participant argued 'The major question to all of us is how do we deliver a project of green crowdsourcing on top of other constraints of load shedding and where people have limited data connection due to high costs of internet?'. The participant suggested that the government plays an important role in regulating and moderating the costs in townships and rural communities as a means of strengthening the use of a crowdsourcing application. The participants from the government highlighted efforts underway by the government to improve inclusion and access for communities in townships and rural areas. One participant from the government stated that 'I think from a policy perspective, we would like to take account of the experiences on the ground, and we interact a lot with different players to take into account what are the challenges and as government we are working on rolling out spectrum and broadband to improve their connectivity for everybody, especially in the rural areas'. This approach is vital in ensuring that data in townships and rural areas is available, indirectly improving green crowdsourcing.

Finally, the challenge of data availability poses a major risk for crowdsourcing in South Africa, as it undermines connectivity. One of the participants in an FGD argued that 'It is a very complex issue that is reality in South Africa; connectivity, data cost, as well as the constraints of delivering under load shedding, which now again create congestion and [has an] effect on timely delivery of goods'. The participants suggested that it requires collaboration and partnerships among critical stakeholders to fix the problem of connectivity. This opinion was summarised in a comment from one of the participants: 'But there's a lot of things that have to work together. Like if the speaker rightfully said, if we have now the connectivity and we don't have electricity, then things are not going to work well together. So, there are many different players that must come together to make things work for the consumer on the ground'. It is imperative for the developers of a green crowdsourcing application to involve all the stakeholders in the development and use of the mobile application for the project to succeed. These stakeholders provide important inputs and resources that complement each other, making it possible for the project to succeed.

5. Discussion

Our study explored the emergent risks in green crowdsourcing applications in South Africa. In contrast to research on traditional crowdsourcing applications, in this paper, we provide a synthesis of risks to green crowdsourcing. Green crowdsourcing is unstructured, dynamic and flexible, as demonstrated in the Dilivari application.

Firstly, our study established that security risk management is critical for the effective performance of green crowdsourcing applications in South Africa. These findings are similar to those of previous studies that have also found that security risks have an impact on crowdsourcing [24,39,74,79,98]. Despite the benefits of green crowdsourcing applications benefiting people and the economy [2] and addressing environmental problems [4], our study highlighted that security risks like personal privacy, theft and robbery all affect green crowdsourcing. Personal privacy is compromised as personal information is available to all participants in crowdsourcing; Sannon and Cosley [25] argue that flexibility in unstructured platforms compromises personal privacy.

Theft and robbery have become common in crowdsourcing. In their study, Mpofu [41] found that parcels could easily be stolen by individuals and likewise robbers could use the application to target particular individuals. Their study found that participants in crowdsourcing could use the application to trick the distributor into bringing goods to a particular location and then rob the participant in the car. Criminals take advantage of crowdsourcing applications to commit theft and robbery. Despite these findings, the literature has focused mainly on internet security and front-end protection, where web attacks are ubiquitous in the crowdsourcing environment [108,109]. The situation is aggravated in green crowdsourcing, which is unstructured and flexible, allowing everyone to participate as a driver. Flexibility allows criminals to deliberately leak participants' private information [34]. Chen and Kapravelos [108] noted that browser extension security attacks require prioritisation when monitoring and modifying data. Kim et al. [109] called for the installation of malware to control the user. Kazai et al. [71] advocated for the use of off-the-shelf technology in risk management. Risk management strategies commonly adopted by previous scholars prioritise the addressing of potential security and privacy risks [74] because of endless in-house data breach incidents [24]. The risks in green crowdsourcing which is unstructured increase vulnerability by leaking participant locations [34], travel time [35], personal information [36], hacks [37]. Despite attempts to improve privacy in China by allowing trusted access [38], balancing trusted and untrusted sources proved daunting [37]. These security risks are exacerbated in less developed countries due to poverty and low technological advancement. Management of security risks is imperative for sustaining peoples' livelihoods [5], profits [6,7] and the environment [4].

Secondly, our study established that in South Africa, green crowdsourcing applications face legal risks. Legal risks undermine green crowdsourcing which is critical for environmental sustainability. The applications use pre-existing travel routines [9], commuting trips [11] maximising car occupancy [20], utilisation of unexploited space [10], and shared freight transportation [21]. In our study, legal risks undermine the successful performance of green crowdsourcing. This was also found in earlier studies in developing countries [24,55–57]. Our study established that legal risks have a negative impact on the performance of green crowdsourcing applications. Guarding against legal risks is critical to the success of green crowdsourcing applications, enabling the free flow of vital information for production. Legal risk management creates an environment that is conducive to regulation, monitoring and enforcement of contracts in the crowdsourcing environment [54]. Furthermore, promoting public participation, transparency, administrative efficiency, and effectiveness in the administration of contracts in a virtual environment is vital [50]. In addition, the emergence of a new unstructured and flexible crowd platform equally requires a new policy and regulatory paradigm [64]. Crespo [65] highlights that the legal system was not intended to regulate relationships in a technologically driven shared environment. A green crowdsourcing application must provide appropriate mechanisms for liability in the entire process of sourcing, from initiation to delivery of goods. Green crowdsourcing involves several drivers who may also become clients and contractual obligations must, therefore, be appropriately managed. This study also established that contract breach is a likelihood and requires adequate mechanisms to manage this risk. These findings complement those of [55]. In his study, he stresses the need for appropriate legal, policy and regulatory mechanisms for the management of the risk of contract breaches in the

crowdsourcing environment. Furthermore, he highlights that Bloomberg reports 90 million disputes annually in the virtual environment. The development of appropriate policy and regulatory frameworks tailored for the appropriate management of contracts in the crowdsourcing environment is critical for its success. Dimov [55] suggests helpful steps for the clarification of contract and legal obligations, such as mechanisms for dispute resolution, and the provision of mechanisms for alternative negotiated agreements and the facilitation of mediation. Appropriate legislation and policies must be implemented for the management of breaches of contracts. Previous scholars have closely examined risks associated with legal risks in the crowdsourcing environment, such as employment law [56], patent inventorship [57], data security and copyright ownership [59]. However, this study focused on liability and contract breaches during green crowdsourcing transactions in South Africa. It is, therefore, imperative to strengthen legal risk management by streamlining crowdsourcing aspects in software development [60] to harness policy making [61], manage crime [54], legislate [31], and create awareness [60]. Inadequate management of legal risks in crowdsourcing will limit the achievement of environmental sustainability goals.

Thirdly, whilst green crowdsourcing comes with benefits for people [5], profits [6,7] and the environment [4], our study found that human risks: negligence, accidents, trust and service quality are prevalent. This is supported by earlier studies [9,10,71,105], whose findings have assisted in the development of resilient green crowdsourcing applications for developing countries. Participation of human beings in the crowdsourcing environment is lauded as it is critical for establishing suboptimal outputs [105], reliable and relevant labelling [76], and quality assurance [78]. But some scholars have observed limited trust and random behaviour among the participants in a crowdsourcing environment [79,80]. Our findings highlight the point that human risks in relation to negligence, accidents, trust and quality of service affect green crowdsourcing applications in South Africa. Human risk management is critical in the improvement of the performance of crowdsourcing applications [16], enabling the free flow of vital information for productivity. People participate in the entire process of crowdsourcing, making them vital to the effective management of crowdsourcing. Specifically, our study established negligence as a risk associated with green crowdsourcing. Our findings are supported by those of [71], who established that human task neglect was a common risk in crowdsourcing. Any of the participants involved in crowdsourcing, from initiation to delivery, could neglect to perform their required tasks, significantly impacting the quality of the service delivered.

In addition, the study established that accidents during deliveries constitute a critical part of the risks in crowdsourcing. Telima et al. [72] cited traffic accidents as a major challenge in crowdsourcing environments in Egypt. In this regard, some academic literature has identified the use of intelligence software and IoT for the improvement of crowdsourcing [74,75,98]. Yang et al. [73] argue that the use of crowdsourcing applications with intelligence abilities facilitates the collection of comprehensive and coherent traffic-related data. Zhang et al. [74] support this, arguing that the IoT could be used to manage traffic systematically to reduce accidents. On the other hand, Le et al. [97] advocate the development of a traffic incident management system.

Our study also established that trust is a critical risk in an environment where people are used to physical transactions as opposed to online transactions. These findings are supported by those of [11], who found that successful green crowdsourcing depends on trust. To address the human risk of a lack of trust, appropriate reward and compensation mechanisms should be developed to strengthen trust in crowdsourcing environments [4,10]. The development of incentives and mechanisms for successful green crowdsourcing requires risk management of trust among participants. Our study findings are aligned with those of previous scholars who have established that quality service is at risk in a crowdsourcing environment [94]. Aker et al. [95] found that individuals involved in deliveries did not necessarily have the critical skills required to undertake deliveries. The literature highlights the critical aspects of service quality in a crowdsourcing environment as human-to-human

engagement [99], customer understanding [96] and knowledge curation [98]. Participants in green crowdsourcing may lack the human engagement skills to connect with customers with other individuals [99]. Furthermore, Huang et al. [99] argue that an improvement in understanding the customer during the delivery process may positively affect the quality of service in the pure green crowdsourcing environment. Finally, [98] argues that good service delivery requires knowledge curation in the sense that green crowdsourcing incorporates knowledge management systems to enhance customer experience. Human risk management must cover those critical risks resulting from people's involvement.

Finally, our study established that connectivity risks affect the performance of green crowdsourcing applications. Similarly, earlier studies [1,111,112] observed the challenge of connectivity. Despite the benefits of green crowdsourcing: improved livelihoods, business profitability [2] and environment sustainability [4], connectivity risks impact the attainment of these benefits. Some studies emphasised connectivity risks: compatibility [112], and internet access [1,32]. However, in our exploration of these risks, we found that compatibility, internet access, load shedding, smartphone penetration, and high data costs were the main risks associated with connectivity in green crowdsourcing in South Africa.

Our study established that compatibility and internet access costs were the main risks in green crowdsourcing in South Africa. Our finding is similar to Buettner's [111], who also observed that technological compatibility poses a risk to the acceptability of crowdsourcing applications. Prpic and Shukla [1] recommend that developers of crowdsourcing ensure the applications are flexible and scalable in order to meet the local conditions. We found that the connectivity risks associated with our green crowdsourcing application had to do with technology that was incompatible with consumer requirements. Successful crowdsourcing applications require the involvement of a wider group of people and should be adjusted to the unique perspectives of the various stakeholders. The findings of this study suggest that partnerships with stakeholders in urban and rural areas in South Africa would enhance the development of compatible applications. Partnerships for improved connectivity bringing together private and public–private actors would help toward the effective operation of green crowdsourcing in South Africa. A successful partnership requires holistic and comprehensive participation of the government, telecommunication companies, developers of the application, academia and community. Incorporating all the stakeholders is imperative for the effective and sustained improvement of green crowdsourcing in South Africa. The government plays a critical role in policy, legislation, crime management, and the provision of incentives for the private sector. Telecommunication companies are critical in the extension of connectivity. The communities and citizens both in rural and urban areas use green crowdsourcing applications. The developers of the application are critical in incorporating the critical requirements for addressing the technological improvements on the application. academia and researchers support in researching and providing insights on the need for improvements for an effective green crowdsourcing environment.

In addition, green crowdsourcing applications have to be aligned with indigenous knowledge systems is critical for success. Integration of perspectives from diverse individuals from outside the business could incorporate varied skills, backgrounds and perspectives that are critical in the development of appropriate business solutions. Collaboration between the government and telecommunication companies can play a significant role in bolstering connectivity in townships and rural areas. The participants of the study made the point that internet access in these areas has a negative effect on the performance of green crowdsourcing in South Africa. Our study established that internet access has become a major risk to our new green crowdsourcing application in South Africa. This is supported by earlier studies that have emphasised the importance of internet access for the progress of crowdsourcing [1,32]. Brabham [32] underscored the importance of internet access as a critical requirement for crowdsourcing. In addition, Prpic and Shukla [1] argued that the internet has revolutionised the concept of crowdsourcing. Previous studies confirm our findings on the risk of lack of internet access as a critical risk to crowdsourcing, as individuals and organisations cannot participate in such crowdsourcing without internet

access. It is, therefore, imperative to the success of a green crowdsourcing application that access to the internet in townships and rural areas in South Africa is improved.

We broaden the existing debate in relation to connectivity risks: load shedding, smartphone penetration and high data costs are current emergent phenomena in South Africa. The ability of communities in townships and rural areas to use the application is wholly dependent on connectivity when using data. Load shedding undermines the ability of those in townships and rural areas to use mobile phones. Furthermore, applications will not function because internet connectivity depends on the availability of electricity. In [106], it was observed that South Africa has failed for some time to resolve the electricity crisis. Furthermore, load shedding has affected all sectors of the economy and has affected green crowdsourcing as well. Low smartphone penetration was also found to pose a major risk to green crowdsourcing. Currently, smartphone penetration in South Africa stands at 10.7 percent and is estimated to increase to 37.96 percent [148]. This is still very low and has an impact on the use of green crowdsourcing. In addition, our study found that high data costs constituted a technological and connectivity risk to the performance of green crowdsourcing in this country. High data costs affect the ability of individuals to connect to the internet and, therefore, hold risks for the success of green crowdsourcing. Moyo and Munoriyarwa [148] observed that data costs in South Africa are among the highest in the world despite the existence of four service providers, Vodacom, MTN, Cell C and Telkom. High data costs remain a major hurdle to the advancement of green crowdsourcing as these costs discourage the use of the app and increase the service cost. Collaboration between the various industry players in addressing load shedding, smartphone penetration and data costs is essential if green crowdsourcing is to succeed. In order to ensure people's livelihoods are improved and there is environmental sustainability as a result of green crowdsourcing, the connectivity risks have to be addressed.

6. Implications

6.1. Practical Contribution

In practice, the development of a mobile application for the improved coordination of the supply and distribution of groceries to both urban and rural areas in Africa benefits people, profits and environmental sustainability. In this study, we used a rigorous and transparent mechanism to study the risks of emergent technology. Furthermore, the findings in the study are critical for the improvement of artefacts developed using design science.

This study is critical in strengthening and improving the performance of a mobile application as the risks and underlying challenges facing the application were addressed. The efficient performance of the innovative green crowdsourcing application Dilivari is important for the improvement of the livelihood of South Africans. An appropriate and relevant innovation simplifies the living conditions of people by allowing them to access the right quantity and quality of affordable goods from stores in a timely manner. Improvements to the application will be useful in strengthening business entities. Risks undermining profitability will be effectively addressed by using analytics, forecasting, and networking appropriately. This could prove successful in harnessing business profit. Practically, the green crowdsourcing application uses analytics to forecast demand and supply and this can improve business profit. In addition, the application contributes to the reduction of carbon emissions in its use of last-mile logistics. The affordability of the Dilivari application's technology for use by independent shoppers, transporters and couriers makes it very useful in developing economies in Africa.

In conclusion, appropriate management of risks inherent in the application significantly improves its relevance, reliability, efficiency, and effectiveness in the coordination of a multi-embedded grocery supply chain for people, businesses and the environment.

6.2. Methodological Contribution

The methodology used in this study provides a guide for studying risks and underlying challenges associated with artefacts developed using design science. In our study, an

exploratory research design was used to better understand the risks in the new Dilivari green crowdsourcing mobile application. Exploratory research facilitated our understanding of the various stakeholder views of critical risks and underlying challenges in this application. The case study design was critical to an in-depth understanding of these risks and challenges. We conducted FGDs and key informant interviews to deepen our understanding and contextualisation of the risks in green crowdsourcing. This approach provided a rigorous and transparent mechanism for studying risks in emergent technology and was crucial in making improvements and innovations. We demonstrated an integrated approach for designing artefacts involving stakeholders, designers, users, and potential users of novel artefacts.

6.3. Theoretical Contribution

This study of Dilivari, an innovative mobile application with socially embedded solutions for improvement in the coordination of a multi-embedded grocery supply chain in Africa, strengthens the evolving theory of crowdsourcing. Furthermore, it helps in identifying emergent and critical risks in green crowdsourcing. The critical risks of load shedding, internet access, data costs, as well as physical security, which other crowdsourcing technologies have taken for granted, have come to the forefront in developing countries. An understanding of these circumstances is critical for the development of relevant, effective, efficient and reliable supply chain coordination of a grocery supply chain in Africa and beyond. This study of the risks in green crowdsourcing constitutes a critical theoretical contribution to the transformation of green crowdsourcing. This study could enhance efforts in addressing the significant challenges of traffic congestion, and environmental management. The second contribution is the representation of green crowdsourcing risks in the empirical model based on a qualitative inquiry. In order to advance theory and practice, we recommend that future studies should collect experimental data to facilitate generalization. Conclusively, the categorization of different benefits, forms of crowdsourcing and challenges, and the differentiation between the contexts in crowdsourcing provide a conceptual model for future research. Exploration and understanding of the appropriate strategies for the management of these risks is critical for the advancement of theory and practice.

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