COMPUTATIONAL RESEARCH PROGRESS IN APPLIED SCIENCE & ENGINEERING (CRPASE)

CRPASE: TRANSACTIONS OF MECHANICAL ENGINEERING

Journal homepage: http://www.crpase.com

CRPASE: Transactions of Mechanical Engineering 7 (1) Article ID: 2323, 1–6, March 2021 ISSN 2423-4591

Research Article

Statistic and Probabilistic Variations and Trends of Rainfall Data of TRNC

Mir Mohammad Ali Malakoutian[1*], Pooria Mostafapoor[2], Yas Malakoutian[3]

[1] *Department of Architecture and the Built Environment, University of the West of England, KN4112, Bristol, BS16 1QY, United Kingdom*
[2] *Information Systems an Operations Management, Department of Business School, The University of Texas at Arlington, Arlington, USA*
[3] *Faculty of Urban Engineering, Department of Art and Architecture, University of Guilan, Rasht, Iran*

Keywords

Rainfall,
TRNC,
T-test,
F-test,
Wet or dry spells.

Abstract

The characteristic summer aridity of the region has significant implications in several socio-economic sectors. Cyprus is facing its worst ever water shortage in the last few decades. Climate models are widely used to project present and future changes of climate variables. Although the ability of models has improved, systematic biases can be found in model simulations. Therefore, it is recommended the accuracy of model simulations of past or contemporary climate to be evaluated by comparing the results with observations. Therefore, with the monthly rainfall data of TRNC six meteorological regions for the hydrologic years from September 1975 to August 2014 period, the homogeneity tests were as well carried out. The results show that P-value=0.38>0.05. Therefore, the Central Mesaria time series is normally distributed. In addition, it can be understood the number of wet spells is 18 (means 47%), number of Dry spells is 21 (means 53%). Therefore, the Central Mesaria is in dry spell during the studied period.

1. Introduction

The Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC-AR4) indicates significant summer warming in south-eastern Europe and the Mediterranean, while downward trends are associated with the mean annual rainfall [1,2]. The combined effect of high temperatures and low rainfall poses challenges to many economic sectors as well as significant threat on desertification [3,4]. For instance, the IPCC-AR4 highlights that, water stress will increase in southern Europe, and hence agriculture will have to cope with increasing water demand for irrigation. In addition, the observed climate changes are likely to enhance the frequency and intensity of extreme events' occurrence, such as heatwaves and droughts [5] which may critically affect the society and economy of small island countries, like Cyprus. There is therefore a need for more accurate climate model predictions that will provide meteorological information on national level and enable relevant climate change impact studies to assist adaptation strategies.

Weather forecasting plays an important role in our daily life. Especially in engineering, it shows itself more significantly. Among meteorological data, mainly the rainfall variations are the subject that the researchers are interested a lot [6,7]. Although rainfall has a high positive effect on ecological sustainability of the living organisms, but can cause disasters like flooding or drying up of the existing reservoirs due to global warming. Hence, estimating the daily, monthly, seasonally and even the yearly amount of rainfall values for different locations may guide the researchers to some extent, for their future strategies [8,9].

Data is an information (observation or experimental result or numerical figure or evidence) that is gathered for examining (or using during the decision making process) from which conclusions can be obtained. The topic of statistics involves the study of how to gather, sum up, and interpret any existing data since such conclusions are essential for the decision making processes Bowerman and Oconnell, 1997. Any properly classified collection of objects about which a statistical investigation is being created is a

* Corresponding Author: Mir Mohammad Ali Malakoutian
E-mail address: m.malakoutian8@gmail.com

Received: 17 January 2021; Revised: 18 March 2021; Accepted: 21 March 2021

Please cite this article as: M. M. A. Malakoutian, P. Mostafapoor, Y. Malakoutian, Statistic and Probabilistic Variations and Trends of Rainfall Data of TRNC, Computational Research Progress in Applied Science & Engineering, CRPASE: Transactions of Mechanical Engineering 7 (2021) 1–6, Article ID: 2323.

population. So the number of individuals in any population is the size of that population which can be finite or infinite. A finite set of items taken from the population with a specific plan is called a sample. The total number of individuals in a sample is called the sample size. Generally, if the data are less than or equal to 30, in statistics is referred as sample.

From the available literature, it was observed that, not too many studies have been carried out on the rainfall distribution patterns of North Cyprus. Ismail and Goymen (1985) discussed the general outlook of rainfall in North Cyprus whereas Kypris 1995, only studied the rainfall data of South Cyprus, and attempted to find monthly base diachronic changes. Biyikoglu 1995, analyse the rainfall data of TRNC to some extent. Altunc 1995 and 1997, published two conference papers for the water problems of TRNC based on the basic meteorological parameters. Tayanc 1997, studied the opportunity of making cloud seeding over Cyprus. Altan and Sen 2000, studied the rainfall analysis of TRNC where Pashiardis 2003, studied the records of rainfall of South Cyprus to some extent, for agricultural planning needs [10]. Kimyaci 2004, examined the extreme rainfall data and established the intensity–duration and frequency curves for North Cyprus [11]. Sharifi 2006, studied in detail, the basic hydro-climatological variations and trends of N. Cyprus but his studied time period was pretty short [12].

The engineering problems in general and the hydrologic cycle especially contain quantity of events such as rainfall, runoff, infiltration, evaporation, etc. that can be explained through above mentioned approach where the time component as well interferes. Usually, the number of available data in engineering are small in size, so the sample statistics are used during analyses.

2. Methodology

2.1. Study Area

After the peace operation in 1974, TRNC was established in 1983, as a separate unilateral state on the northern one third of the island, where the remaining part is under the control of so called Cyprus Government. Its capital is Nicosia (Lefkoşa) being the unique divided capital in the world. The population of the whole island based on recent census in 2000 was 748000 of which 68 percent is Greek, 27 percent is Turkish and the remaining 5 percent belongs to various minorities [11].

Island of Cyprus intense Mediterranean climate with a typical seasonal rhythm strongly marked with respect to temperature, rainfall and weather in general. Winters, rather changeable are mild, with some rain and snow on Troodos Mountain, are from November to mid-March and separated by short autumn and spring seasons of rapid change in weather conditions. In summer, the extension of the summer Asian Thermal Low is evident throughout the eastern Mediterranean in all seasonal circulation patterns [13,14], associated with high temperatures and abundant sunshine with hot dry summers from mid-May to mid-September. Hence, in summer, the island is mainly under the influence of a shallow through of low pressure extending from the great continental depression cantered over southwest Asia. It is a season of high temperatures with almost cloudless sky. Rainfall is almost negligible but isolated thunderstorms sometimes occur which give rainfall amounting to less than 5% of the total in the average year. In winter, Cyprus is near the track of fairly small depression that cross the Mediterranean Sea from west to east between the continental anticyclone of Eurasia and the generally low-pressure belt of North Africa. These depressions give periods of disturbed weather usually lasting from one to three days and produce most of the annual rainfall.

The wet season extends from November to March, with most of the rain falling between December and February (approximately 60% of the annual total). Rainfall is generally associated with the movement of moist maritime flows to the North, occurring particularly over areas of high elevation [13,14]. Winter rainfall is closely related to cyclo-genesis in the region [15]. Nevertheless, it is not uncommon for isolated summer thunderstorms to occur, which however contribute to less than 5% to the total annual rainfall amount.

In this study, amending 10 more recent years monthly based regional rainfall data of North Cyprus to the previously studied rainfall data by Sharifi 2006, is re-examined so as to establish the most appropriate statistically acceptable probability function(s) and model(s) through which the near future occurrences could be forecasted [12]. Since the exact hydrologic model for any data is never known, among the popular models existing in literature, some of them were selected for this study.

Island of Cyprus is meteorologically grouped into 14 main geographical regions as shown in Figure 1, but due to political reasons, no official communication based on exchanging, sharing or using the gathered relevant data of any documents is possible hence, for this small island, the southern part excludes the northern part in any study including hydro-meteorological studies so as the northern part.

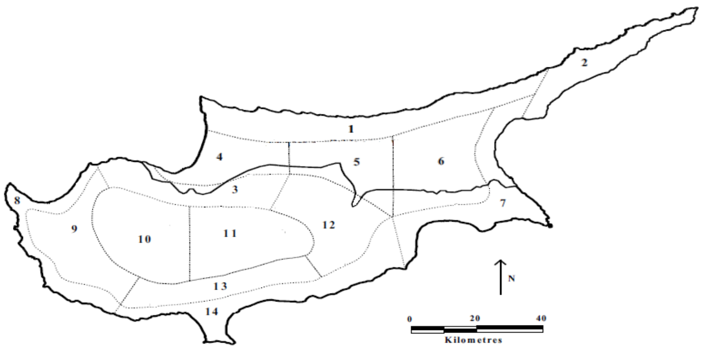

Figure 1. Geographical regions map of Cyprus based on meteorological aspect (obtained from Meteorology Office, TRNC).

3. Result and Discussion

2.2. Statistical analysis methods

2.2.1. Homogeneity Test

Homogeneity and its opposite, heterogeneity, relate the statistical properties of any one part of an overall data are the same as any other part. Homogeneity can be studied to several degrees of complexity among them homoscedasticity examines how much the variability of data-values changes throughout a data [16]. It is used to determine whether frequency counts are distributed identically across different data subset groups. A test of homogeneity compares the proportions of responses from two or more populations. In other word homogeneity tests determine if within the time series data there is a specific time period at which a change within the data occurs. Knowing that, the climate change studies based on long climate records where the homogeneity testing is inevitable. One type of non-homogeneity in long meteorological time series is the sudden shifts of the mean level compared with surrounding sites. Such unrepresentative shifts are often related to relocations of the station but also may be caused by changes in observing schedules and practices, changes in instrument exposure or abrupt changes in the immediate environment. Changes in the surroundings also may be more gradual in the case of an urban influence, which affects mainly temperature data thus needs homogeneity testing[17,18]

2.2.2. ANOVA

In order to check the homogeneity, correlation and comparison of any two sets of, a common method called Analysis of Variances ‘ANOVA’ is used. Student’s t-test and Fisher’s F-test are mostly used distributions for this purpose. The formulations of these tests are given as below; beside the formulation, the determined answers from the equations should be checked by appropriate tables of t-test and F-test given in appendix, based on the degrees of freedom and the interested confidence intervals. If the obtained value is less than the calculated critical value, the test proves the homogeneity and the test is hence assumed to be acceptable. In fact *t*-test is comparing the means and F-test is comparing the standard deviations of the datas .[19,20]

2.2.3. T-test

The means of the two sets $\bar{x}$ and $\bar{y}$ were found. The standard deviations of the two sets s_x and s_y were determined. Then the formula [21]

$$t = \frac{(\bar{x}-\bar{y})}{\sqrt{\frac{s_x^2}{n}+\frac{s_y^2}{m}}} \qquad (1)$$

Is Calculated. Where $\bar{x}$ & $\bar{y}$ are the means of the datas, sx & sy are the standard deviations of the datas and n & m are the number of data available for each data.

Fixing the degree of freedom and confidence interval and referring to table of t-distribution, allowable (critical) value of *t* is found. Compare the t value with critical $_t$, if the calculated value is smaller, test is acceptable and correlation exists otherwise the two sets of data are not correlated [22, 23]

2.2.4. F-test

This test is based on comparing the standard deviations. The procedure is to determine the standard deviations of two set sx and sy. Obtain the deviation of smaller value over the larger value. As the F-test formula implies [24-28]

$$F = \frac{s_x^2}{s_y^2} \qquad (2)$$

Like t-test, considering the confidence level and degree of freedom, the allowable F value would be read from the appropriate table. The obtained F value and the allowable F value were compared and if the calculated F is smaller than allowable F, a correlation between two sets exists. Otherwise there is no correlation between two sets. The important note in F-test is that, the smaller value of the standard deviation should also be at the numerator and the larger value should be at denominator [29-34]

3. Result and Discussion

The minimum number of required data for any statistical study depends on the range of the available data, its average, and the expected degree of acceptable level of deviation. For this statistical study, to determine the minimum number of required data nmin, an empirical method that bases on two simple tests was performed and the minimum value nmin, which satisfies these tests, is supposed to be the answer of the above mentioned problem. Figure 2 shows the required number of sample size for Central Mesaria regions’ rainfall data, based on the percentage deviations of the mean values. The tests are a kind of altering average tests. The test starts from number of two data (the value of n=1 and n+1=2) and compares the mean deviation of the averages and standard deviations of these n and n+1 values with the subsequently verified mean and standard deviation value that was computed founded on one less than number of data, i.e. If the variation of the average is less than 2 and standard deviation is less than 5 percent, the minimum required number of the data, based on average and standard deviation is then obtained.

As it can be seen through the graph of Figure 2, minimum number of data for Central Mesaria region is 28 years, because after that, the fluctuation would be less than ±2 percent. Figure 3 shows the required number of sample size for Central Mesaria regions’ rainfall data, based on the percentage variation of the standard deviations. As it can be noticed, the minimum number of data based on standard deviation for Central Mesaria is chosen to be 34 years, considering the fluctuations less than ±5 percent. Consequently, the required minimum number of data is 34 years based on comparisons of means and standard deviations according to Table 1.

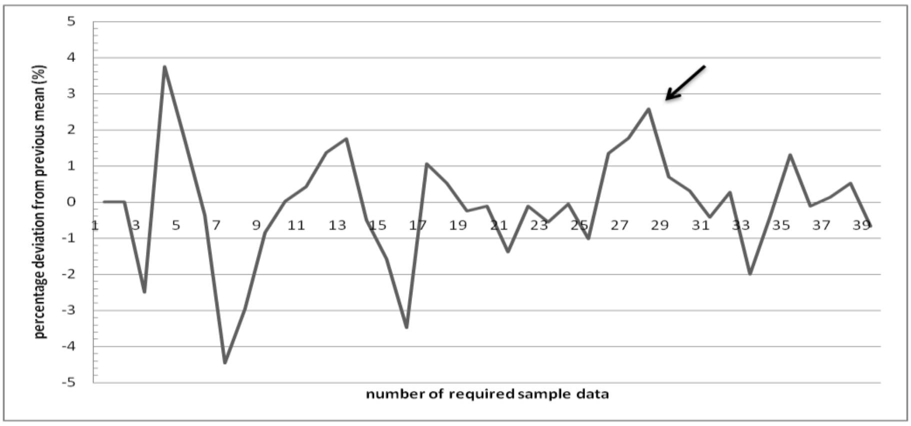

Figure 2. Curve showing the required number of sample size for Central Mesaria regions' rainfall data, based on the percentage deviations of the mean values

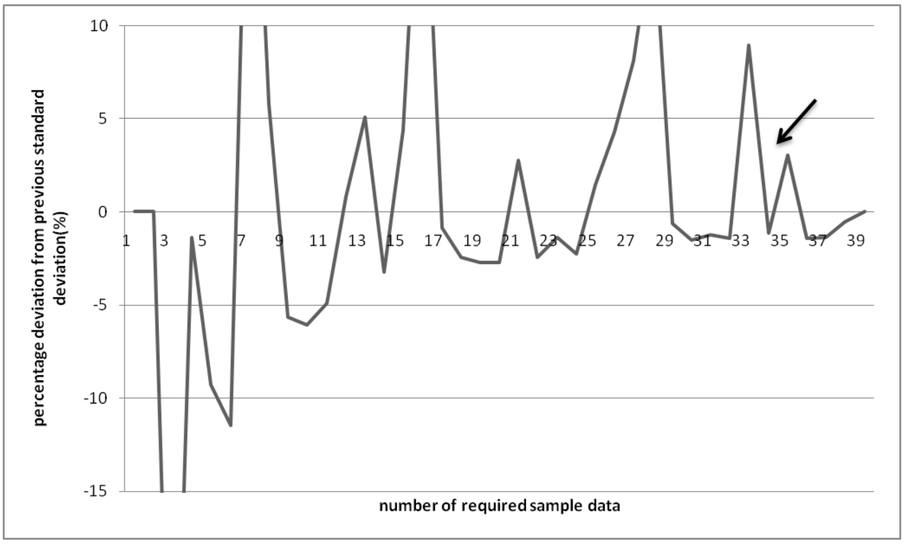

Figure 3. Curve showing the required number of sample size for Central Mesaria regions' rainfall data, based on the percentage variation of the standard deviations

Table 1. Appropriateness of the data sample size of Central Mesaria for statistic and probabilistic studies

Based on Mean (not more than 2% deviation)	Based on Standard Deviation (not more than 5% deviation)
28 < 39 OK	34 < 39 OK

Figure 4. Normality test of Central Mesaria rainfall

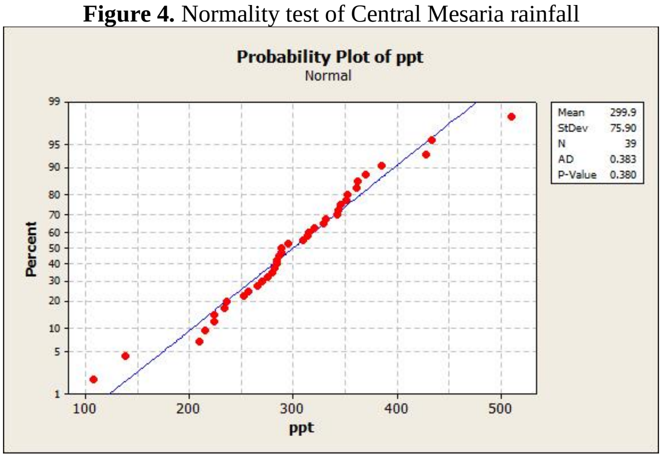

Figure 4 shows the Normality test by Minitab software. According to this figure, P-value=0.38>0.05. Therefore, the Central Mesaria time series is normally distributed. In addition, Table 2 to 4 show the t-test result of various region of studies. As it can be seen in these tables, the calculated t is less than allowable t therefore the correlation exists between Central Mesaria and East Coast. But for the data below correlation doesn't exist between Central Mesaria and North Coast.

Knowing the wet and dry years is important. The wetness or dryness can be checked by several methods such as severity index, drought index. In this paper, an empirical method used which compare the mean RAINFALL DATA of any regions with each RAINFALL DATA of any years, and if it is larger than mean, it implies wetness of that year and if it less than mean it is named dry year. Below the results of study performed on rainfall data of Central Mesaria from year 1975 to 2013 is given. According to the result of this table, it can be understood the number of wet spells is 18 (means 47%), number of Dry spells is 21 (means 53%). Therefore, the Central Mesaria is in dry spell during the studied period.

Table 2. t-test between Central Mesaria and East Coast regions' and its result

n, m	39
Central Mesaria Mean	299.9
East Coast Mean	334.7
Central Mesaria Sd	75.9
East Coast Sd	92.8
degree of freedom	37
level of confidence	95%
Allowable t	1.69
t=-1.5608	Acceptable

Table 3. t-test between Central Mesaria and North Sea regions' and its result

n, m	39
Central Mesaria Mean	299.9
North Coast Mean	461.9
Central Mesaria Sd	75.9
North Coast Sd	100.62
degree of freedom	37
level of confidence	95%
Allowable t	1.69
t =-6.2458	Unacceptable

Table 4. F-test between Central Mesaria and East Coast regions' and its result

n	39
Central Mesaria Sd	75.9
East Coast Sd	92.8
degree of freedom	38
level of confidence	95%
Allowable F	1.72
F=0.6684	Acceptable

Table 5. Numerical representation of wet and dry spells of West Mesaria region based on the mean of the data

Hydrologic Year	Rainfall (mm)	Wet\ Dry	0: Dry 1: Wet	Hydrologic Year	Rainfall (mm)	Wet\ Dry	0: Dry 1: Wet
1975-1976	351.8	wet	1	1993-1994	279.8	Dry	0
1976-1977	270.3	Dry	0	1994-1995	286.5	Dry	0
1977-1978	288.4	Dry	0	1995-1996	209.6	Dry	0
1978-1979	350.9	wet	1	1996-1997	281.5	Dry	0
1975-1976	351.8	wet	1	1997-1998	252.2	Dry	0
1976-1977	270.3	Dry	0	1998-1999	283.9	Dry	0
1977-1978	288.4	Dry	0	1999-2000	214.9	Dry	0
1978-1979	350.9	wet	1	2000-2001	385	wet	1
1979-1980	343.3	wet	1	2001-2002	427.7	wet	1
1980-1981	314.1	wet	1	2002-2003	510.3	wet	1
1981-1982	224.3	Dry	0	2003-2004	361.7	wet	1
1982-1983	235.6	Dry	0	2004-2005	331.3	wet	1
1983-1984	275.2	Dry	0	2005-2006	265.2	Dry	0
1984-1985	295.3	Dry	0	2006-2007	329	wet	1
1985-1986	309.1	wet	1	2007-2008	107.5	Dry	0
1986-1987	345.4	wet	1	2008-2009	257	Dry	0
1987-1988	369.7	wet	1	2009-2010	433.8	wet	1
1988-1989	284.5	Dry	0	2010-2011	288.9	Dry	0
1989-1990	233.9	Dry	0	2011-2012	314.6	wet	1
1990-1991	138.1	Dry	0	2012-2013	360.5	wet	1
1991-1992	342.6	wet	1	2013-2014	224.3	Dry	0
1992-1993	319.9	wet	1	The Mean is 299.9 mm			

10. Conclusions

Among the four probability distribution models, Normal, Log-Normal, Gumbel, and Gamma, the best representative for each meteorological region was determined through the best fitting curve approach. Except East Coast and West Mesaria which are Log-Normal, the other meteorological regions and TRNC obey the Normal distribution model. Rainfall of the 6 meteorological regions of North Cyprus and TRNC as a whole were analyzed and 10 years forecasting data were as well predicted. For this purpose, to determine the best time series model for each regions and for TRNC, the standardized MSE, MAPE, RMSE, and MAD were used. To be able to realize how the meteorological data is varying for a long run, wet and dry spells of yearly rainfall data as well studied. Interestingly all the data in all the meteorological regions suggests dry regions.

References

[1] J. N. Jerin, , A. R. M. T. Islam, , M. A. Al Mamun, M. N. Mozahid, S. M. Ibrahim, Climate change effects on potential evapotranspiration in Bangladesh, Arabian Journal of Geosciences 14 (2021) 1–15.

[2] C. Lemke, B. Gabrys, Meta-learning for time series forecasting and forecast combination, Neurocomputing 73 (2010) 2006–2016.

[3] P. Ginoux, J. M. Prospero, O. Torres, M. Chin, Long-term simulation of global dust distribution with the GOCART model: correlation with North Atlantic Oscillation. Environmental Modelling & Software 19 (2004) 113–128.
[4] X. Gao, F. Giorgi, Increased aridity in the Mediterranean region under greenhouse gas forcing estimated from high resolution simulations with a regional climate model. Global and Planetary Change 62 (2008) 195–209.
[5] G. A. Meehl, T. F. Stocker, W. D. Collins, P. Friedlingstein, A. T. Gaye, J. M. Gregory, Z. C. Zhao, Global climate projections, Chapter 10 (2007).
[6] M. L. Neshaei, V. N. M. Gilani, Investigation of Cross Shore Sediment Transport Using Physical and Numerical Methods. Journal of Applied Science 8 (2013) 795–805.
[7] Y. Sotoudeh, S. Samsami, , A. M. Alipoor, E. Amoei, V. N. Moghaddam, Reduction the risk of cavitation phenomenon in dam spillway with controlling the cavitation index, Advances in Environmental Biology (2013) 2293–2298.
[8] M. B. Movahhed, J. Ayoubinejad, F. N. Asl, , M. Feizbahr, The Effect of Rain on Pedestrians Crossing Speed, Computational Research Progress in Applied Science & Engineering (CRPASE) 6 (2020) 186–190.
[9] I. Bargegol, V. N. M. Gilani, The effect of rainy weather on walking speed of pedestrians on sidewalks, Buletin Teknol. Tanaman 12 (2015) 217–222.
[10] D. C. Kypris, Diachronic changes of rainfall and the water resources in Cyprus, In Water resources management under drought or water shortage conditions (1995) 11–18.
[11] S. Kimyacı, M Sc Thesis: Rainfall data, establishment of intensity duration –frequency curves for Cyprus, Eastern Mediterranean University, 2004.
[12] Y. Sharifi, Hydro-Climatological Variations and Trend in TRNC. M.Sc. Thesis EMU (2006).
[13] E. Kostopoulou, P. D. Jones, , Comprehensive analysis of the climate variability in the eastern Mediterranean, Part I: Map pattern classification, Int. J. Climatol. 27 (2007a) 1189– 1214.
[14] E. Kostopoulou, P. D. Jones, Comprehensive analysis of the climate variability in the eastern Mediterranean, part II: relationships between atmospheric circulation patterns and surface climatic elements, Int. J. Climatol. 27 (2007b) 1351–1371.
[15] J. G. Pinto, T. Spangehl, U. Ulbrich, P. Speth, Assessment of winter cyclone activity in a transient ECHAM4-OPYC3 GHG experiment, Meteorol. Z., 15 (2006) 279–291.
[16] V. N. M. Gilani, M. Ghasedi, M. Ghorbanzadeh, M. J. Samet, Estimation delay variation and probability of occurrence of different level of services based on random variations of vehicles entering signalized intersections. IOP Publishing, In IOP Conference Series: Materials Science and Engineering 245 (2017) 042023.
[17] S. Ashraf, Z. Aslam, S. Saleem, S. Afnan, M. Aamer, Multibiometric Sustainable approach for human Appellative, CRPASE Trans. Electr. Electron. Comput. Eng. 6 (2020) 146–152.
[18] S. M. Hosseinian, V. N. M. Gilani, Analysis of factors affecting urban road accidents in rasht metropolis. ENG Transactions 1 (2020) 1–4.
[19] P. Mobtahej, Psychology of Change Management in Development Process within Software Industry. Computational Research Progress in Applied Science & Engineering 6 (2020) 294–300.
[20] H. Behbahani, V. N. M. Gilani, M. J. Samet, R. Salehfard, Analysis of Crossing Speed of the Pedestrians in Marked and Unmarked Crosswalks in the Signalized and Un-Signalized Intersections (Case Study: Rasht city). In IOP Conference Series: Materials Science and Engineering 245 (2017) 042014 IOP Publishing.
[21] A. G. Mahani, P. Bazoobandi, S. M. Hosseinian, H. Ziari, Experimental investigation and multi-objective optimization of fracture properties of asphalt mixtures containing nano-calcium carbonate. Construction and Building Materials 285 (2021) 122876.
[22] H. Ziari, H. Divandari, S.M. Seyed Ali Akbar, S. M. Hosseinian, Investigation of the Effect of Crumb Rubber Powder and Warm Additives on Moisture Resistance of SMA Mixtures, Advances in Civil Engineering (2021).
[23] I. Bargegol, V. N. M. Gilani, Estimating delay of vehicles in nearside legs of the signalized intersections under expectation method in under-saturation conditions for isolated intersection. Trends Journal of Sciences Research 2 (2015) 121–125.
[24] A. Rahman, A. Khan, A. A. Raza, Parkinson's Disease Detection Based on Signal Processing Algorithms and Machine Learning. CRPASE: Transactions of Electrical, Electronic and Computer Engineering6 (2020) 141–145.
[25] P. Mobtahej, Evaluation of Innovation Maturity Model (IMM) Framework on Assessment of Software Development Projects. Computational Research Progress in Applied Science & Engineering 6 (2020) 251–258.
[26] M. Mirmozaffari, R. Yazdani, E. Shadkam, L. Tavassoli, S., & Massah, R. VCS and CVS: New Combined Parametric and Non-parametric Operation Research Models. Sustainable Operations and Computers (2021).
[27] M. Mirmozaffari, E. Shadkam, S. M. Khalili, K. Kabirifar, R. Yazdani, T. A. Gashteroodkhani, A novel artificial intelligent approach: comparison of machine learning tools and algorithms based on optimization DEA Malmquist productivity index for eco-efficiency evaluation. International Journal of Energy Sector Management (2021).
[28] M. Mirmozaffari, N. A.Golilarz, S. S. Band, Machine Learning Algorithms Based on an Optimization Model Preprints (2020) 2020090729.
[29] N. A. Golilarz, M. Mirmozaffari, T. A. Gashteroodkhani, L. Ali, H. A. Dolatsara, A. Boskabadi, M. Yazdi, Optimized wavelet-based satellite image de-noising with multi-population differential evolution-assisted harris hawks optimization algorithm. IEEE Access 8 (2020) 133076–133085.
[30] M. Yazdani, K. Kabirifar, B. E. Frimpong, M. Shariati, M. Mirmozaffari, A. Boskabadi, Improving construction and demolition waste collection service in an urban area using a simheuristic approach: A case study in Sydney, Australia. Journal of Cleaner Production 280 (2021) 124138.
[31] M. Mirmozaffari, M. Yazdani, A. Boskabadi, H. A. Dolatsara, K. Kabirifar, N. A. Golilarz, A novel machine learning approach combined with optimization models for eco-efficiency evaluation. Applied Sciences 10 (2020) 5210.
[32] M. M. A. Malakoutian, M. Khaksar, SBM model based productivity evaluation, ENG Transactions 1 (2020) 1–9.
[33] M. Mirmozaffari, A. Alinezhad, Ranking of Heart Hospitals Using cross-efficiency and two-stage DEA, IEEE, In 2017 7th International Conference on Computer and Knowledge Engineering (ICCKE) (2017) 217–222
[34] M. Mirmozaffari, M. Zandieh, S. M. Hejazi, A Cloud Theory-based Simulated Annealing for Discovering Process Model from Event Logs, Dignified Researchers Publication, In 10th International Conference on Innovations in Science, Engineering, Computers and Technology (ISECT-2017) (2017) 70–75.