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The Impact of Information Systems and the Circular Economy in the Rural Tourism Sector. An Evaluation of the Algarve Region

<https://doi.org/10.2478/ejthr-2026-0005>

received April 21, 2025; accepted October 24, 2025

Abstract: Rural tourism in the Algarve is one of the main types of tourism that has grown in importance over the last ten years. Its importance shows a new capacity for tourism supply and demand, as well as a new methodology to improve the rural market. In addition, the sustainability of the rural tourism sector and its performance based on the circular economy is a good indicator that the rural market has improved its competitiveness and resilience. The research aims to describe the importance of the link between the circular economy (CE) and the information system (IS) in the rural tourism sector in the Algarve region. The quantitative research focused on the importance of the combination of these variables in rural tourism (RT) through the analysis of rural organisations. The author addresses the following research question: How has the rural tourism sector promoted CE and IS to increase its competitiveness? The analysis presents a challenging opportunity to discuss the use of IS and CE in rural organisations in terms of sustainability and competitiveness in the sector. The research provides an accessible exploratory study of circular management in RT while offering the opportunity to discover a new management methodology based on IS and CE. Furthermore, it is of interest to academics, policy makers, and others working in the hospitality sector.

Keywords: circular economy; information systems; rural business model; artificial intelligence; rural tourism; Algarve region

1 Introduction

Tourism has a significant economic and social impact on Portugal's economy (Apriyanti, 2024). Statistical data demonstrates the importance of tourism to the GDP, the employment rate, and economic development (Pease & Rowe, 2005). Rural tourism (RT) is a form of sustainable and responsible tourism that allows tourists to participate in the daily life and distinctive traditions and cultures of small rural communities, which are usually dominated by agriculture, poverty, and marginalisation (Priatmoko et al., 2023). The increasing demand for RT has contributed to the worldwide expansion of the tourism sector in recent decades, helping establish tourism as one of the fastest growing sectors of the global economy (Costa et al., 2024). As a new form of supply meeting the increasing demand, RT is one of the industry's most important sectors for sustainable development, as it promotes a new kind of service, but also a new kind of relationship between the environment and hospitality (Lane, 2005). This chapter provides an overview of the RT sector in the Algarve region, the links between the information system (IS) and the circular economy (CE), and the use of artificial intelligence (AI) by rural organisations to increase sustainability.

The link between CE and IS emphasises the ability of this sector to participate more in sustainable development, but also the ability to be more environmentally friendly, as it is possible to establish a link between the IS solutions that serve as pillars or facilitators for successful development and application of CE models (Demestichas & Daskalakis, 2020). As technology becomes a crucial factor in the digital transformation of the RT paradigm, local participation evolves into local community empowerment (Lapuz, 2023). In terms of the potential of the rural sector in the Algarve region, this paper discusses the relationship with CE and IS and considers the use of Artificial Intelligence (AI) to improve its sustainability (Choudhary et al., 2025; Semwal et al., 2024, June).

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To test the relationship between these two variables: CE and IS in the rural organisations, the author used a quantitative analysis based on an electronic questionnaire sent to rural organisations that somehow use both simultaneously. Based on the research on the relationship between these variables, we argue that it is possible to establish a link between CE, IS and the RT sector in the Algarve.

In this article, the following research question is posed: How does the RT sector promote CE and IS? The research question is supported by the following objectives: 1) to investigate the relationship between the IS and the CE; 2) to indicate the best practises applied by RT based on the IS and the CE.

The paper is divided into six sections: first the introduction, then the presentation of the relevant literature, followed by a third section with an overview of the methodological approach. The fourth section presents the results; the fifth section discusses the research findings, while the sixth section presents the main findings, contributions, practical implications and drawbacks.

2 Literature Review

2.1 The Rural Tourism (RT) sector in the Algarve region: A strategy overview

Due to changes in Europe's rural areas and new social demands, rural development has undergone a significant transformation process in recent decades (Randelli et al., 2014). According to Duarte (2010), the expansion of RT is a trend that applies to most European countries. The RT gained a certain visibility after 1986. The aim was to develop rural areas in social and economic terms and to restore their cultural heritage. The revitalisation of rural areas encouraged an increase in the supply of accommodation and cultural development based on the dynamics of tourism and its applicability to rural development (Pego, 2014). Changes in the behaviour of tourism customers in terms of travel preferences and motivations have also been crucial to this development (Duarte, 2010). To be competitive in the 21st century economy, rural areas must become a model of integrated and sustainable development based on the mobilisation of endogenous resources, the orientation towards telecommunications infrastructures, the creation of economic incentives and the fragmentation of industrial production processes based on the use of emerging sectors that respond to a growing demand for leisure and the management of environmental resources (Ruíz-Real et al., 2022). Another perspective points out that RT focuses on

activities related to nature and natural resources offered by specialised companies and different types of accommodation related to rural activities (e.g. agrotourism, farm holidays, wine tourism, ecotourism, green tourism, etc.) (Inês, 2021). Few authors have presented RT in Portugal and the Algarve (Kastenholz, 2005; Jesus & Franco, 2016; Silva, 2022) as a positive strategy for the development of rural areas, but also for increasing the income of the social product. The rural development strategy in the Algarve region is centred on cooperation and competition to create a sustainable service offer (Inês, 2021).

The conceptualisation of RT development in the Algarve is also linked to digital performance and circular performance (Manniche et al, 2017; Del Vecchio et al, 2022; Pego, 2022). However, research to date is still far from developing a deeper understanding of how companies can design their business models in line with CE principles and there is a need to investigate the impact of CE in specific industries, especially those with greater environmental impacts such as tourism (Del Vecchio et al., 2022) and specifically the RT sector in the Algarve. In fact, there is a strong link between potential RT and CE, as the sector offers a good strategy to achieve circular economy in the preservation of the rural environment, reuse, renovation, remanufacturing, recycling and composting through tourism practises (Pego & Lourenço, 2024). Circular tourism is a model in which each tourism stakeholder (tourist, Destination Management Organisations (DMOs), providers (hotels, restaurants, etc.) and the local population) adopts an environmentally friendly approach (Rodriguez et al., 2020). The Algarve region has gained worldwide recognition for its beautiful beaches, natural parks and important historical sites, establishing itself as a premier tourist destination (Martins & Correia, 2024). Due to changes in Europe's rural areas and new social demands, rural development has undergone a significant transformation process in recent decades (Randelli et al., 2014). According to Duarte (2010), the expansion of RT is a trend that applies to most European countries. The RT gained a certain visibility after 1986. The aim was to develop rural areas in social and economic terms and to restore their cultural heritage.

Changes in tourist behaviour in terms of travel preferences and motivations were also crucial to this development (Duarte, 2010). To be competitive in the 21st century economy, rural areas must become a model of integrated and sustainable development based on the mobilisation of endogenous resources, the provision of data and telecommunications infrastructures, the creation of economic incentives that can take advantage of current decentralisation trends and the fragmentation of

industrial production processes, and the use of emerging sectors that respond to the growing demand for leisure and the management of environmental resources (Ruíz-Real et al., 2022). Another perspective points out that RT is focused on activities related to nature and natural resources offered by specialised companies and different types of accommodation related to rural activities (e.g. agro-tourism, farm holidays, wine tourism, ecotourism, green tourism, etc.) (Inês, 2021). Few authors have presented RT in Portugal and the Algarve (Kastenholz, 2005; Jesus and Franco, 2016; Silva, 2022) as a positive strategy for rural development, but also for increasing the income of the social product. In this sense, a comparative analysis of tourism indicators should be carried out (Marzo-Navarro et al, 2020). The rural development strategy in the Algarve region should be oriented towards cooperation and competition with other tourism organisations to create a sustainable offer of services (Inês, 2021).

2.2 Information Systems(IS) and the circularity in Rural Tourism

2.2.1 The IS and rural organisations

The tourism industry can be optimised as one of the first economic sectors in which business functions are based almost exclusively on IS (Peace & Rowe, 2005). The use of IS in the various economic sectors faces the challenge of improving specialisation and competitiveness (Pego, 2022). The benefits of using the Internet for the tourism sector have been discussed by Peace and Rowe (2005), especially the connection with customers and suppliers. The most important information systems related to the tourism sector are computerised reservation systems (CRS) and global distribution systems (GDS) (Buhalis, 1998). According to Pego (2014), the main IS used in tourism are: CRS, GDS, multi-media system, interactive television, smart cards, business information system and software. The same author believes that CRM (Customer Relationship Management) is not very common in the tourism industry, while GDS and CRS play an important role for customers and businesses. Sarkis and Zhu (2008) describe the ways communication, computer technologies, cyber-physical systems, data analysis and artificial intelligence algorithms, data collection and IoT, data management and storage, and software and simulation technologies can play an essential role in the adoption of CE concepts and the implementation of CE programmes by governments, organisations and society. In this regard, IS are responsible for increasing the participation of CE in organisations, as they are the basis for environmental pro-

jects, but also for the capacity of the value chain of organisations (Yu et al., 2023). Tourism and IS play an important role in CE, as circular tourism businesses emerge and strengthen value chains that are reconfigured by the increasing implementation of reuse, recycling, etc. (Vargas-Sánchez, 2021). The interest is to pursue a norm in which CE in tourism and IS interact to promote benefits in the economy. Many authors (Axhami et al., 2023; Salmi & Hmioui, 2023; Sutarman, 2023) have discussed the sustainability and performance of organisations, in terms of tourism potential, to encourage organisations to use IS, leading to an increase in the efficiency of the value chain and performance of the organisations. IS have played a fundamental role in tourism (Pröll & Retschitzegger, 2000). Digital transformation combined with the ability to find solutions within organisations presents a new challenge for seizing opportunities (Shahi & Sinha, 2021). Few studies on the development of CE and IS have been presented for the RT sector (Teodoro et al., 2017; Pato, 2020; Santos et al., 2023), one was presented for the Algarve region (Bernardo & Pego, 2015). IS and the circular economy can work together sustainably, as a process in which variables play an important role in achieving sustainable output in the economy (Demestichas & Daskalakis, 2020). Rural organisations have increased the use of IS in terms of their development in rural areas and their inclusion in regional development (Pego, 2014). The most commonly used TIS in rural organisations are the DMO (Destination Management System) (Bédard et al, 2008; Adeyinka-Ojo et al, 2014; Pego, 2014). According to the study presented by rural organisations, in addition to the DMO website, other platforms such as digital social media (Hays et al., 2013) and AI (Wei, 2021; Xie & Yu, 2022) must also be used.

2.2.2 The circular economy rural path

While IS can be a way to optimise resources, CE is away to promote sustainability. Sarkis & Zhu (2008) describe that communication, computing technologies, cyber-physical systems, data analysis and artificial intelligence algorithms, data collection and IoT, data management and storage, and software and simulation technologies can play an essential role in the implementation of CE concepts and the adoption of CE programmes by governments, organisations and society. As such, information technologies are responsible for increasing the participation of CE in organisations as they are the basis for the environmental projects but also for the capacity of the value chain of organisations (Yu et al., 2023). The tourism sector has not received much attention in the context of CE development. Many of the studies found a focus on agri-

culture and agricultural research, but few have shown the link with environmental policy. RT development is based on the concept of CE as a strategy for sustainable agricultural development, which is based on the 3-R principle and includes green, organic, and sustainable agriculture (Rodríguez et al., 2020).

The circular economy is a multi-level system of resource utilisation that aims to close all resource loops fully. Recycling and other means that optimise the scope and direction of resource flows contribute to CE as supporting practises and activities. In its conceptually perfect form, all resource loops will be completely closed (Figge et al., 2023). CE offers a reverse idea of resource regeneration to eliminate the linearity of the production and consumption system and support sustainability goals. The analysis of the CE definition revealed that the resilience and stakeholder perspective is not explicitly included in the definition so far, although stakeholders are considered as part of a natural and ecological system (Awan et al., 2020). The perspectives of tourism valuation and the links between IS and the CE can be discussed when it comes to tourism's involvement in the environment, but also in the promotion of low-carbon activities and the reuse of goods. In this sense, Kaszás et al. (2022) list some important aspects to measure CE in tourism: sustainable mobility (green transport, sharing economy); food (locally produced food, short supply chains, community gardens); shared accommodation and other tourism accommodation (distributed hotels); reuse of items (reuse centres, social entrepreneurship) and other areas potentially linked to closing material loops in tourism.

Development in the Algarve is also linked to digital performance and the CE (Pego, 2022). Digital performance in line with the CE (Manniche et al., 2017; Del Vecchio et al., 2022) in the RT sector in the Algarve region has not been discussed recently. However, research to date is still far from developing a more profound understanding of how companies can design their business models in line with CE principles, and there is a need to investigate the impact of CE in specific industries, especially those with greater environmental impacts, such as tourism (Del Vecchio et al., 2022), and specifically in the RT sector in the Algarve region.

2.3 AI in rural organisations

The use of AI in organisations began with the need to improve their decision-making and performance in the marketplace. The use of AI represented a new challenge for the organisations and led to an improvement in their strategies and solutions. In this context, rural organisa-

tions were also a good starting point for this methodology within their production processes, namely supporting visitors with special access needs and informing management about visitor behaviour, and it is also very helpful in the tourism industry as it enables people with reduced mobility to travel the world (Erianda et al., 2023). In addition, AI is also associated with the possibility of creating a new level of decision-making in the management of rural organisations. The use of IS and AI can contribute to a sustainable solution within the organisation, but also with its ability to promote solutions to a specific type of problem (Pego, 2015; Pego & Bernardo, 2018). In line with the organisation's ability to make the best decisions to provide good governance and best practises, the ability to make the right decision and its performance within the organisation can be considered when managers use AI based on the prediction of problems by the algorithms to solve problems and make intelligent decisions (Brink et al., 2024). According to Che et al. (2013), AI can provide researchers with a different global methodology for designing and conducting tourism research. AI can be seen as a new method, approach, or strategy for tourism research that brings about positive change, especially in rural communities, in terms of sustainable practices (e.g. ecovillages, supporting local economies, smart waste management systems, AI-driven environmental monitoring, renewable energy consumption and rural tourism platforms (Erianda et al., 2023).

CE offers a reverse idea of resource regeneration to eliminate the linearity of the production and consumption system and support sustainability goals. The analysis of the CE definition revealed that resilience and the stakeholder perspective are not explicitly included in the definition to date, although stakeholders are considered part of a natural and ecological system (Awan et al., 2020). The perspectives of tourism valuation and the links between IS and CE can be discussed when it comes to the environmental engagement of tourism, but also in the promotion of low-carbon activities and the reuse of goods. In this sense, Kaszás et al. (2022) list some important aspects to measure the CE in tourism: sustainable mobility (green transport, sharing economy); food (locally produced food, short supply chains, community gardens); shared accommodation and other tourism accommodation (distributed hotels); reuse of items (reuse centres, social entrepreneurship) and other areas potentially linked to closing material loops in tourism. In addition, the concept of circular economy is linked to sustainability, as the sector is primarily focused on environmental protection efforts that involve effective resource management to improve the environmental and social aspects of the industry (Martins & Correia, 2024).

3 Methodology

3.1 The Rural Tourism market and the use of IS and the CE in the Algarve region

The analysis carried out in this paper has shown that RT is able to approximate CE and IS. The intensity of utilisation is also seen as one of the most important factors for the development of RT, but also of tourism itself. Therefore, based on this analysis, it was decided to approach the rural organisations receptive to combining these two variables (CE and IS). To maintain consistency with the aim of having a greater impact on tourism services, as discussed in the paper, the use of AI to enhance the resilience of competitiveness is also included. The current research demonstrates a new capacity of RT, AI, and CE to improve services and to develop a new approach to the sustainability of rural resilience (Mihai, 2023; Zhang, 2023). The article focuses on this research question: How does the RT sector promote CE and ITC? To answer this question, the following hypotheses (Sekaran, 2005) and objectives were analysed (Table 1):

3.2 Data collection

The questionnaire was sent to 51 rural organisations in the Algarve between June 2022 and April 2023 (Table 2). The sampling rate was calculated based on the total number of RT organisations in 2021 and the use of IS and CE. Some of the organisations also use AI to deliver their services.

A structured questionnaire was used to assess managers from RT organisations. The questionnaire consisted of two sections: The first analysed the use of IS and the second the use of CE in their daily practise. A 7-point Likert scale was used to ensure precision and comparability (Emerson, 2017; Abreh et al., 2025). Anonymity and confidentiality were assured to the respondents. Data collection was conducted online to gain efficient access to a geographically dispersed population (Lefever et al., 2007). The online questionnaire was distributed by email to the RT organisations

according to the table above and included an introductory text, a link to the questionnaire and a brief explanation of the purpose of this research. The questionnaire was available online from 1 June 2022 to 1 April 2023, with all questions classified as mandatory to increase completion rates and validity. The questionnaire was developed iteratively. Constructs, questions and scales from the literature were identified and categorised into sub-dimensions of the new service dimensions. Repetitive or unclear questions were removed, and closed-ended questions were used to make it easier to answer in less time. A pilot test was conducted in two RT organisations to refine the questionnaire.

4 Results

The response rate was 85%. In line with part of the study results, the average of responses on the usefulness of IS, including AI, was 80%, and the organisations agree that the use of IS promotes reservations and information about the country. Regarding the use of IS within the organisation and the link between organisations, the results were 85.9% of variance. The main information services used by rural organisations are websites (15.8%) and room and beverage management (10.9%).

Table 1: Research framework

Objectives	O1: To investigate the relationship between the IS and the CE; O2: To indicate the best practises applied by RT on the basis of the IS and the CE;
Hypotheses	H1: Can IS and CE be used to promote sustainable development in RT? H2: Can the IS and CE be used for decision making in RT?

Table 2: Algarve Rural organisations with CE and AI

Algarve Council	Number of organisations
Albufeira	3
Alcoutim	1
Aljezur	17
Castro Marim	1
Faro	2
Lagoa	1
Lagos	4
Loulé	8
Monchique	0
Olhão	3
Portimão	0
Sagres	0
São Brás de Alportel	0
Silves	2
Tavira	7
Vila do Bispo	0
VRSA	2
Total	51

Table 3: Results Summary

Variables	Rate/Indicator
Response Rate	85%
Usefulness of using AI and IS	80%
The main information services used by rural organisations	websites (15.8%) room and beverage management (10.9%).
Cron-Bach alpha (score reliability)	$\varphi = 0.909$ (good internal consistency, which means good reliability of the questionnaire)
KMO	KMO=0.67 (it needs another statistical test to confirm the use of the IS and the CE)
Use of AI I their organisation	90%
Use of the CE as an important instrument for sustainability	60%

The Cron-Bach alpha (score reliability) makes it possible to determine the lower limit of the internal consistency of a group of variables or items. $\varphi = 0.909$ indicates good internal consistency, which means good reliability of the questionnaire, as it is between 0.8 and 0.9 (George & Mallery, 2024). The KMO test measures the homogeneity of the variables by comparing the simple correlations with the partial correlations observed between the variables. The KMO test shows moderate homogeneity (KMO = 0.67) (Marôco, 2018), which means that we need to perform another statistical test to confirm the use of the IS and the CE.

To confirm H0 and H1, we used Bartlett's test for sphericity for all variables, which has a p-value of less than 0.001; therefore, H0 and H1 are rejected.

There is near consensus that there is a lack of interconnectedness between rural organisations based on circularity. The relationship between CE services and the use of information services showed a weak correlation, which also indicates that these two variables are not very well researched in the rural organisations. From the managers' side, it was possible to draw conclusions about the concept of circular economy, with unanimous answers about how they can promote the circular economy and its benefits in terms of services.

In summary, almost 90% of organisations use AI, and 60% see CE as useful for promoting their organisation (Table 3). The responses also showed that AI is not yet developed for rural organisations, e.g. the time for a specific answer to a specific problem is sometimes too long; decision making in a rural organisation based on AI is an obstacle because sometimes the manager cannot deal with the complexity of the problem. Most organisations use the concept of waste management, reuse of water and

renewable energy, clothing, and food as circular products (e.g. fruit and vegetables that are not sold).

5 Discussion

There is a lack of information on CE in the rural areas of the Algarve region and on its relationship with the ability to utilise IS and AI. At the same time, the relationship between these variables are not considered by the managers when they apply for the decision-making process. From the analysis of the questionnaire, the following can be deduced: 1) the questionnaire shows a strong willingness to use IS and the circular economy; 2) the response rate was 85%; 3) the average of responses to the usefulness of IS, including AI, was 80%, and the organisations agree that the use of IS promotes positive impacts in the reservation and information about the local; 4) there is almost a consensus that there is a lack of networking between rural organisations. The correlation between CE services and the use of technology is positive and promotes the competitiveness of rural organisations with circular services, namely waste management or the use of electricity. From the managers' side, conclusions could be drawn about the concept of CE, with unanimous answers about how they can promote CE and its benefits in terms of services, which means that almost 90% of the organisations use IS and 60% consider CE useful for promoting competitiveness. The methodology of business organisation based on AI is not yet developed for rural organisations, e.g. the time for a specific answer to a specific problem is sometimes too long; decision making within a rural organisation based on AI is an obstacle because sometimes the manager cannot cope with the complexity of the problem. In terms of CE, most organisations use the concept of waste management, reuse of water and renewable energy, clothing and food as circular products (e.g. fruit and vegetables that are not sold).

Despite the new concept of CE for rural activities and its connection with technology, the results have shown that rural organisation scan deal with technological challenges. Furthermore, the technology used and the CE in the rural organisation are based on management decisions, i.e. the use of technology to make organisational decisions and increase customer participation in the organisation, such as travel, as long as the CE in waste and food management is a particular market segmentation to improve the rural business model. A CE business model aims to create a more sustainable and regenerative approach to tourism that minimises waste and maximises

the efficient use of resources, as well as creating positive synergies in the service value chain.

Some conclusions can be drawn about the relationship between CE and IS:

- (a) *IS integration can improve several aspects:* Data-driven decision making: Using data analytics and digital platforms to gather information about tourists' behaviour, preferences and environmental impact; smart destination management: implementing smart destination management systems that use technologies such as the Internet of Things (IoT), sensors and data analytics to efficiently monitor and manage resources such as waste management, energy consumption and traffic flow;
- (b) *Digital platforms for CE services:* developing digital platforms that facilitate CE services in the tourism sector; Blockchain for transparency: implementing blockchain technology for transparency in the supply chain and ensuring that sustainability claims made by tourism businesses are verifiable; Virtual and augmented reality for sustainable experiences: Using virtual and augmented reality to create immersive experiences that reduce the need for physical travel; mobile apps for sustainable travel: Providing information and tools for travellers to make sustainable choices;
- (c) *IS for community engagement:* using information and communication technologies to involve local communities in the tourism decision-making process. The ability of rural areas to adapt to this circular model based on IS can be a positive strategy for the competitiveness of rural organisations and for networking in the smart value chain. Networking with customers and suppliers can be improved and increase the competitiveness of rural organisations. Furthermore, the answer to the research question about the impact on rural organisations when using IS and CE is positive: the organisations have a positive impact when using both variables simultaneously, and the use of IS and CE promotes sustainability and competitiveness.

Overall, the use of IS and CE in RT increases the organisation's involvement in value chain optimisation, decision making, reuse of raw materials, and the ability to adapt the potential of rural markets. It is important to emphasise that the analysis of RT in the Algarve allows us to conclude that it is possible to seek a balanced relationship between three vectors: Circularity in tourism, AI, and IS.

The ability of rural areas to adapt to this circular model based on AI can be a positive strategy for the competitiveness of rural organisations as well as for networking in the

smart value chain. Networking with customers and suppliers can be improved and increase the competitiveness of the rural organisation. Furthermore, the answer to the research question about the impact on rural organisations when using IS and CE is positive: the organisations have a positive impact when using both variables simultaneously.

6 Conclusions

The study reflects the ability of rural organisations to combine IS and CE on a sustainable basis. Based on the questionnaire sent to rural organisations, it was found that there is a weak correlation between the CE and IS variables. The results also showed that the sustainability of RT based on CE is not as well developed as the use of AI to promote best practises. The importance of refining a new methodology for sustainable practices has yet to be explored, as the combination of IS and CE approaches needs to be optimised and considered an integral part of RT. In the long term, the capacity of RT competitors and their resilience to reach the market needs to be considered in the management process.

Conflicts of Interest

The authors of the article "The Impact of Information Systems and the Circular Economy in the Rural Tourism Sector. An Evaluation of the Algarve Region" declare no conflict of interest.

Bionote

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