



# Food waste management in the retail sector: challenges that hinder transition to circular economy

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Received: 16 September 2021 / Accepted: 27 December 2021 / Published online: 13 January 2022  
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## Abstract

The retail sector is one of the growing sectors all over the world. As the sector grows, the amount of food waste generated increases, and waste management becomes more complicated day by day. The amount of waste produced, especially in the food retail sector, shows how much waste management policies should be planned. However, waste management policies cannot be carried out effectively in the food retail sector, especially in emerging economies. Since waste management is not well planned, it faces many difficulties in recycling activities. For this purpose, the study aims to investigate the challenges encountered in the inability to evaluate food wastes in the retail sector within the framework of circular economy to highlight retailer markets to have effective waste management policies. For this reason, 16 challenges of food waste management were listed, and the relations of these challenges with each other were analyzed with the fuzzy TISM method. As a result of the study, challenges are determined as the most crucial issues for food waste management in the retail sector. As managerial and policy implications, suggestions are made on the necessity of new policies, the usability of Industry 4.0 technologies for the problem, i.e. in the retail sector.

**Keywords** Retail sector · Waste management · Total interpretive structural modelling · Food waste

## Abbreviations

CE	Circular Economy
FW	Food Waste
ISM	Interpretive Structural Modelling
MCDM	Multicriteria Decision Making Model
TISM	Total Interpretive Structural Modelling

## Introduction

The way to transform the problem of excessive resource use, which negatively affects the whole world, into an economic benefit, depends on the transformation of waste [1], which is seen as a worthless and financial burden, into a value added to the environment and economy, in other words, the circular economy (CE) [2, 3]. Moreover, the environmental and economic benefits of the CE are important for a sustainable world [4, 5]. In addition, this issue is one of the core topics of “Sustainable Development Goals” determined by United Nations [3], clearly states that the primary objective is to immediately reduce our ecological footprint by changing the way produced and consumed products and resources to achieve economic growth and sustainable development [6].

From the food waste (FW) perspective, especially, 1/3 of all food produced worldwide turns into waste [7] instead of contributing to the CE [8]. FW occur throughout the entire supply chain and causes substantial financial losses and natural resources waste [9]. Especially, the retail sector is of great importance in reusing and recycling FW [4]. Since the retail sector accounts for an average of one-third of the gross national product worldwide, it also has an impact on many sectors [10]. With globalization, speed, innovation and

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being smarter have come to the fore in the retail sector and this has caused shortening in the life cycle of the sector [11]. Leader brands of the global retail sector are trying to implement different strategies, new technologies [12], intelligent approaches and policies to continue to be in the sector in an intensely competitive environment for FW.

In other words, the amount of FW generated in the retail sector, which is increasing in number and importance worldwide, also reaches high levels [13]. For example, especially in America, the food supply chain wastes 45% of all products, 35% of seafood, 30% of grains and 20% of meat and dairy products each year [14]. In the food retail sector, wastes also occur in the fresh food and production department and the food section of retail stores [15]. Therefore, FW management has significant impact on retail businesses from the especially environmental aspects [16]. The increased costs associated with FW management are compounded by a growing consumer awareness that causes many to use their purchasing decisions to support or reject a company's policies [14]. There is a need for ways to improve waste management in retail stores, especially in emerging economies such as Turkey [17].

Effective FW management cannot be done in emerging economies [16] such as Turkey, which is considered as a case in the study. The contribution of FWs to CE is very low due to many reasons, such as inadequacies in the law, lack of technical infrastructure and information, and high investment costs in emerging economies [15]. For example, in recent years, the retail sector in Turkey has been advancing rapidly, and the amount of FW is increasing [17]. Especially in Turkey, except for a few large retail companies, retailers cannot manage the resulting FW in a way that contributes to the CE [16]. This waste management problem, as in other emerging economies, arises from many problems such as insufficient government support, insufficient information sharing and awareness raising [17]. When the necessary infrastructure is provided in the retail sector and support and sanctions are increased, it is possible for retailers to collect and separate the wastes and to evaluate the wastes in terms of CE in Turkey [16]. For this reason, effective FW management in emerging economies especially in Turkey becomes extremely important in terms of contributing to CE [18].

Moreover, as mentioned before, the retail sector is one of the sectors that can contribute the most to the CE [18]. According to [21], retailers can provide benefits to CE by following reverse activities of FW occur in retailer stores [19]. Besides, adopting CE activities for FW occurs in retailer stores can provides recognition, gaining a place in consumer perception and competitive advantage, by bringing retailers to the forefront [22]. Moreover, FW management has become important for CE in terms of evaluating the wastes generated in the food retail sector, transforming waste into new products, raw materials or providing

energy valorization or other ways of food valorization for the retail sector [19]. Therefore, in this study, FW management for transition to CE consists of all types of benefits gained from FW.

As research motivation of the study, FW is challenging issue especially for emerging economies because of some insufficiencies in waste management. Therefore, it is essential to determine challenges of FW management for transition to CE [20] in retail sector and also determining these challenges is essential to provide opportunities retailer markets to organize new policies, adopting new intelligent approaches and waste management procedures for FW management, which is research gap in the literature. Therefore, the research questions of the study can be summarized as:

- RQ1: What are the challenges of FW management for transition to CE in the retail sector?
- RQ2: What is the relationship between challenges of FW management for transition to CE in the retail sector?

By considering research questions, the objectives of the study listed as below;

- Determining the challenges of FW management for transition to CE in retail sector by considering the detailed literature review
- Implementing fuzzy Total Interpretive Structural Modelling (TISM) to sector-leading experts in an emerging economy to find permanent solutions to these determined challenges

As mentioned before, in emerging economies, challenges that hinder the transition to the circular economy is an essential issue, and the main contribution of the study is to specify the challenges of FW management for transition to CE in the retail sector and to find permanent solutions to cope with these challenges using fuzzy TISM. In this study, fuzzy TISM is used, because the primary purpose of fuzzy logic is to create control and decision-making processes with models close to human thought using meaningful information [21].

The following sections of the study are as follows. In Sect. 2, literature review about FW management in the retail sector. Section 3 defines the challenges of FW management for transition to CE in retail sector. Section 4 covers methodology, which is fuzzy TISM. Section 5 consists of the implementation and results of this study. Sections 6 and 7 highlight discussion and managerial implications, respectively. Section 8 conclude of the study. In the following section, a literature review about FW management in the retail sector is explained in detail.

## Literature review: FW management in retail sector

With the fact that FW is a critical issue in the literature [16, 19], the number of studies dealing with the food retail sector is increasing. By considering the literature, it is stated that the retail sector acts as a watchman in FW management [13, 16]. With effective waste management [23] and the right policies in the retail sector, higher levels of FW can be prevented [19, 24].

FWs occur due to reasons such as wrong planning, expired products, manual product controls, and lack of technologies [25]. In the food retail sector, FW primarily exists in stores. Food retailers, who can implement effective waste management and are aware of the necessity of reducing waste, make operational improvements to reduce FW, deliver edible foods to those in need, follow new technological developments or intelligent approaches to extend the shelf life of products, donate foods suitable for animal feed, increase consumer awareness, work with suppliers [16]. The association takes measures such as planning agreements to reduce FW, turning FW into organic waste and turning it into energy production, preventing excess stock with discounted sales [25, 26].

By considering literature review, studies are carried out to measure the FW generated in the store and to analyze the databases within the framework of FW management [16, 27–29]. From another point of view, studies carried out to predict store-based or general FW in the retail sector and to find solutions according to the estimation results help to eliminate the uncertainty of waste amounts [30, 31].

Moreover, studies on the reduction of FW in the retail sector also come to the fore [32], as well as the desire of the retail sector to work on this issue [33]. Issues such as directing FW management in the retail sector [34] are among the topics studied in the retail industry. A summary literature review of these studies is given in Table 1.

As shown in Table 1, although there are various studies that covers the determination of the reasons that affect the generation of FW in retail sector, and prevent the reduction of waste are a crucial issue for literature [35–39], these

studies do not consist of FW management in the retail sector for transition to CE.

To sum up, by considering literature review, the research gaps of the study is summarized as determining FW management challenges and specifying these challenges for transition to CE, which provides the evaluation of FWs by reusing, recycling, i.e. in line with these mentioned research gaps, FW is taken into consideration as a main idea of this study, which are crucial for the world but especially in emerging economies like Turkey. Therefore, the study aims to be a guide for increasing the importance given to FW in retail industries with new policies and procedures.

## Determining challenges to FW management in the retail sector within the framework of circular economy

As mentioned before, FW management is an essential issue for the retail sector, especially from environmental aspects. However, instead of a few leading companies, retail companies do not consider FW management effectively since there is various challenges to FW management in the retail sector for transition to CE. Therefore, by considering literature, challenges to FW management in the retail industry within the circular economy framework are determined as shown in Table 2. Table 2 is given to clarify what the listed challenges mean and why they are included in the topic.

At the end of the determining challenges, expert validations are completed, and the number of challenges is increased to 16 challenges with matching expert opinions and literature review. These experts who validate these challenges have high-level knowledge about FW in retail industries from a member of municipalities, academicians and managers in retail industries.

In this study, the relationship between the challenges that prevent FW management will be examined. Fuzzy TISM will be used to explore the relationship between challenges. Therefore, in the following section, the methodology of this study is given.

## Methodology

Interpretive Structural Modelling (ISM) was developed for structure complex systems, and it is a directed graph representation of a complex system with iterative application of graph theory in the 1970s by Warfield [43]. Moreover, ISM can be defined as a process that transforms vague and poorly expressed mental system models into well-defined models useful for many purposes [44]. The output of the ISM analysis consists of nodes representing system variables and links representing aspects of relations between these

**Table 1** The focused areas for FW in retail sector

Focused area	Author (s)
Measurement of the amount of FW	[16, 27–29]
Amount of FW forecasting	[30, 31]
Willingness of the sector for reducing FW	[32, 33]
Consumer and purchasing behaviour	[27, 34, 39]
Drivers and barriers	[35–38]

**Table 2** Challenges FW management in the retail sector for transition to CE

Challenges	Definition	Author (s)
Lack of governmental policies and regulations	The inadequacy of government policies and regulations regarding FW management [32] for transition to CE prevents the collection and utilization of FW in a way that benefits the circular economy [40]. Especially in the food retail sector, the inadequacy of government support and regulation for the collection and evaluation of these wastes causes the waste to negatively affect sustainability [32]	[32, 40]
Lack of managerial policies	In line with government policies and within the framework of emerging difficulties, companies avoid circular waste management practices and policies [41]. The policy deficiencies in the companies cause the wastes generated to not be evaluated and recycled [40]. Due to the intensity of the amount of waste generated in the food retail sector, inadequacy in the management policies of the companies prevents the process [40]	[40, 41]
Lack of knowledge about waste management in the context of CE	Waste management and organizing waste management in a way that will benefit the circular economy requires knowledge [23]. In particular, the lack of knowledge of the stakeholders about the collection and storage of FWs [37] and the inclusion of these wastes in the circular economy prevents the effective implementation of this process [41]	[23, 37, 41]
Lack of technical infrastructure in waste collection and recycling in the context of CE	Lack of technical infrastructure is another criterion that prevents waste collection and recycling [42]. The lack of technical infrastructure in waste collection and recycling within the framework of the circular economy causes waste management practices to be implemented [25]. The inadequacy of digital technologies required in the process reveals the lack of technical infrastructure [23]	[23, 25, 42]
Difficulties about implementation of waste management in the context of CE	In order to have effective waste management, waste amount analysis should be done in real time [30]. Uncertainties in the amount of waste prevent the implementation of waste management. There can be lack of capacity due to the amount of waste that cannot be determined in waste management process [31] Particularly, the amount of waste generated in the food retail sector varies, and the unknown of these amounts hinders waste management [30]	[30, 31]
Lack of coordination and cooperation among closed-loop supply chain members	Lack of cooperation and coordination among members of closed-loop supply chains on waste management causes insufficient information transfer among the members of the supply chains [35]. In order for waste management to be carried out effectively, each member of closed-loop supply chain must work in an integrated manner with each other [43]. The lack of information sharing among members negatively affects the waste management process [45]	[35, 43, 44]
High costs for investment and waste management technologies	The technological infrastructure required for the implementation of waste management and the effective management of the process requires high investment costs [17]. High costs cause the necessary planning for waste management to not be made [37]. The ineffective implementation of waste management and the inability to provide recycling processes threaten sustainability by harming the environment, human health and the economy [17]	[17, 37]
Lack of certifications of waste collectors	Certification ensures the emergence of legal processes in waste management and the implementation of the right waste management policy [44]. The lack of certificates required to check whether the recycled raw materials purchased from suppliers comply with the standards in the waste management process hinders the effectiveness of the waste management process [42]	[42, 44]

**Table 2** (continued)

Challenges	Definition	Author (s)
Lack of control and supervision by local government	One of the most important actors in effective FW management is local and central governments [45]. The inadequacy of the controls, inspections and policies carried out by local and central governments causes the companies and other stakeholders to not be aware of FW management and the process cannot be carried out [18]	[18, 45]
Lack of product and package design	The fact that the product, packaging and package designs in the sector are not handled with a zero-waste product design perspective prevents the product and package design from being reused and recycled [25]. The food retail sector, which is one of the sectors where product and package designs are seen the most, cannot ensure effective waste management due to this reason [41]	[25, 41]
High waste diversity (metal, glass, wood, paper, plastic)	The high diversity of FW generated prevents the realization of recycling activities within the scope of the circular economy [46]. The excess of waste types requires different technologies and different planning [12]	[12, 46]
Limited space for the storage or collection of wastes	To have an effective waste management process, it is necessary to have an appropriate storage and collection area [46]. The limited areas required for the storage and collection of wastes, especially inside the stores, cause deficiencies in operations [47]. Visual problems arise due to the lack of suitable area for the collection of wastes inside the stores or in the warehouses, the design of the store not being made accordingly, and the appearance of waste in the middle according to [46]	[46, 47]
Diseconomies of scale	The fact that wastes are large and diverse in terms of quantity causes economies of scale and a decrease in productivity [48]. While a single type of waste or known amount of waste contributes to economies of scale, uncertainty and diversity in waste amounts cause economies of scale [49]	[48, 49]
Lack of awareness in stakeholders	Lack of awareness among stakeholders prevents the realization of waste management with a circular economy perspective [49]. Lack of awareness among stakeholders also leads to lack of information sharing [50]	[49, 50]
Lack of circular economy business models in the sector	The most important issue in waste management is that waste should be evaluated with a circular economy perspective [51]. Recently, the fact that manufacturers are more customer-oriented than resources prevents the realization of waste management in terms of circular economy [52]	[51, 52]
Problems with the effectiveness and efficiency of reverse logistics activities	One of the issues to be addressed in waste management is reverse logistics. Reverse logistics ensures that wastes can be recycled and recycled [53]. Especially in the food retail sector, problems arise regarding the effectiveness and efficiency of reverse logistics activities due to reasons such as the abundance and uncertainty of the amount of waste [54]	[53, 54]

variables [43]. The model presents a hierarchical structure that reveals the contextual relationships between system variables [53]. However, ISM has some disadvantages, such as interpretation of links and a lack of consideration for transitive linkages [55]. On the other hand, the ISM is very important as it shows the interpretation of relations in the form of a matrix for each binary element in its corresponding cell, which can be fuzzy or binary [43]. Therefore, when the ISM is integrated with the interpretive matrix, it improves the methodology and framework of TISM [56]. Hence, in this study, fuzzy TISM is used by integrated with fuzzy logic.

TISM is one of the multicriteria decision-making model (MCDM) in the literature [56] and it is practical to give the ability to show both transitive and direct relations to make the structural model fully interpretative [57]. Moreover, fuzzy logic is generally preferred to avoid ambiguity in the implementations [21]. Furthermore, fuzzy TISM has many advantages such as showing the direction and level of influence between the criteria [55], providing more interpretability, giving logical structure for managers and policymakers and increasing the intelligibility for the

structural model [58]. As one of the disadvantages of this method, it does not allow ranking between criteria [56].

Before moving steps of fuzzy TISM, a flowchart of the methodology is given in Fig. 1. According to Fig. 1, after a detailed literature review, challenges to FW management in the retail sector within the circular economy framework are determined. After expert validations, data are collected from sector experts. Then, implementation of the study is completed by fuzzy TISM.

Steps of fuzzy TISM are given as below.

Step 1: decision-making process

First of all, the initial stages, such as determining the purpose of the study and collecting information, are completed. The appropriateness of the decision makers' expertise should be assessed [59].

Step 2: criteria selection

In the second stage, a set of criteria is created to investigate relations with each other in terms of impact/impact or affected/affected or both [59]. A fuzzy triangular language cluster containing five linguistic terms is used to make the assessment [60]. The scale used is given in Table 3.

Step 3: evaluation by decision makers and preparing SSIM

At the stage, the determinations of all decision makers participating in the implementation are collected and the Structural Self-Interaction Matrix is obtained [61]. Decision makers use four various linguistic terms denoted by V, A, X and O during their evaluation [59]. Decision

**Table 3** Linguistic scale [60]

Linguistic scale	Fuzzy numbers
Very High (VH)	(0.75, 1, 1)
High (H)	(0.5, 0.75, 1)
Low Influence (L)	(0.25, 0.5, 0.75)
Very Low Influence (VL)	(0, 0.25, 0.5)
No Influence (NO)	(0, 0, 0.25)

makers evaluate the criteria in terms of both the relationship and the direction of the relationship.

Step 4: aggregate SSIM and fuzzy reachability matrix

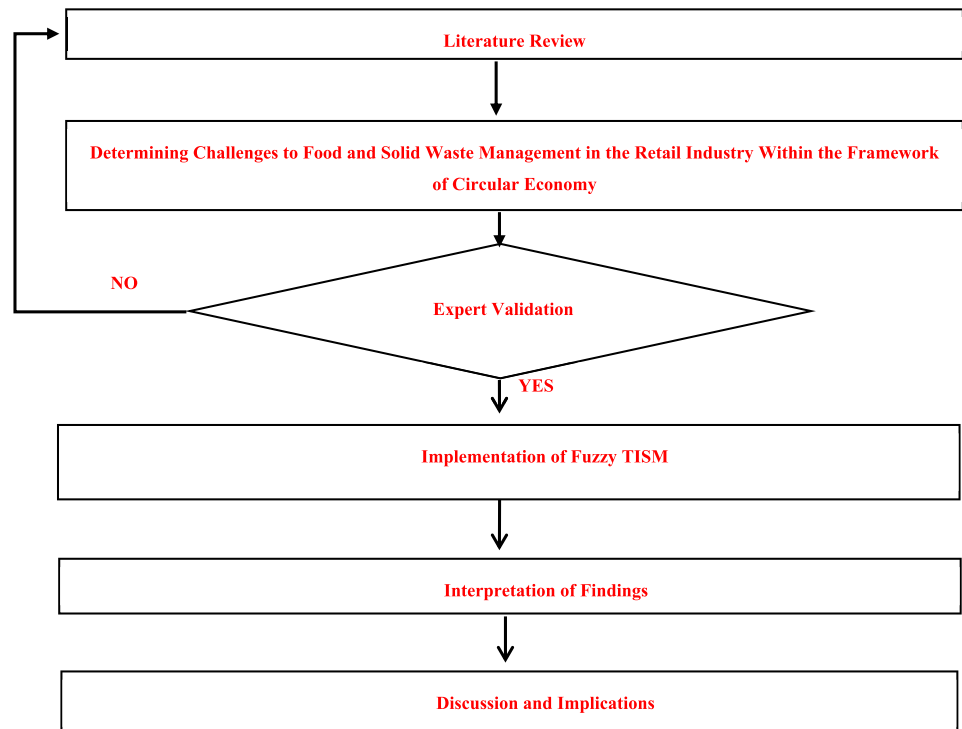
The decision makers' evaluations are calculated by considering the highest frequencies and the aggregated SSIM matrix is created. After that, by changing linguistic expressions with corresponding fuzzy numbers, a fuzzy reachability matrix should be formed by changing the aggregated-SSIM matrix [61].

Step 5: determination of driving power and dependence

In the last step, driving power (sum of rows) and dependency (sum of columns) are calculated. After that, a defuzzification process called CFCS (conversion of fuzzy data to exact scores) is used [62]. The last value is used to plot the driving power and dependency matrix.

In the following section, the implementation of the study is explained.

**Fig. 1** Flowchart of the methodology



## Case study: an example from an emerging economy

Turkey is the 17th largest economy and one of the emerging economies in the world [63, 64]. Among other sectors, the retail sector has an important place in Turkey [65]. As in the rest of the world, the retail sector in Turkey continues to grow rapidly [66]. Despite the steady growth of local and international chain stores and recent mergers and acquisitions, traditional players constitute the majority of the local retail market [67]. The development of the retail sector in the country has a positive impact on many areas such as investment, employment and formal economy in the country [68].

The retail sector in Turkey generally includes companies that sell food and beverage, clothing retailers, home textiles, non-food retailers, automotive fuel and pharmaceutical products, medical and orthopaedic products, cosmetics and personal care materials [64]. The retail sector in Turkey is classified as food and non-food retailing, and the food retail sector accounts for 62% of total retail sales [66].

The increase in the food retail sector is related to the economic situation in Turkey as it is worldwide. The food retail sector constitutes the most significant expenditure category in Turkey [65]. As of 2018, with the increase in inflation and food prices, discount markets have come to the fore [69]. By considering the retail sales volume index of Turkish food retailers, the annual average for food, beverage and tobacco products has increased, and the sector has grown [70]. In Turkey, which is an emerging economy, although awareness about FW has increased recently, there is still an inadequacy in terms of policies [70]. Therefore, Turkey is discussed in the implementation of the study.

In this study, the implementation of the study is conducted by five experts who are working in retail companies, which are global German retailers, global French retailers, Turkey's leading retail company, leader and 2nd leader company in discount stores in Turkey. These experts have knowledge about FW management in the

retail sector, and the detailed information about experts is given in Table 4.

These experts evaluated 16 challenges using linguistic variables. Following the fuzzy TISM stages, the end aggregate SSIM matrix has been reached as shown in Table 5.

Then, as shown in Table 6, the obtained aggregate SSIM matrix is transformed into a fuzzy reachability matrix with the help of a linguistic scale.

Driving power and dependency values are calculated with the help of fuzzy triangular numbers, and a fuzzy accessibility matrix is obtained. Moreover, the CFCS method is implemented for defuzzification. Driving power value is the sum of the rows, and also the dependency value is the sum of columns, and then as the last step of fuzzy TISM, the driving power and dependence matrix is drawn, that divides the challenges into four groups as autonomous, dependent, connected and independent as shown in Fig. 2. The autonomous group does not contain challenges that neither affect nor are affected by others. Dependent criteria are influenced by others, while independent criteria affect other criteria. Moreover, independent criteria do not affect by the other criteria. Lastly, the criteria placed in the junction area affect other criteria and are also affected by other criteria.

## Results

As a result, TISM gives the relationship between these determined challenges of FW management transition to CE, which are listed in Table 2. After expert evaluations based on challenges, which are given in Table 2, the results are gathered by TISM computations.

In line with these results, the study's added value is to evaluate these challenges obtained based on the literature and expert opinions from the FW management transition to CE perspective, and to guide for decision makers in line with the results about the relationship between the challenges. At the end of the implementation, the driving power and dependence matrix is obtained, as shown in Fig. 2. As shown in this figure, challenges are separated as independent, linkage, autonomous and dependent challenges based on the level of affecting each other.

**Table 4** The expert's information

Experts	Company type	Department	Profession	Work experience (in year)
Expert 1	Global German Retailer	Food and Beverage	Manager	8
Expert 2	Leader of Discount Store	Purchasing	Store Manager	12
Expert 3	Leader Company of Retail Sector	Product Safety and Environmental Management	Group Manager	6
Expert 4	2 <sup>nd</sup> Leader of Discount Store	Purchasing	Store Manager	7
Expert 5	Global French Retailer	Quality Assurance & Sustainability	Sustainability Manager	5

**Table 5** Aggregate SSIM matrix

	C16	C15	C14	C13	C12	C11	C10	C9	C8	C7	C6	C5	C4	C3	C2
C1	O(NO)	V(H)	V(H)	O(NO)	V(H)	O(NO)	V(VH)	V(VH)	V(H)	O(NO)	V(H)	O(NO)	V(H)	O(NO)	V(VH)
C2	A(H)	X(VH)	X(H)	A(H)	V(H)	O(NO)	V(VH)	A(VH)	O(NO)	O(NO)	X(VH)	A(VH)	V(VH)	A(H)	V(VH)
C3	O(NO)	X(H)	X(VH)	A(VH)	O(NO)	O(NO)	V(VH)	A(H)	V(H)	O(NO)	X(H,VH)	V(H)	V(H)	0	0
C4	O(NO)	X(H)	X(H)	A(H)	A(VH)	A(VH)	O(NO)	A(H)	X(VH)	X(VH)	X(H)	V(VH)	0	0	0
C5	V(H)	V(L)	O(NO)	A(VH)	A(VH)	A(VH)	O(NO)	A(L)	O(NO)	A(VH)	X(H)	0	0	0	0
C6	O(NO)	V(H)	X(H)	O(NO)	A(H)	O(NO)	O(NO)	V(H)	A(VH)	A(VH)	0	0	0	0	0
C7	O(NO)	V(H)	O(NO)	O(NO)	O(NO)	X(VH,H)	O(NO)	V(H)	O(NO)	0	0	0	0	0	0
C8	X(VH)	V(H)	A(H)	O(NO)	O(NO)	A(H)	O(NO)	O(NO)	0	0	0	0	0	0	0
C9	O(NO)	V(H)	A(H)	O(NO)	A(H)	O(NO)	O(NO)	0	0	0	0	0	0	0	0
C10	O(NO)	A(H)	A(H)	O(NO)	O(NO)	O(NO)	0	0	0	0	0	0	0	0	0
C11	V(H)	O(NO)	O(NO)	X(VH)	O(NO)	0	0	0	0	0	0	0	0	0	0
C12	V(H)	O(NO)	O(NO)	O(NO)	0	0	0	0	0	0	0	0	0	0	0
C13	V(VH)	V(VH)	O(NO)	0	0	0	0	0	0	0	0	0	0	0	0
C14	O(NO)	A(VH)	0	0	0	0	0	0	0	0	0	0	0	0	0
C15	A(VH)	0	0	0	0	0	0	0	0	0	0	0	0	0	0

**Table 6** Fuzzy reachability matrix

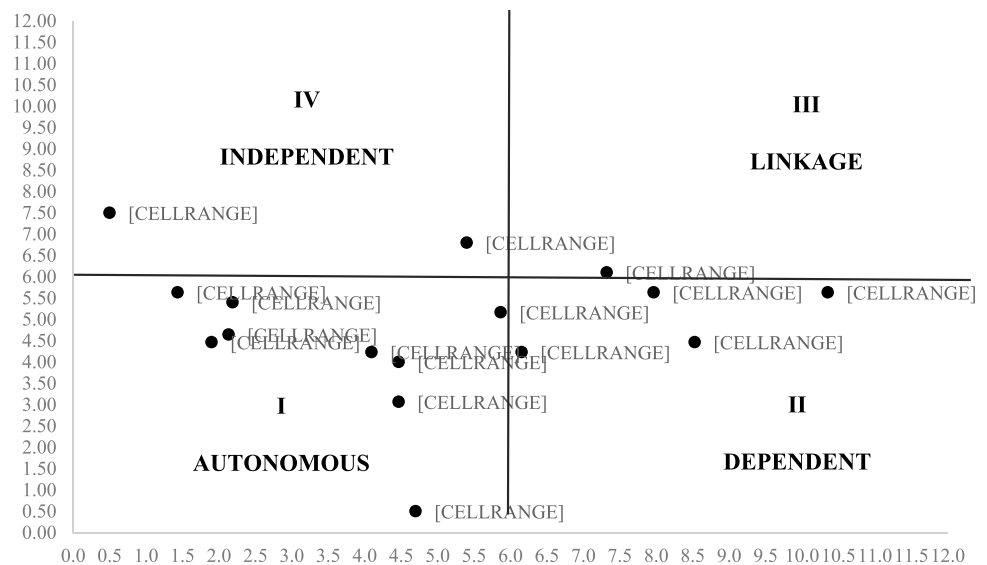
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16
C1		VH	NO	H	NO	H	NO	H	VH	VH	NO	H	NO	H	H	NO
C2	NO		NO	VH	NO	VH	NO	NO	NO	VH	NO	H	NO	H	VH	NO
C3	NO	H		H	NO	H	NO	NO	NO	VH	NO	NO	NO	VH	H	NO
C4	NO	NO	NO		VH	H	VH	VH	NO	NO	NO	NO	NO	VH	H	NO
C5	NO	VH	VH	NO		H	NO	NO	NO	NO	NO	NO	NO	NO	L	H
C6	NO	VH	VH	VH	H		NO	NO	H	NO	NO	NO	NO	H	H	NO
C7	NO	NO	NO	VH	VH	VH		NO	H	NO	VH	NO	NO	NO	H	NO
C8	NO	NO	NO	VH	NO	VH	NO		NO	NO	NO	NO	NO	NO	H	VH
C9	NO	VH	VH	H	L	NO	NO	NO		NO	NO	NO	NO	NO	H	NO
C10	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO	NO
C11	NO	NO	NO	VH	VH	NO	H	H	NO	NO		NO	VH	NO	NO	H
C12	NO	NO	NO	VH	VH	H	NO	NO	H	NO	NO		NO	NO	NO	H
C13	NO	H	VH	H	VH	NO	NO	NO	NO	NO	NO	NO		NO	VH	VH
C14	NO	H	VH	VH	NO	H	NO	H	H	H	VH	NO	NO		NO	NO
C15	NO	VH	H	H	NO	NO	NO	NO	NO	H	NO	NO	NO	VH		NO
C16	NO	H	NO	NO	NO	NO	NO	VH	NO	NO	NO	NO	NO	NO	VH	

By considering Fig. 2, autonomous group covers most of the challenges, which are lack of knowledge about waste management in the context of CE (C3), high costs for investment and waste management technologies (C7), lack of certifications of waste collectors (C8), lack of control and supervision by local government (C9), lack of product and package design (C10), high waste diversity (metal, glass, wood, paper, plastic) (C11), limited space for the storage or collection of wastes (C12), diseconomies of scale (C13), problems with the effectiveness and efficiency of reverse logistics activities (C16).

Moreover, the dependent group covers lack of managerial policies (C2), lack of technical infrastructure in waste

collection and recycling in the context of CE (C4), difficulties about the implementation of waste management in the context of CE (C5), lack of circular economy business models in the sector (C15). Independent group consists of a lack of governmental policies and regulations (C1) and a lack of stakeholders' awareness (C14). Lastly, linkage group includes lack of coordination and cooperation among closed-loop supply chain members (C6).



**Fig. 2** Driving power and dependence matrix

## Discussion

As mentioned before, FW management and policies about FW management is an essential issue in the retail sector, especially in emerging economies [10]. Deficiencies in FW management policies in emerging economies prevent the effective implementation of FW management in the retail sector [70]. Therefore, as a contribution, the study aims to determine the challenges of FW management for transition to CE in the retail industry with a detailed literature review and finds relations between these challenges in the retail sector in an emerging economy. The results obtained in this study are expected to guide decision makers, and it is expected that choices will be made according to the results obtained.

As a result, in this study, the lack of governmental policies and regulations (C1) and lack of awareness in stakeholders (C14) are in the independent zone means that although they affect other challenges, they do not affect all other challenges [32]. [71] highlighted that effective FW can be successful when awareness of stakeholders increases. Furthermore, similar to our study, [72] stated that policy and legal issues are significant for FW management, especially in emerging economies.

As mentioned before, the lack of coordination and cooperation among closed-loop supply chain members (C6) is determined in the linkage groups, which is affected by all other challenges and affects them [44]. According to [73], coordination and cooperation among closed-loop supply chain members are critical for FW management transition to CE. The fact that there are few challenges in this group indicates that the number of challenges affecting each other in two directions is low.

Moreover, lack of managerial policies (C2) [41], lack of technical infrastructure in waste collection and recycling in the context of CE (C4), difficulties about the implementation of waste management in the context of CE (C5) [47, 48], lack of circular economy business models in the sector (C15) are determined in the dependent group. For example, from another study [74], investments in FW prevention technologies depend on the country's technological infrastructure. These challenges are affected by all other challenges but do not affect these challenges.

## Managerial and policy implications

As a managerial implication, lack of coordination and cooperation among closed-loop supply chain members is a problem that affects the waste management process and has different effects. To prevent this, Industry 4.0 technologies should be adopted or Big data technologies analysis can be made to ensure coordination and cooperation among supply chain members in the process. With the help of Industry 4.0 or other intelligent approaches, problems arising from communication and cooperation can be avoided.

Moreover, to have effective FW management in the retail sector, companies need to see this as a competitive advantage through a differentiation strategy. Therefore, they should develop policies to ensure excellence in the FW management process. Companies should include FW management policies in their strategic plans.

Furthermore, to eliminate the difficulties experienced in ensuring waste management within the scope of the circular economy, companies can evaluate in two ways. First of all, to prevent the formation of FW in the retail sector, sales forecasting methods should be improved from the beginning

of the process. They can provide sales forecasting methods with Electronic Data Interchange (EDI) originating from an automated replenishment system. Second, they can provide waste management by making demand plans regarding the amount of waste generated.

In addition, since the profit margin in the retail sector is low, cost minimization stands out. In this sense, resource-based approaches gain importance. To solve the problem of the lack of circular economy business models in the industry, it is necessary to contribute to cost leadership based on resource-based view.

Considering the results of the study, the issues that need to be focused on in the retail sector are shaped within the framework of legal and government. From the legal perspective, implications for policymakers, it is necessary to regulate the policies and incentives about FW management to be created by the state. For example, laws should be established to prevent waste from discount stores. A tax incentive system or a return management system should be established for companies in the retail sector. Moreover, the number of food banks can be increased. By examining the example of developed countries, benchmarking can be made with good practices in the sector.

One of the most critical elements in waste management is to ensure communication and coordination between stakeholders. NGOs are also extremely important as regulatory institutions especially in developed countries, besides central and local governments. To ensure this process in emerging economies, conferences and training should be organized to increase knowledge sharing among stakeholders, and organizations should be prepared to understand FW management and CE.

To overcome the problem of lack of circular economy business models in the sector, the government can make case studies in terms of geography; this can be applied to other places with its new policies while making smarter in its operations. The circular economy business models contain multiple stakeholders, and it should be considered in conjunction with the stakeholder clause above. In the agreements, responsibility should be shared and given to the retailers. Even though linear and traditional models are still being used, applications should be made in terms of CE.

Furthermore, to overcome the lack of technical infrastructure in waste collection and recycling in the context of CE, government incentives should be given in these matters and governmental policies should be organized in line with this issue. In addition, the government can be organized financial investments to improve technical infrastructure. The ones who will invest in the process should be the municipality or the central authorities. When the necessary infrastructure can be provided, the number of companies working on the subject will increase. Moreover, the government can support the use of intelligent approaches in FW management.

## Conclusion

With the globalizing world, FW is increasing day by day, and the intensity of competition in the retail sector is increasing, as in every sector. With the increasing importance of the retail sector, one of the sectors that cause the most FW, pressure on waste management policies and waste prevention is increasing. There are many reasons for the formation of FW in the retail sector, and food retailers are increasingly focusing on finding sustainable solutions for FW management, especially from environmental aspects. Therefore, the study aims to identify the challenges encountered in the inability to evaluate FWs in the retail sector in an emerging economy with the circular economy point of view as a central contribution. Hence, 16 challenges of FW management were listed and the relations of these challenges with each other were analyzed with the TISM method. With this aim, by determining these challenges, it is aimed to reveal the necessity of finding solutions to these challenges with new policies and implementations.

As a result of the study, while independent group includes of lack of governmental policies and regulations and lack of awareness in stakeholders, the autonomous group covers lack of knowledge about waste management in the context of CE, high costs for investment and waste management technologies, lack of certifications of waste collectors, i.e. furthermore, while dependent group covers lack of managerial policies, lack of technical infrastructure in waste collection and recycling in the context of CE, i.e., linkage group includes lack of coordination and cooperation among closed-loop supply chain members. To sum up, as can be seen at the end of the study, challenges arise regarding politics and government, especially in emerging economies.

As a limitation of the study, although Turkey, one of the emerging economies, is discussed in this study, it is applicable in different emerging economies as well. Moreover, due to the nature of the selected sector, the results obtained may differ as the industry differs. In addition, the implementation of the study in developed countries may reveal different results. For further researches, the study may be implemented for local chains. Moreover, a similar study can be made for developed countries, and a comparison can be made between emerging economies and developed countries. In addition, improved analyses can be made by integrating the results obtained in other MCDM methods such as fuzzy DEMATEL, TODIM, VIKOR according to the necessity of the problem. Furthermore, in this study, the challenge set is generally determined, but the challenge set can be specified for the country or sector to be discussed.

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