Ref.:  Ms. No. IFS-222974  
Title: Selection of Ergonomic Risk Assessment Method with Pythagorean Fuzzy Sets: Practice in Emergency Medical Services Journal of Intelligent & Fuzzy Systems

Appendix 1.

Studies using the PF-AHP and PF-WASPAS methodology

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Author(s)** | **Year** | **Method** | | **Application** | |
| Ilbahar and Kahraman [33] | 2018 | | PF-WASPAS | Retail store performance measurement |
| Ilbahar et al. [11] | 2018 | | PF-AHP | Risk assessment for occupational health and safety |
| Gul [16] | 2018 | | PF-AHP | Occupational health and safety risk assessment |
| Gul and Ak [34] | 2018 | | PF-AHP | Ratings in occupational health and safety risk assessment |
| Senol et al. [35] | 2019 | | PF-AHP | Determine the most influential logistic factors |
| Yucesan and Kahraman [36] | 2019 | | PF-AHP | Risk evaluation and prevention in hydropower plant operations |
| Ozkan et al. [37] | 2019 | | PF-AHP | Assessing blockchain risks |
| Karasan et al. [38] | 2019 | | PF-AHP | Its application to landfill site selection problem |
| Karasan et al. [39] | 2019 | | PF-AHP | Risk analysis of the autonomous vehicle driving systems |
| Bolturk and Kahraman [40] | 2019 | | PF-WASPAS | As/RS technology selection |
| Ilbahar et al. [41] | 2019 | | PF-WASPAS | Assessment of renewable energy alternatives |
| Mohagheghi and Mousavi [42] | 2019 | | PF-WASPAS | High-technology project evaluation and project portfolio selection |
| Shete et al. [12] | 2020 | | PF-AHP | Assessing the possibilities of sustainable supply chain innovation |
| Yildiz et al. [43] | 2020 | | PF-AHP | ATM site selection problem |
| Ilbahar et al. [44] | 2020 | | PF-WASPAS | Prioritization of renewable energy sources |
| Yucesan and Gul [45] | 2020 | | PF-AHP | Hospital service quality evaluation |
| Yazici et al. [46] | 2021 | | PF-APH | Maintenance Strategy Selection in the Hydroelectric Power Plants |
| Erol et al. [47] | 2021 | | PF-AHP | Selection of occupational safety specialists |
| Ayyildiz and Gumus [48] | 2021 | | PF-AHP | Hazardous material transportation |
| Ayyildiz et al. [49] | 2021 | | *PF-AHP&*  *PF-WASPAS* | Refugee camp location selection |
| *Hatiboglu et al.* | *This study* | | *PF-AHP&*  *PF-WASPAS* | *Ergonomic risk evaluation selection method for emergency medical service* |

Appendix 2

The aggregated pairwise comparison matrix for Entry Parameter parameters sub-criteria

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | C1.1 | | | | C1.2 | | | | | C1.3 | | | | |
|  | ML | MU | VL | VU | ML | MU | VL | VU | ML | | MU | VL | VU |
| C1.1 | 0.549 | 0.562 | 0.362 | 0.416 | 0.289 | 0.403 | 0.555 | 0.642 | 0.298 | | 0.452 | 0.477 | 0.629 |
| C1.2 | 0.543 | 0.654 | 0.283 | 0.410 | 0.527 | 0.549 | 0.416 | 0.466 | 0.391 | | 0.493 | 0.495 | 0.582 |
| C1.3 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | 0.000 | 0.000 |

Appendix 3

The aggregated pairwise comparison matrix for Force Applied parameters sub-criteria

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | C2.1 | | | | C2.2 | | | |
|  | ML | MU | VL | VU | ML | MU | VL | VU |
| C2.1 | 0.500 | 0.500 | 0.500 | 0.500 | 0.350 | 0.495 | 0.443 | 0.584 |
| C2.2 | 0.443 | 0.584 | 0.350 | 0.495 | 0.500 | 0.500 | 0.500 | 0.500 |

Appendix 4

The aggregated pairwise comparison matrix for Final Assessment parameters sub-criteria

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | C3.1 | | | | C3.2 | | | |
|  | ML | MU | VL | VU | ML | MU | VL | VU |
| C3.1 | 0.500 | 0.500 | 0.500 | 0.500 | 0.383 | 0.502 | 0.484 | 0.593 |
| C3.2 | 0.484 | 0.593 | 0.383 | 0.502 | 0.500 | 0.500 | 0.500 | 0.500 |

Appendix 5

The aggregated pairwise comparison matrix for Utility parameters sub-criteria

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | C4.1 | | | | C4.2 | | | | C4.3 | | | |
|  | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU |
| C4.1 | 0.500 | 0.500 | 0.500 | 0.500 | 0.332 | 0.450 | 0.532 | 0.627 | 0.477 | 0.629 | 0.298 | 0.452 |
| C4.2 | 0.532 | 0.627 | 0.332 | 0.450 | 0.500 | 0.500 | 0.500 | 0.500 | 0.561 | 0.689 | 0.277 | 0.419 |
| C4.3 | 0.298 | 0.452 | 0.477 | 0.629 | 0.277 | 0.419 | 0.561 | 0.689 | 0.500 | 0.500 | 0.500 | 0.500 |

Appendix 6

The difference matrix for the main criteria

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | C1 | | C2 | | C3 | | C4 | |
|  | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| C1 | 0.000 | 0.000 | -0.126 | 0.126 | -0.179 | 0.050 | -0.299 | -0.169 |
| C2 | 0.041 | 0.289 | 0.000 | 0.000 | -0.162 | 0.033 | -0.512 | -0.300 |
| C3 | -0.050 | 0.179 | -0.033 | 0.162 | 0.000 | 0.000 | 0.239 | 0.473 |
| C4 | -0.417 | -0.270 | 0.300 | 0.512 | -0.473 | -0.239 | 0.000 | 0.000 |

Appendix 7

The difference matrix for main criteria with respect to entry parameter

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | C1.1 | | C1.2 | | C1.3 | |
|  | Lower | Upper | Lower | Upper | Lower | Upper |
| C1.1 | 0.128423 | 0.184937 | -0.32825 | -0.14586 | -0.30715 | -0.02331 |
| C1.2 | 0.126844 | 0.347708 | 0.060903 | 0.128423 | -0.18556 | -0.00166 |
| C1.3 | 0 | 0 | 0 | 0 | 0 | 0 |

Appendix 8

The difference matrix for main criteria with respect to force applied parameter

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | C2.1 | | C2.2 | |
|  | Lower | Upper | Lower | Upper |
| C2.1 | 0 | 0 | -0.21809 | 0.048305 |
| C2.2 | -0.04831 | 0.218094 | 0 | 0 |

Appendix 9

The difference matrix for main criteria with respect to the final assessmentparameter

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | C3.1 | | C3.2 | |
|  | Lower | Upper | Lower | Upper |
| C3.1 | 0 | 0 | -0.20501 | 0.017881 |
| C3.2 | -0.01788 | 0.205008 | 0 | 0 |

Appendix 10

The difference matrix for main criteria with respect to utility parameter

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | C4.1 | | C4.2 | | C4.3 | |
|  | Lower | Upper | Lower | Upper | Lower | Upper |
| C4.1 | 0 | 0 | -0.28256 | -0.08063 | 0.023314 | 0.307153 |
| C4.2 | 0.080628 | 0.282558 | 0 | 0 | 0.138961 | 0.397714 |
| C4.3 | -0.30715 | -0.02331 | -0.39771 | -0.13896 | 0 | 0 |

Appendix 11

Interval multiplicative matrix for main criteria

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | C1 | | C2 | | C3 | | C4 | |
|  | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| C1 | 1.000 | 1.000 | 0.648 | 1.543 | 0.539 | 1.189 | 0.356 | 0.558 |
| C2 | 1.151 | 2.709 | 1.000 | 1.000 | 0.572 | 1.123 | 0.171 | 0.354 |
| C3 | 0.841 | 1.855 | 0.891 | 1.749 | 1.000 | 1.000 | 2.284 | 5.116 |
| C4 | 0.237 | 0.393 | 2.822 | 5.865 | 0.195 | 0.438 | 1.000 | 1.000 |

Appendix 12

Interval multiplicative matrix with respect to enter parameter

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | C1.1 | | C1.2 | | C1.3 | |
|  | Lower | Upper | Lower | Upper | Lower | Upper |
| C1.1 | 1.558238 | 1.894112 | 0.321831 | 0.604249 | 0.346155 | 0.922634 |
| C1.2 | 1.549765 | 3.323247 | 1.23411 | 1.558238 | 0.526815 | 0.99428 |
| C1.3 | 1 | 1 | 1 | 1 | 1 | 1 |

Appendix 13

Interval multiplicative matrix with respect to force applied parameter

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | C2.1 | | C2.2 | |
|  | Lower | Upper | Lower | Upper |
| C2.1 | 1 | 1 | 0.470824 | 1.181565 |
| C2.2 | 0.846335 | 2.123934 | 1 | 1 |

Appendix 14

Interval multiplicative matrix with respect to final assessment parameter

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | C3.1 | | C3.2 | |
|  | Lower | Upper | Lower | Upper |
| C3.1 | 1 | 1 | 0.492593 | 1.063705 |
| C3.2 | 0.94011 | 2.030075 | 1 | 1 |

Appendix 15

Interval multiplicative matrix with respect to utility parameter

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | C4.1 | | C4.2 | | C4.3 | |
|  | Lower | Upper | Lower | Upper | Lower | Upper |
| C4.1 | 1 | 1 | 0.376845 | 0.756934 | 1.083853 | 2.888875 |
| C4.2 | 1.321118 | 2.653613 | 1 | 1 | 1.615999 | 3.949769 |
| C4.3 | 0.346155 | 0.922634 | 0.253179 | 0.618812 | 1 | 1 |

Appendix 16

The determinacy value matrix (*τ*) for the main criteria

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | C1 | C2 | C3 | C4 |
| C1 | 1.00 | 0.75 | 0.77 | 0.87 |
| C2 | 0.75 | 1.00 | 0.80 | 0.79 |
| C3 | 0.77 | 0.80 | 1.00 | 0.77 |
| C4 | 0.85 | 0.79 | 0.77 | 1.00 |

Appendix 17

The determinacy value matrix (*τ*) with respect to entry parameter

|  |  |  |  |
| --- | --- | --- | --- |
|  | C1.1 | C1.2 | C1.3 |
| C1.1 | 0.943486 | 0.817608 | 0.716161 |
| C1.2 | 0.779135 | 0.93248 | 0.8161 |
| C1.3 | 1 | 1 | 1 |

Appendix 18

The determinacy value matrix (*τ*) with respect to force applied parameter

|  |  |  |
| --- | --- | --- |
|  | C2.1 | C2.2 |
| C2.1 | 1 | 0.733601 |
| C2.2 | 0.733601 | 1 |

Appendix 19

The determinacy value matrix (*τ*) with respect to final assessment parameter

|  |  |  |
| --- | --- | --- |
|  | C3.1 | C3.2 |
| C3.1 | 1 | 0.777111 |
| C3.2 | 0.777111 | 1 |

Appendix 20

The determinacy value matrix (*τ*) with respect to utility parameter

|  |  |  |  |
| --- | --- | --- | --- |
|  | C4.1 | C4.2 | C4.3 |
| C4.1 | 1 | 0.798069 | 0.716161 |
| C4.2 | 0.798069 | 1 | 0.741246 |
| C4.3 | 0.716161 | 0.741246 | 1 |

Appendix 21

Matrix of weights before normalization (t)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | C1 | C2 | C3 | C4 |
| C1 | 1.000 | 0.820 | 0.666 | 0.397 |
| C2 | 1.452 | 1.000 | 0.682 | 0.207 |
| C3 | 1.039 | 1.062 | 1.000 | 2.836 |
| C4 | 0.269 | 3.424 | 0.243 | 1.000 |

Appendix 22

Matrix of unnormalized weights with respect to entry parameter

|  |  |  |  |
| --- | --- | --- | --- |
|  | C1.1 | C1.2 | C1.3 |
| C1.1 | 1.628621 | 0.378585 | 0.454329 |
| C1.2 | 1.898368 | 1.301904 | 0.620683 |
| C1.3 | 1 | 1 | 1 |

Appendix 23

Matrix of unnormalized weights with respect to force applied parameter

|  |  |  |
| --- | --- | --- |
|  | C2.1 | C2.2 |
| C2.1 | 1 | 0.606097 |
| C2.2 | 1.089496 | 1 |

Appendix 24

Matrix of unnormalized weights with respect to final assessmentparameter

|  |  |  |
| --- | --- | --- |
|  | C3.1 | C3.2 |
| C3.1 | 1 | 0.604708 |
| C3.2 | 1.154082 | 1 |

Appendix 25

Matrix of unnormalized weights with respect to utility parameter

|  |  |  |  |
| --- | --- | --- | --- |
|  | C4.1 | C4.2 | C4.3 |
| C4.1 | 1 | 0.452417 | 1.422557 |
| C4.2 | 1.586056 | 1 | 2.062803 |
| C4.3 | 0.454329 | 0.32318 | 1 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| G1 | | | | | G2 | | | | G3 | | | | U1 | | | | U2 | | | |
|  | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU |
| REBA | 0.144 | 0.197 | 0.925 | 0.954 | 0.179 | 0.244 | 0.886 | 0.930 | 0.152 | 0.206 | 0.916 | 0.947 | 0.127 | 0.174 | 0.917 | 0.945 | 0.160 | 0.218 | 0.883 | 0.921 |
| RULA | 0.111 | 0.151 | 0.951 | 0.967 | 0.112 | 0.157 | 0.941 | 0.961 | 0.126 | 0.171 | 0.937 | 0.958 | 0.102 | 0.144 | 0.935 | 0.957 | 0.154 | 0.210 | 0.889 | 0.925 |
| OWAS | 0.111 | 0.151 | 0.951 | 0.967 | 0.138 | 0.188 | 0.925 | 0.950 | 0.099 | 0.137 | 0.954 | 0.969 | 0.122 | 0.168 | 0.921 | 0.947 | 0.108 | 0.156 | 0.924 | 0.949 |
|  | N1 | | | | N2 | | | | K1 | | | | K2 | | | | K3 | | | |
|  | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU |
| REBA | 0.225 | 0.303 | 0.811 | 0.875 | 0.248 | 0.333 | 0.767 | 0.843 | 0.202 | 0.275 | 0.856 | 0.911 | 0.214 | 0.289 | 0.825 | 0.883 | 0.139 | 0.188 | 0.925 | 0.951 |
| RULA | 0.202 | 0.273 | 0.838 | 0.891 | 0.230 | 0.310 | 0.789 | 0.856 | 0.169 | 0.228 | 0.894 | 0.930 | 0.207 | 0.279 | 0.834 | 0.889 | 0.124 | 0.168 | 0.936 | 0.958 |
| OWAS | 0.179 | 0.245 | 0.860 | 0.905 | 0.181 | 0.251 | 0.840 | 0.891 | 0.127 | 0.177 | 0.925 | 0.950 | 0.222 | 0.300 | 0.815 | 0.878 | 0.101 | 0.140 | 0.951 | 0.967 |

Appendix 26 The weighted sum model matrix.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | ML | MU | VL | VU |  |
| REBA |  | 0.580 | 0.785 | 0.247 | 0.412 | 0.690 |
| RULA |  | 0.505 | 0.686 | 0.322 | 0.476 | 0.613 |
| OWAS |  | 0.457 | 0.627 | 0.370 | 0.521 | 0.566 |

Appendix 27

The weighted product model matrix

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| G1 | | | | | G2 | | | | G3 | | | | U1 | | | | U2 | | | |
|  | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU |
| REBA | 0.978 | 0.988 | 0.037 | 0.076 | 0.966 | 0.982 | 0.047 | 0.095 | 0.972 | 0.984 | 0.047 | 0.089 | 0.928 | 0.951 | 0.109 | 0.159 | 0.917 | 0.945 | 0.110 | 0.167 |
| RULA | 0.969 | 0.980 | 0.070 | 0.107 | 0.940 | 0.959 | 0.115 | 0.161 | 0.963 | 0.977 | 0.073 | 0.113 | 0.913 | 0.938 | 0.139 | 0.190 | 0.914 | 0.941 | 0.117 | 0.174 |
| OWAS | 0.969 | 0.980 | 0.070 | 0.107 | 0.952 | 0.969 | 0.088 | 0.133 | 0.952 | 0.967 | 0.102 | 0.143 | 0.925 | 0.948 | 0.115 | 0.165 | 0.881 | 0.915 | 0.172 | 0.231 |
|  | N1 | | | | N2 | | | | K1 | | | | K2 | | | | K3 | | | |
|  | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU | ML | MU | VL | VU |
| REBA | 0.914 | 0.947 | 0.095 | 0.162 | 0.879 | 0.923 | 0.119 | 0.196 | 0.957 | 0.976 | 0.053 | 0.108 | 0.912 | 0.945 | 0.102 | 0.168 | 0.967 | 0.980 | 0.058 | 0.099 |
| RULA | 0.901 | 0.935 | 0.120 | 0.186 | 0.867 | 0.913 | 0.138 | 0.214 | 0.944 | 0.965 | 0.087 | 0.138 | 0.908 | 0.941 | 0.110 | 0.175 | 0.962 | 0.975 | 0.073 | 0.114 |
| OWAS | 0.887 | 0.923 | 0.144 | 0.209 | 0.830 | 0.881 | 0.193 | 0.269 | 0.923 | 0.948 | 0.130 | 0.182 | 0.916 | 0.948 | 0.093 | 0.160 | 0.952 | 0.968 | 0.098 | 0.138 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | ML | MU | VL | VU |  |
| REBA | 0.530 | 0.676 | 0.264 | 0.437 | 0.625 |
| RULA | 0.471 | 0.613 | 0.339 | 0.510 | 0.568 |
| OWAS | 0.425 | 0.563 | 0.399 | 0.569 | 0.525 |