A APPENDICES

A.1 THE FOUND FUZZY SET EXTENSIONS WITH THE MOST COMMON KEYWORDS

Table A1: The found fuzzy set extensions with the most common keywords (RQ2, RQ3)[a]

No	Fuzzy set extensions	Keywords
1	atanassov intuitionistic fuzzy set	group decision making [1], [2], terminological difficulties [3], [4]
2	axiomatic fuzzy set	semantic interpretation [5–7], eigenfaces [8], rough set model [9]
3	balanced fuzzy set	fuzzy neural network [10], learning [11], mcdm [12]
4	bipolar fuzzy set	graph representation [13, 14], relational analysis method [15], terminological difficulties [16] [17], MULTIMOORA [18], [19]
5	complex fuzzy set	granular computing [20], graph representation [13], [21], machine learning [22, 23], particle swarm optimization [24], mcdm [25], [26], [27]
6	complex intuitionistic fuzzy set	mcdm [28], [29]
7	complex pythagorean fuzzy sets	group decision making [30]
8	complex q-rung orthopair fuzzy set	topsis [31, 32]
9	convex fuzzy set	relational database [33]
10	dynamic fuzzy sets	group decision making [34], image segmentation [35, 36], medical diagnosis [10], moving object detection [35]
11	dual hesitant fuzzy set	group decision making [37], madm [38], mcdm [39], topsis [40], correlation coefficient [41, 42]
12	dual hesitant fuzzy soft set	correlation coefficient [43, 44], expert system [45], mcdm [46], medical diagnosis [46]
13	eigen fuzzy sets	image analysis [47], convex combination [48]
14	fermatean fuzzy set	group decision making [49], mcdm [50, 51], topsis [50, 52, 53], medical diagnosis [54], semigroups [55]
15	fuzzy multiset	information fusion [56], medical diagnosis [57, 58], terminological difficulties [57]
16	fuzzy rough set	information system [59], machine learning [60], object recognition [61], particle swarm optimization [62], 3-way decision [59]
17	fuzzy soft set	normal parameter reduction [63]
18	general type-2 fuzzy set	karnik-mendel algorithm [64, 65], computing with words [66], controller [67], gene-expression data [68]
19	hesitant fuzzy linguistic term set	madm [69], mcdm [70–72], topsis [70], vikor [69], group decision making [73]
20	hesitant fuzzy set	madm [74, 75], magdm [74, 76], management [77], mcdm [78], mcgdm [79], medical diagnosis [80], multiplicative consistency [81], pattern recognition [82], quality function deployment [83], supplier selection [83], todim [84], topsis [74, 83], vikor [74, 77], 3-way decision [85], big data [86]
21	hesitant fuzzy soft set	madm [87], magdm [88, 89], topsis [89], group decision making [90]
22	interval neutrosophic hesitant fuzzy set	madm [91], topsis [92], vikor [92], correlation coefficient [92, 93]
23	interval neutrosophic set	madm [94], mcdm [94, 95], correlation coefficient [95]
24	interval type-2 fuzzy set	karnik-mendel algorithm [65, 96], madm [97], magdm [98], management [99, 100], mcda [101], mcdm [102], mcgdm [103], mobile robot [104], neural network [105], particle swarm optimization [106], perceptual computing [107], qualiflex [108], risk management [100], software development [109], stability analysis [110], supplier selection [111], topsis [99], tracking control [112], vikor [113], best-worst method [114], c-means algorithm [115], controller [107], data envelopment analysis [116], dematel [99, 111], dynamic system [117], edge-detection method [118], facility location selection [119], fmea [120], fuzzy multiple attributes group decision-making [121], green supplier selection [113], construction [122]
25	interval-valued dual hesitant fuzzy set	madm [123], mcdm [124], topsis [125], correlation coefficient [125], group decision making [126]
26	interval-valued fuzzy set	mcdm [127], prediction [128], terminological difficulties [129], topsis [130]
27	interval-valued hesitant fuzzy set	madm [131], magdm [132], mcdm [133], pattern recognition [134], topsis [135], vikor [136], correlation coefficient [137], green supplier selection [136]
28	interval-valued intuitionistic fuzzy set	madm [138, 139], magdm [140], mcdm [141], mcgdm [142], pattern recognition [134], programming [143], risk management [144], topsis [139], vikor [145], ahp [144], supplier selection [146]

No	Fuzzy set extensions	Keywords
29	interval-valued pythagorean fuzzy set	mcdm [147], topsis [148]
30	interval-valued q-rung orthopair fuzzy set	madm [149, 150], topsis [150–152], 3-way decision [153], aras [154], fmea [154], magdm [152], group decision making [155]
31	interval-valued spherical fuzzy set	topsis [156], group decision making [156]
32	intuitionistic fuzzy rough sets	minimization [157, 158]
33	intuitionistic fuzzy set	expert system [159], fault diagnosis [160], fmea [161, 162], fuzzy c-mean [163], fuzzy clustering [164], fuzzy neural network [165], fuzzy time series [166], anp [167], generalized nets [168], genetic algorithm [169], gra [170], image processing [171], information system [172], intuitionistic fuzzy c-means [164], mabac [161], madm [173], magdm [174], magnetic resonance imaging [164], mathematical programming [175], matrix game [176–178], mcda [175], mcdm [179], mcgdm [180], medical diagnosis [181, 182], multimoora [183], multiperson [175, 184], neural network [165], particle swarm optimization [185], pattern recognition [186, 187], programming [188], promethee [189], quality [168], recommender system [190], renewable energy [191], reputation [192], risk management [193], 3-way decision [194], supplier selection [195], supply chain [196], todim [197], topological spaces [198–200], topsis [193, 195], vendor selection [195], vikor [161, 197, 201], correlation coefficient measure [186], covid-19 [180], data envelopment analysis [201], data mining [202], decision support system [173], dematel [203], electre [204]
34	intuitionistic fuzzy soft set	gra [205], group decision making [206]
35	l-fuzzy set	qualitative reasoning [207], topological spaces [208]
36	linguistic hesitant fuzzy set	madm [209], mcdm [210], quality [211], todim [211], topsis [212], vikor [213], best-worst method [211], correlation coefficient [209, 212], group decision making [214]
37	linguistic intuitionistic fuzzy set	madm [215], magdm [73, 216], topsis [217], decision support model [218], group decision making [219], sentiment analysis (Liang and Wang 2019), cognition (Liu et al. 2020d)
38	linguistic pythagorean fuzzy set	madm (Han et al. 2020), magdm (Rong et al. 2020; Khan et al. 2022b), mcgdm (Sarkar and Biswas 2021; Zhang et al. 2021), topsis (Garg 2018; Han et al. 2020; Sarkar and Biswas 2021), gra (Khan et al. 2022b), group decision making (Zeng et al. 2018; Lin et al. 2020)
39	m-polar fuzzy set	madm (Naeem and Divvaz 2022), topsis (Riaz et al. 2022), disease (Albahri et al. 2022), fuzzy concept lattice (Singh 2018), graph representation (Singh 2019c), multi-polar (Kazancı and Davvaz 2023)
40	multi-fuzzy set	diagnosis (Wang et al. 2015b)
41	multi-valued neutrosophic set	qualiflex (Peng et al. 2017b; Peng and Tian 2018), todim (Ji et al. 2018), correlation coefficient (Peng et al. 2017b, a), electre (Peng et al. 2017a), madm (Saqlain et al. 2020), mcdm (Peng et al. 2017a), mcgdm (Peng et al. 2015)
42	n-dimensional fuzzy sets	reciprocity (Bedregal et al.), cloud computing (Zanotelli et al. 2022), fuzzy negations (Mezzomo et al. 2018), information fusion (De Miguel et al. 2017b)
43	neutrosophic set	supplier selection (Zhang et al. 2020a), topsis (Nafei et al. 2021), vikor (Karaşan et al. 2019), group decision making (Zhang et al. 2020a), image segmentation (Chai et al. 2021)
44	neutrosophic soft set	todim (Yanmaz et al. 2020), topsis (Peng and Liu 2017; Naeem et al. 2020), vikor (Karaşan et al. 2019), correlation coefficient (Karaaslan 2017), edas (Peng and Liu 2017), group decision making (Naeem et al. 2020)
45	normal fuzzy set	todim (Şahin 2018), correlation coefficient (Şahin 2018), madm (Şahin 2018; Yang and Chang 2020)
46	paired fuzzy set	terminological difficulties (Montero et al. 2016)
47	picture fuzzy set	relational analysis method (Wei 2017; Ran 2021), todim (Ran 2021), topsis (Zhang et al. 2020b; Gül and Aydoğdu 2021), vikor (Singh and Kumar 2021), MCDM (Luo and Zhang 2023)
48	pythagorean fuzzy set	renewable energy (Xie et al. 2020), risk management (Li et al. 2020a), service quality (Zeng et al. 2016a; Ilbahar and Kahraman 2018), supplier selection (Wu et al. 2019), sustainability (Xie et al. 2020), todim (Sarkar and Biswas; Wang et al. 2019b; Ashraf et al. 2021), topsis (Thao and Smarandache 2019; Zhang et al. 2020c), vikor (Ming et al. 2020), waspas (Ilbahar and Kahraman 2018), biogeography-based optimization (Zheng et al. 2017), codas (Bolturk 2018), conflict analysis (Du et al. 2022), copras (Thao and Smarandache 2019), correlation coefficient measure (Ejegwa et al. 2021), deep learning (Zheng et al. 2017), dematel (Giri et al. 2022; Li et al. 2022), edas (Li et al. 2022), gra (Khan et al. 2020), green supplier selection (Wu et al. 2019), linmap

No	Fuzzy set extensions	Keywords
		(Chen 2019), management (Oztaysi et al. 2019), market volatility (Wang et al. 2019b), moora (Huang et al. 2020b), occupational-health (Demir and Karamaşa 2020), promethee (Chen 2018)
49	pythagorean fuzzy soft sets	topsis (Athira et al. 2019; Riaz et al. 2020b; Zulqarnain et al. 2021a), ahp (Zulqarnain et al. 2021b; Atalay et al. 2021), correlation coefficient (Zulqarnain et al. 2021a), madm (Zulqarnain et al. 2021a)
50	pythagorean hesitant fuzzy set	qualiflex (Jana and Roy 2023), topsis (Khan et al. 2017; Zhong et al. 2019), group decision making (Khan et al. 2017), mcdm (Zhong et al. 2019)
51	polygonal fuzzy set	rule interpolation (Cheng et al. 2015; Chen and Adam 2018a), sparse fuzzy rule-based systems (Cheng et al. 2015)
52	probabilistic fuzzy set	time series prediction [forecasting] (Gupta and Kumar 2019), (Chen and Adam 2018b), ann (Zhang et al. 2012a), c-means algorithm (Gupta and Kumar 2023), k-means clustering (Gupta and Kumar 2023), pattern classification (Zhang and Li 2011), controller (Zhang and Li 2011, 2012)
53	probabilistic hesitant fuzzy set	todim (Liao et al. 2022), vikor (Naeem et al. 2021; Krishankumar et al. 2021), correlation coefficient (Song et al. 2019), magdm (Jiang and Ma 2018)
54	q-rung orthopair fuzzy set	quality (Gong et al. 2020; Li et al. 2021), todim (Darko and Liang 2020), topsis (Wei et al. 2018; Garg et al. 2021; Liu et al. 2022a; Vimala et al. 2023), vikor (Khan et al. 2021a), 3-way decision (Liang and Cao 2019; Tang et al. 2020), correlation coefficient (Li et al. 2020b; Singh and Ganie 2022), mabac (Peng and Liu 2019), mcdm (Joshi and Gegov 2020; Ali and Naeem 2022), supplier selection (Mahmood and Ali 2021), inequalities (Peng et al. 2023)
55	random fuzzy set	bootstrap techniques (Ramos-Guajardo et al. 2013, 2014), c-means algorithm (Giordani and Ramos-Guajardo 2016), machine learning (Tansuchat et al. 2021)
56	rough fuzzy set	transformation-based interpolation (Chen et al. 2016), 3-way decision (Zhai et al. 2017; Zhai and Zhang 2018), decision systems (An et al. 2021), gaussian kernel (An et al. 2021), granular computing (Liu 2009; Małyszko and Stepaniuk 2009), inclusion degree (Sun and Gong 2007; Lee and Chang 2011; Zhang and Sun 2022), incremental learning (Huang et al. 2017), information system (Wu et al. 2006; Sun et al. 2017; Yu et al. 2019)
57	simplified neutrosophic set	correlation coefficient (Wu et al. 2016; Şahin and Zhang 2018), mcdm (Peng et al. 2014; Ye 2014a; Şahin and Liu 2017), medical diagnosis (Ye 2015; Abdel-Basset et al. 2021)
58	Single-valued neutrosophic set	topsis (Nancy and Garg 2019), ahp (Sodenkamp et al. 2018), correlation coefficient (Ye 2014b; Özlü 2023), madm (Mondal et al. 2018; Garai et al. 2020), magdm (Ye 2014c), mcdm (Ye 2014b; Ashraf et al. 2017), power average (Liu et al. 2019c)
59	spherical fuzzy set	todim (Liu et al. 2020b; Wu et al. 2020), correlation coefficient (Guleria and Bajaj 2021), madm (Kutlu Gündoğdu and Kahraman 2020), state-of-the-art (Ozceylan et al. 2022)
60	three-dimensional fuzzy set	controller design (Zhang et al. 2012b), distributed parameter system (Li et al. 2007), stability analysis (Zhang et al. 2010b, a)
61	type-1 fuzzy set	computing with words (Nusratov et al. 2017), facility location selection (Kahraman et al. 2003; Mokhtarian et al. 2014), fuzzy multiple attributes group decision-making (Chen et al.), karnik-mendel algorithm (Lim and Chan 2015; Chen et al. 2018), mcdm (Ponnialagan et al. 2018), perceptual computer (Wu 2014), recognition (Saha et al. 2018), topsis (Mokhtarian et al. 2014)
62	type-2 fuzzy set	vikor (Wang et al. 2019a), artificial intelligence (De Miguel et al. 2022), data envelopment analysis (Namvar and Bamdad 2021), data mining (Lin et al. 2016), edge detection (Gonzalez et al. 2019b), fuzzy ahp (Erdoıan and Kaya 2016), fuzzy c-mean (Ji et al. 2014), fuzzy image processing (Castillo et al. 2017), granular computing (Al-Hmouz et al. 2018), hidden markov models (Zeng and Liu 2004), image processing (Castillo et al. 2017; Hussain and Jyotibora 2018), inference system (Huang et al. 2022), magdm (Chen and Kuo 2017), mcgdm (Liu et al. 2022b), medical diagnosis (Bustince et al. 2016c), mobile robot (Bencherif and Chouireb 2019), ontology (Lee et al. 2013), particle swarm optimization (Agarwal et al. 2014), regression model (Zou et al. 2018), risk management (Rao et al. 2017), social network (Naderipour et al. 2017), subtractive clustering (Ren et al. 2008; Ngo and Pham 2012), supplier selection (Hendiani et al. 2020), terminological difficulties (Bustince et al. 2016c; Yiyan et al. 2020)
63	typical hesitant fuzzy set	consistency (Matzenauer et al. 2022), correlation coefficient (Matzenauer et al. 2021), group decision making (Matzenauer et al. 2020)

No	Fuzzy set extensions	Keywords
64	t-spherical fuzzy set	topsis (Munir et al. 2021), correlation coefficient (Guleria and Bajaj 2021), madm (Al-Quran 2021), medical diagnosis (Guleria and Bajaj 2021), pattern recognition (Guleria and Bajaj 2021)
65	z-number	ahp (Alkan and Kahraman 2022), delphi (Lawnik and Banasik 2021), group decision making (Yang et al. 2022a), mcdm (Tavakkoli-Moghaddam et al. 2015), mobile robot (Abiyev et al. 2019), qualiflex (Wu et al. 2021), sustainability (Hoseini et al. 2020), topsis (Yaakob et al. 2018)

[a] Note that all terms in Table A1 are presented as they are extracted from WoS and processed by VOSviewer.

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