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The Risk of Earthquakes in Romania – A Statistical Point of View

Abstract. *From a seismic point of view, Romania is dominated by the events in the Vrancea area. There was only one major earthquake that occurred in the last 300 years with its epicentre outside this area. A seismic risk assessment involves the estimation of the probability of damage and losses resulting from potential future earthquakes. This damage and loss might occur to buildings, infrastructure, people, or even the environment. Our study starts with the inventorying and statistical processing of information regarding seismic events grouped by intensity classes. The connection between the depth of the focal point and the intensity of earthquakes, the frequency of destructive earthquakes, as well as the statistical distribution of significant earthquakes, are subject to analysis. The statistical models of behaviour on different intensity classes of the magnitude are being tested. Calculations are made regarding the statistical characteristics of strong earthquakes in the Vrancea seismogenic area in the Carpathian Mountains - Romania, as well as the distribution of significant earthquakes over 50-year timespans. We've found a strong correlation between the depth of the epicentre and the intensity of the earthquake. For the destructive earthquakes, simulations were carried, using the proper function. At intervals of 50 years each, the chances of recording less than three events are moderate, between one and ten are higher, and more than ten are low.*

Keywords: *seismic risk, statistical model, modelling, validation, statistical prediction, statistical distributions.*

JEL Classification: C46, C53, C15.

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1. Introduction

From a geological point of view, Europe confirms high seismic risk areas such as Italy, Turkey, Iceland, Serbia, Bulgaria, Greece, and Romania. The seismic intensity zones are marked by a colour code. In Romania, the Eastern Region of the country (Figure 1: Note: Red dots – epicentres of superficial (crustal) earthquakes, Black dots – epicentres of intermediate earthquakes in the Vrancea area) stands out in the area of the curvature of the Carpathian Mountains. Clusters of black dots on the map represent the frequencies of earthquakes. A region with a high concentration of earthquakes can be distinguished, which is known as the Vrancea area. Depending on the depth, three categories of earthquakes are mainly registered in Romania: superficial - where the hypocentre is located at a depth between 0 and 5 km from the earth’s surface; crustal or ordinary - where the hypocentre is located at a depth between 5 and 30 km from the earth's surface, reaching up to 60 km in the Vrancea area; and intermediate, with the hypocentre placed at a depth ranging between 60-70 km and 100-220 km from the earth’s surface, and these are specific to the Vrancea area. The Vrancea seismogenic region is located at continental convergence, placed at the contact point of three tectonic plates: the East European plate, the Intra - Alpina and Moesica subplates.

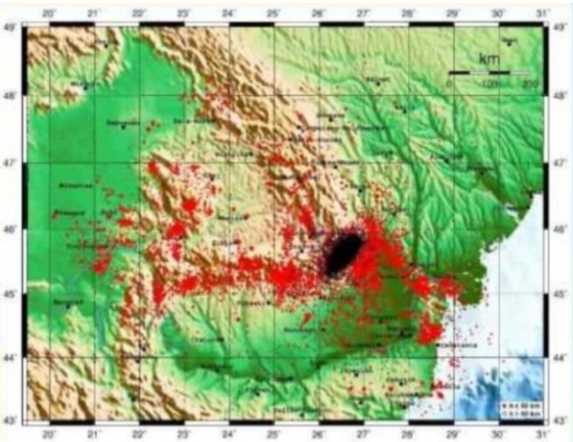


Figure 1. Seismic map of Romania

Source: E. S. Georgescu, I. G. Craifaleanu. Hazard, vulnerability and seismic risk in Romania, ECBR, October 2021.

In addition to the Vrancea area, the following areas are relatively active in Romania: the Fagaras - Câmpulung area, where there was only one major seismic event (1916, with Mw 6.4 degrees) in the modern period, the Danubian area in the vicinity of the Danube river, with events of lower intensity (less than 6 Mw). Other seismicity areas in Romania: Banat Zone, Crisana-Maramures, Barlad, Predobrogeana, and Intramoesica Zones, which are distinct zones but with a low frequency of seismic events of significant magnitude (INFP, 2022).

A zonation of the continent from a seismic point of view is developed based on a classification of the areas using the average values of the peak ground acceleration transforming the data from the Global Seismic Hazard Assessment Project - GSHAP into hazard classes (UNDRR, 2022). The activity area of the earthquakes that affect continental Europe is called the “Mediterranean and Trans-Asian” area, and most of the earthquakes in this area have focal points aligned along the mountain ranges, a situation that was also confirmed in Romania.

2. Literature review

The characterisation of the seismogenic zones in Romania is presented (Radulian et al., 2000) by highlighting the distinctiveness of earthquakes in the Vrancea region and the characterization of the major fault system located on the eastern edge of the Pannonian Basin and the Carpathian orogen, up to the intra-Carpathian region. The seismological distinctiveness of the Vrancea region in the southeast of the Carpathian Mountains is well-known for strong earthquakes of medium depth (Bokelmann and Rodler, 2013), and there are geodynamic models to describe the processes of wave transmission in the lithosphere. Radulian (2015) develops the same problem of specific nature of the Vrancea earthquakes, highlighting the distinctive elements of the Vrancea area, as a focus of earthquakes or as a “earthquake nest”, of intermediate depth, with similarities around the world such as Bucaramanga (Colombia) or Hindu Kush (Afghanistan). In Romania, in the last years, the studies on earthquakes produced an increase in the awareness of the population and authorities. After the two major earthquakes that occurred in Romania, there is not much information about traditional buildings that suffered complete collapse or major damage (Dutu et al., 2018).

An extension of the analysis of the seismic area in Romania, towards the seismogenic zone of the Black Sea and its echoes in the continental crust in the North-West is carried out by Beșuțiu and Zugrăvescu (2004). The recorded data are processed, and the mathematical models used allow a more accurate description of the geopotential fields and their evolution in the Black Sea area. Bala et al. (2021) establish the patterns of seismicity in the Vrancea area of the Eastern Carpathians in Romania, with a specific intermediate depth ranging between 55 – 105 km and 105 – 180 km, determined by the configuration of tectonic stresses. A detailed analysis based on observations of major earthquakes in the Pannonian Basin and the Curvature Carpathians area in Romania is performed by Grünthal and Stromeyer (1992). A goal of researchers in this field is that of mathematical modelling of earthquakes, the method employed by Ogata (1988) using stochastic models to describe the origin times and magnitude of earthquakes, in the case of Japan. Faenza et al. (2007) determine the dependences in time and space between earthquakes, obtained through Monte Carlo simulations on the case of a region in the area of the Lower Rhine - Germany. The topic of statistical modelling of the seismic activity generated by hydrocarbon extraction through hydraulic fracturing in western Canada is developed by Kothari et al. (2020). A catalogue of zonal earthquakes specific to the continental shelf to establish the recurrence of major earthquakes is valorised by Ali and Akkoyunlu (2022) for an active zone in eastern Turkey in the area of the Anatolian Plate and the intersection of the Arabian Plate and the Eurasian Plate. For Romania, Popescu et al. (2018) prepared a detailed catalogue with the definition of the seismogenic zones in the area of the Carpathian Mountains and their surroundings, over an observation interval between 1998 and 2012, for which 259 intermediate depth seismic events and 90 crustal seismic events were analysed. A complete, homogeneous and accessible catalogue with input data to facilitate the calculation of the seismic hazard, by developing and completing previous versions made at the National Institute for Earth Physics, is compiled by Oncescu, et al. (1999). Constantinescu et al. (1976) made a description of some earthquakes and their causes, which was continued later by Sandi et al. (2005). Using the data sequence of Vrancea earthquakes over the interval (1100–1973) and by decomposing them by types of events, according to the nature of the faults and the cyclicity of the events, Purcaru (1979) made predictions for the future. Therefore, for the major earthquake of 1977, the author made, in 2005, the prediction 1980 ± 13 years and the following ones between 2030 and 2040, respectively, 2070 and 2090.

3. Statistical processing of data on seismic events

3.1 General matters

Primary information on seismic phenomena is extracted from the catalogue provided by the National Institute for Earth Physics. Considering that the earthquake-generating focus in Romania is the Vrancea area, and they occur in the subcrustal lithosphere, at the bend of the Eastern Carpathians, and significant earthquakes outside the area are extremely rare, in this phase of the study, given the extended horizon of observation which includes the range of the years 984 - 2022, and the large number of recorded events, the statistical treatment will be done on the entire database.

The processed database includes 31,537 earthquakes identified in the Romanian space (longitude: min 43.5941 – max. 48.23 and Latitude: min 20.1 – max. 29.84), in the period 1 January 1984 – 31 March 2022.

It is a known fact that the occurrence of major seismic phenomena is a “rare event” from a statistical point of view. Statistical studies of earthquakes typically start from the fact that rare events are well-modelled by the law of exponents – if one considers the sequence of time intervals separating the events, or Poisson's law if the frequency of earthquakes is modelled as an event described by a discrete variable. The ease of using these two distribution laws, distinct of nature, consists in the fact that they are defined by the same parameter, describing the same phenomenon: the behaviour of a system over time, from a continuous or discrete point of view. Such a study carried out on seismic phenomena in Romania, covering the time period 1400-1977, did not confirm the hypothesis of an exponential behaviour, the confirmed model being the bi-parametric Weibull model (Vodă and

Isaic-Maniu, 1983). An extension of the horizon of observation (1100-2004) but also of the spectrum of the intensity of the monitored earthquakes, was treated in Dragan and Isaic (2011). In the material presented, information from the technical literature was used, respectively, other approved sources such as those of the National Institute for Earth Physics, mainly the ROMPLUS catalogue (INFP-2022), the scientific product of the specialised institute.

3.2 Statistical description of earthquake

The 31537 seismic events recorded over the entire observation horizon are distributed by intensity classes (Figure 2).

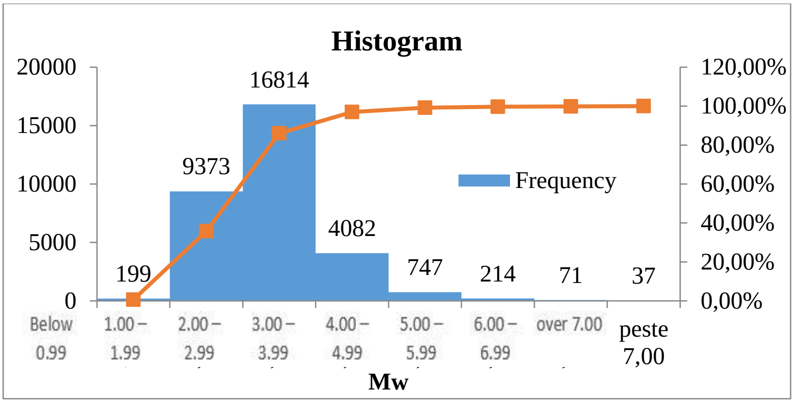


Figure 2. Distribution of earthquakes recorded in the period 984-2022
Source: Authors' processing.

Considering that in the period before the 19th century, the data usually show major earthquakes, for a comparison over time, it is logical to select only the peak values. The trend of the evolution of the annual earthquakes of maximum intensity starting from the year 984, turns out to be linear (Figure 3). The graph allowed the identification of subperiods with different trends, for which chronological trend equations were tested and validated (Table 1).

The recorded data presented two depth measurement units in Km (25,216 events in the interval 0-220 km) and in *f* - 6327 events in the interval 0-218.4*f* (*f*- Fathom = = 1.8288 m).

The strongest seismic activity on the territory of Romania is concentrated at intermediate depths (60 - 200 km), in a cooler lithospheric body, in gravitational descent, orientated almost vertically (INFP, 2022). High activity was observed in two depth ranges - between 80 and 100 km, and between 120 and 160 km, respectively. Strong earthquakes in the 20th century occurred in both segments: the 1977 (Mw 7.4) and 1990 (Mw 6.9) earthquakes in the upper segment, and the 1940 (Mw 7.7) and 1986 (Mw 7.1) events in the lower segment.

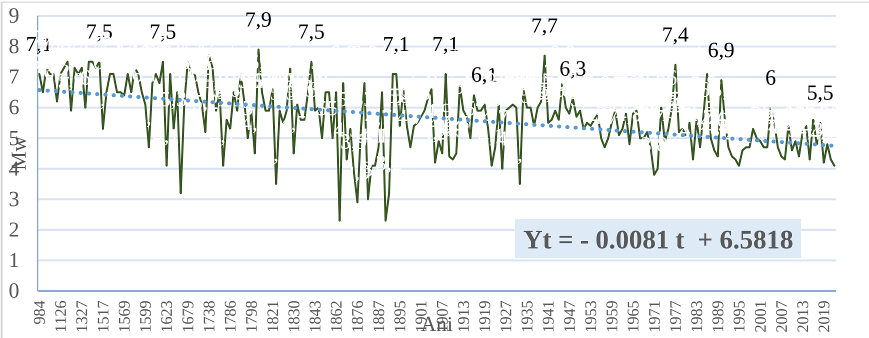


Figure 3. Evolution of maximum intensity earthquakes in the period 984-2022

Source: Authors' processing.

Up to 100 km, almost 75% of the earthquakes recorded on the observation horizon 984-2022 occurred, and up to 160 km depth, 99.6% of the events occurred. The distribution of earthquakes according to depth shows two modal values, recording peak values between 10 and 20 km, respectively between 130-150 km (Figure 4). The big difference between the mean and the median depth indicates a strong asymmetry, also generated by the two modal values.

Table 1. Chronological equations for sub-periods of maximum earthquakes

Sub-period (years**)**	**Trend equation**
984 - 2022	Y_t = -0.0081 t + 6.5818
984 -1499	Y_t = 0.01670 t + 6.8559
1500 -1699	Y_t = -0.0284 t + 6.8168
1700-1799	Y_t = -0.0532 t + 6.5904
1800-1899	Y_t = -0.0065 t + 5.753
1900-1999	Y_t = -0.0065 t + 5.753
1922-2021	Y_t = -0.0109 t + 5.8104

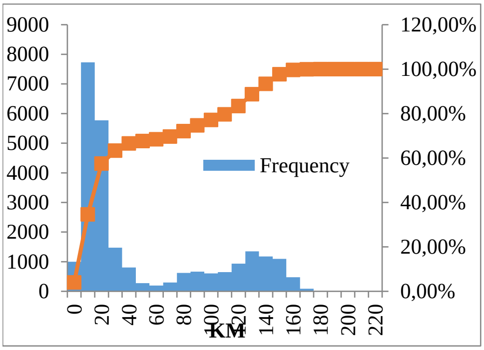
Source: Authors' processing.

The average depth is 45.6 km, the maximum depth was 218.4 km, and the median 15.4 km, which indicates a strong asymmetry, the coefficient of kurtosis recording the value - 0.776, with a strongly flattened distribution, the coefficient of skewness having the value 0.936, far from the standard value of the normal distribution where $k = 3$.

To establish the connection between the average magnitude and depth, the 1633 values were organised two-dimensionally (Figure 5), and the image of the cluster of dots in the vicinity of the regression line suggests a close connection between the two variables.

The estimated regression equation $\hat{Y}_x = 0.01x + 1.8877$ was validated by the usual tests, being statistically confirmed. The value of the correlation ratio (0.85) indicates a strong link between the depth of the epicentre and the magnitude value.

The average depth is 45.6 km with a standard deviation of 51.6. The histogram image indicates a bimodal distribution, with a first peak value in the 10-20 km depth zone and a second one in the 130-140 km zone.



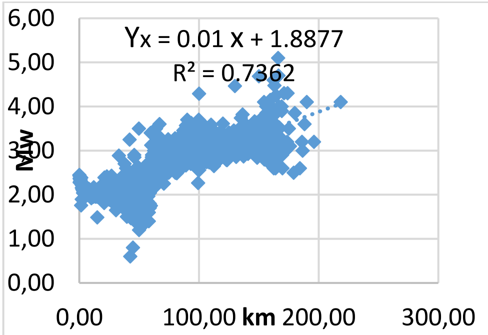


Figure 4. Earthquakes by depth in Km

Figure 5. Dependence between mean magnitude and depth

Source: Authors' processing.

The coefficient of determination 0.86 shows the proportion in which the magnitude is dependent on the depth, and the Fisher (F) and Student (t) tests have significant statistical values and confirm the validity of the estimated equation.

In the last two centuries, in distribution of major earthquakes (over 5 Mw), there is an increase in frequency due to the existence of rigorous records and also the development of techniques for measuring magnitude.

The peak of events was recorded in the interval 1900-1950 with 126 events; in the interval 1350-1400 there was no significant event recorded; also the acceleration of events starts with the year 1700, the coefficient of kurtosis of 9.72 and skewness of 3.055.

4. Fitting the Distribution

4.1 Testing distribution of focal points depth

The distribution was tested in order to identify the distribution law, and following the advancement of several hypotheses, based on successively applied tests, the General Extreme Value (Johnson et al., 1994) was validated, which belongs to the family of extreme distributions that also includes Gumbel, Fréchet and Weibull.

The estimated parameters have the following values: $k = 0.55895$, $\sigma = 440.49$, μ= 301.7, where: k – shape parameter μ- location parameter, σ - scale parameter. Statistical analysis:

Domain

$$1 + k\frac{(x-\mu)}{\sigma} > 0 \quad \text{for } k \neq 0 \tag{1}$$

$$-\infty < x < +\infty \quad \text{for k} = 0$$

probability density function (pdf) of the Generalized Extreme Value (GEV):

PDF

$$(x) = \frac{1}{\sigma}\exp(-(1+kz)^{-\frac{1}{k}}(1+kz)^{-1-\frac{1}{k}} \quad \text{for } k \neq 0 \tag{2}$$

$$f(x) = \frac{1}{\sigma}\exp(-z-\exp(-z) \quad \text{for k} = 0$$

CDF

$$F\,(x) = \exp(-(1+kz)^{-\frac{1}{k}} \quad \text{for } k \neq 0 \tag{3}$$

$$F(x) = \exp(-\exp(-z)) \quad \text{for k} = 0$$

where: $z \equiv \frac{x-\mu}{\sigma}$

Thus, these functions are defined for all *x* when *k* = 0, for all $x \geq \mu - \sigma/k$ when *k* > 0, and for all $x \leq \mu - \sigma/k$ when *k*< 0. Outside this domain, we can consider *f*(*x*) = 0, and *F*(*x*) = 0 when *k*> 0 and *F*(*x*) = 1 when *k*< 0.

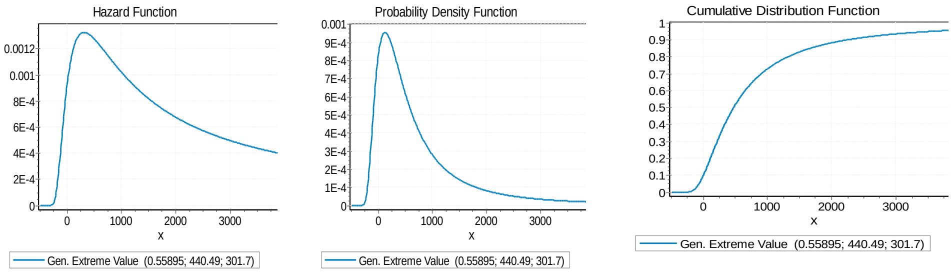


Figure 6. The h(x)-hazard function, f(x)-probability density function and F(x)

Source: Authors' processing.

The validation tests confirmed the statistical hypothesis regarding the distribution of GEV (Generalized Extreme Value) earthquake frequencies depending on the depth of their occurrence, at all frequently used significance levels α = 0.2, 0.1, 0.05, 0.02, 0.01, for all the three tests used: Kolmogorov-Smirnov (calculated statistics 0.13677), Anderson-Darling (0.51626), respectively, Pearson-Fisher with the statistics 0.0389. The comparison with the *p-value* (0.73276 for the Kolmogorov test, respectively, 0.98074 for the Chi Square test) reconfirms the GEV type distribution. The images of the probability density *f(x)*, CDF, respectively, hazard function *h*(*x*) for the estimated parameter values (Figure 6). It arises from the calculations as follows: *f*(0) = 8.1435E-4, *F*(0) = 8.9821E-4 , and *h*(0) = 8.9821E-4, and for *x* =10 the values of the three indicators are: *f*= 0.0045, *F*=0.9726, *h*= 0.16436.

4.2 Characterisation of earthquakes with significant magnitude

The 26 groups of earthquakes of 5, 6 and more than 7 Mw, with a step of 0.1 Mw (Figure 7). The frequency of earthquakes decreases as the magnitude increases, with a few exceptions such as the 6.5 Mw earthquakes, with a frequency of 24, or the 18 earthquakes of 7.1 magnitude. The average frequency of an event over 5 degrees is 12.39, with a variation of 166.5, respectively, a standard deviation of 12.9. The distribution is strongly leptokurtic (Kurtosis = 6.57), respectively, asymmetric (Skewness=2.20).

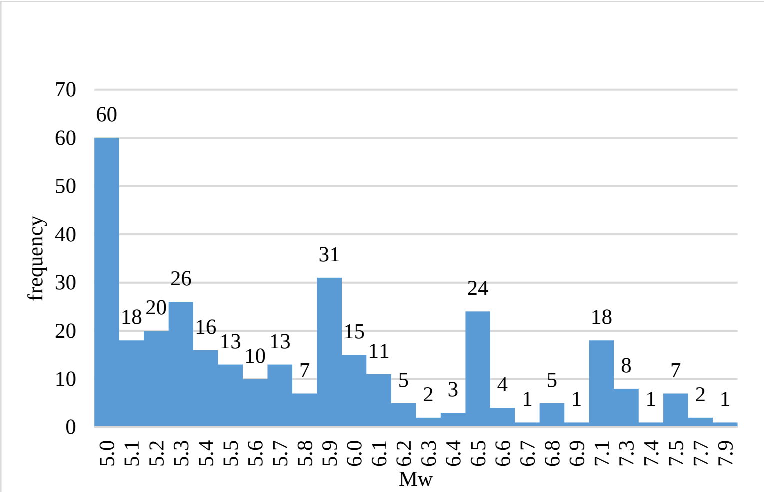


Figure 7. Distribution of major earthquakes (over 5 Mw) recorded in the period 984-2022

Source: Authors' processing.

The testing of the distribution law was carried out by successively applying the three tests, thus the statistic of the *Kolmogorov-Smirnov* test with the value of D_n=0.1414 is lower than the theoretical thresholds at different significance levels, as follows: α=10% (0.2332), α=5% (0.2591), respectively α=1% (0.31064), so the previously advanced hypothesis of the Pareto type 2 distribution is confirmed.

The Andersen - Darling test also confirms the hypothesis raised, since the calculated value A^2 = 0.2613 falls below the critical thresholds 1.9286 at the 10% significance level, 2.5018 at the 5%, threshold or 3.907 at the 1% threshold.

Finally, the *Chi-Squared* χ^2 (Pearson-Fisher) test, with the statistic 0.0347, which is below the critical thresholds at 10% (4.605), at 5% (5.99), but also at 1% (9.21) also confirms the hypothesis of the ***Pareto type 2*** distribution**.**

The estimated parameters of the distribution are:

α - *continuous shape parameter* $(\alpha = 46.514)$,
respectively
β- *continuous scale parameter* $(\beta = 563.67)$.

After having tested different variants, the *Pareto type 2* distribution was considered valid, with the probability density:

$$f(x) = \frac{\alpha\beta^{\alpha}}{(\beta+x)^{\alpha+1}} \quad (4)$$

which, for the value x=0, leads to $f(x)$=0.08252, and for x=10, $f(x)$=0, respectively, the cumulative distribution function takes the following form:

$$F(x) = 1 - \frac{\beta^{\alpha}}{(\beta+x)^{\alpha}} \quad (5)$$

domain: $0 \leq x \leq +\infty$, with the following restrictions on the parameters: $\alpha > 0, \beta > 0$. The specific indicators have the following values:

mean $\frac{\beta}{\alpha-1} = 12.385$, for $\alpha > 1$, and

variance: $\frac{\beta^2\alpha}{(\alpha-2)(\alpha-1)^2} = 166.5$, for $\alpha > 2$

The standard variation has the value 12.9, the coefficient of variation 1.0222, and the symmetry of the distribution is characterised by a Skewness of 1.0222, respectively, the curvature by the Kurtosis coefficient=7.1484. The coefficient of variation had a value of 1.042. The first decile has the value 1, quartile 1 is 2.75, and Q_3 is equal to 18 (Figure 8).

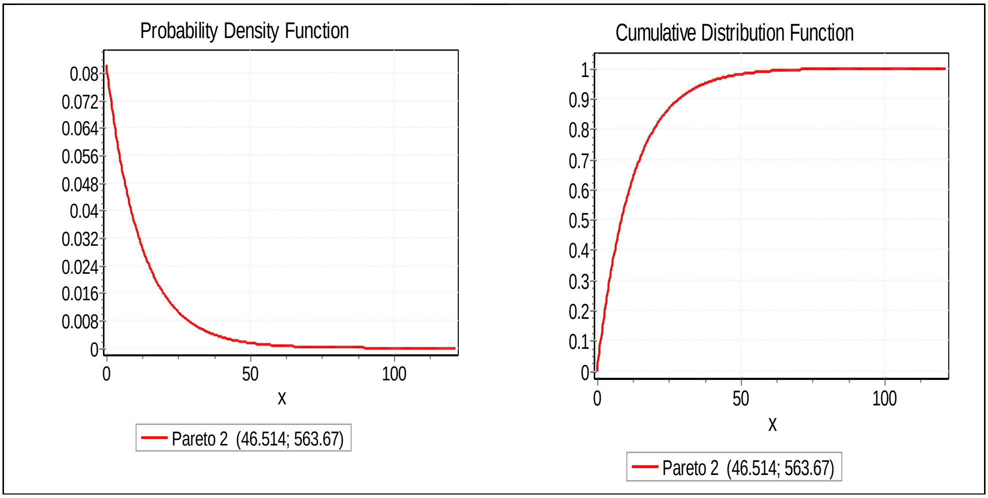


Figure 8. The probability density and the distribution function in case of over 5 Mw earthquakes

Source: Authors' processing.

Regarding the distribution of earthquakes with a magnitude greater than 5 Mw, over 50-year timespans, the tests applied led to the confirmation of the Pareto type 2 distribution law. The statistics of the tests applied had the following values: for the Kolmogorov-Smirnov test 0.1453, for the Anderson-Darlin test 2.0446 and for Chi-Squared the value of 0.36968, in all cases falling below the critical threshold allowed for different values of the decision risk α.

The distribution parameters had the following results: shape parameter α = 1.2122, respectively scale parameter β= 5.6037; the distribution density *f* (*x*,1.2122, 5.6037) and the hazard function *h* (*x*,1.2122, 5.6037). The high probability (about 82%) of recording more than one earthquake can be observed with higher values. The probability of registering a number of earthquakes between 1 and 10 is 53%, and less than 10 is 71%. The chances of recording more than 5 earthquakes are approximately 46%, but more than 10 earthquakes are only 28.9%, a probability that decreases drastically as *x* increases, a situation that is also visible on the *f* (1.2122, 5.6037) and *h* (1.2122, 5.6037) curves, whose trend is accelerating downward.

4.3 Statistical characteristics of destructive earthquakes

We include in the analysis events with a magnitude of over 6 degrees, earthquakes with a magnitude of over 6 degrees, earthquakes with devastating effects on people's lives and on infrastructure. The primary data of the 108 events are organised as a frequency distribution series, starting with magnitude 6 and step 0.1. The distribution is multimodal with clusters at 6 and 6.1 degrees, 26 earthquakes, respectively, 24 earthquakes of 6.5 degrees, and 26 earthquakes of 7.1 to 7.3 degrees. The skewness coefficient is 1.42, and the excess kurtosis is 1.41.

The average value of the frequencies is 6.75, in the range of 1 earthquake, encountered in earthquakes with magnitudes of 6.7, 6.9, 7.4, respectively, 7.9 and 24 events, in the case of earthquakes with a magnitude of 6.5 Mw. The variance/dispersion recorded the value of 47.8, with a standard deviation of 6.9, a distortion of 1.42 (Skewness coefficient) and a fairly flat distribution (Excess Kurtosis 1.314), compared to the normal distribution, where the value of the coefficient is 3.

The average value of the earthquake intensity (6.84) is very close to the main modal value 6.5 Mw, which has a frequency of 24. The secondary modal value is 7.1 with a frequency of 18. The median value was 6.75, Q_1 = 6.325, and the third quartile Q_3 = 7.375. The deciles recorded the following values: D_1= 6.07, respectively, D_9 = 7.76, a value close to the maximum recorded earthquake of 7.9 Mw.

The frequency distribution was validated as of *Log-Logistic* type, while the critical values for a wide range of significance levels, from 0.2 to 0.01, and the *P-value* also confirm the initially formulated null hypothesis.

The Probability Density Function takes the following form:

$$f(x) = \frac{\beta}{\alpha}\left(\frac{x-\gamma}{\alpha}\right)^{\beta-1}\left(1+\left(\frac{x-\gamma}{\alpha}\right)^{\beta}\right)^{-2} \tag{6}$$

Cumulative Distribution Function (CDF)

$$F(x) = \left(1+\left(\frac{\alpha}{x-\gamma}\right)^{\beta}\right)^{-1} \tag{7}$$

The parameters have the meanings below:

β - continuous shape parameter $(\beta > 0)$

α - continuous scale parameter $(\alpha > 0)$

γ - continuous location parameter $(\gamma \equiv 0$ yields the two-parameter Log-Logistic distribution).

The domain of the variable: $\gamma \leq x + \infty$. and the estimated parameters have the following values:

α = 1.4157, respectively β =3.5755, respectively γ = 0,
so that the bi-parametric model can be described as follows:
the probability density for this *bi-parametric model* is:

$$f(x:\alpha,\beta)=\frac{(\beta/\alpha)(x/\alpha)^{\beta-1}}{\left[1+(x/\alpha)^{\beta}\right]^2} \qquad (8)$$

where $x>0, \alpha>0, \beta>0$ and CDF

$$F(x:\alpha,\beta)=\frac{1}{1+(x/\alpha)^{\beta}}=\frac{(x/\alpha)^{\beta}}{1+(x/\alpha)^{\beta}}=\frac{x^{\beta}}{\alpha^{\beta}+x^{\beta}} \qquad (9)$$

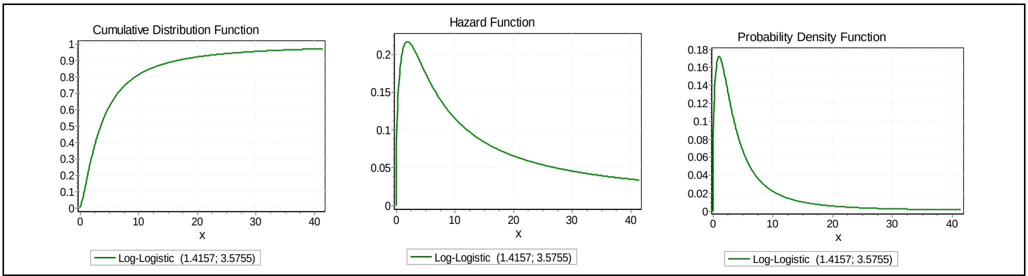


Figure 9. Functions f(x), F(x) and h(x) for devastating earthquakes over 6 Mw
Source: Authors' processing.

The quantile function

$$F^{-1}(p;\alpha,\beta)=\alpha\left(\frac{p}{1-p}\right)^{1/\beta}. \qquad (10)$$

The log-logistic has been used as a simple model of the distribution of wealth or income in economics, where the Gini coefficient is $1/\beta$ (Kleiber and Kotz, 2003; Al-Shomrani et al., 2016) it is known as the Fisk distribution. The log-logistic distribution provides one parametric model for survival analysis. The survival function is

$$S(t)=1-F(t)=\left[1+(x/\alpha)^{\beta}\right]^{-1}, \qquad (11)$$

and so the hazard function is

$$h(t)=\frac{f(t)}{S(t)}=\frac{(\beta/\alpha)(x/\alpha)^{\beta-1}}{1+(x/\alpha)^{\beta}}. \qquad (12)$$

For various values of the variable x, the main statistical indicators of the Log-logistic distribution, *f(x)*, *F(x)*, *S(x)* and of the intensity of events *h(x)* (Figure 9).

The data indicate that as the number of possible seismic events increases, the intensity rate *h(x)* of the events decreases drastically (Table 2).

Table 2. Values of the Log-logistic distribution indicators f

	x = 0	**x = 1**	**x =5**	**x = 10**	**x = 25**
f (x)	0	0.17187	0.06694	0.02171	0.00319
F(x)	0	0.14140	0.61650	0.81091	0.94009
S (x)	1.000	0.85860	0.38350	0.18909	0.05991
h (x)	0	0.20017	0.17455	0.11480	0.05323

Source: Authors' processing.

5. Conclusions

The overwhelming majority of earthquakes in Romania are in the Vrancea area, at the curvature of the Carpathian Mountains, in the last 300 years only one major earthquake occurred with the epicentre outside this area, the 1916 earthquake. The Vrancea seismogenic region is located at the continental convergence, placed at the contact point of three tectonic plates: the East - European plate, the Intra - Alpina and Moesica subplates and intermediate, and the hypocentre of most earthquakes is located at a depth between 60-70 km and 100-220 km from the earth's surface;

In addition to the Vrancea area, the following areas are relatively active in Romania: the Fagaras - Câmpulung area, the Danubian area in the vicinity of the Danube river, the Banat zone, the Crisana-Maramures, Barlad, Predobrogeana, and Intramoesica Zones, which are distinct zones but with a low frequency of seismic events of significant magnitude.

The analysis of the seismic activity is facilitated for Romania by the preparation and permanent updating of a complete, homogeneous and accessible catalogue with input data to facilitate the calculation of the seismic hazard, through the development and completion of previous versions drawn up at the National Institute for Earth Physics, a catalogue updated periodically.

Thus, total recorded events amount is 31537, of which 86.0% are up to a magnitude of 4 degrees, 980 earthquakes were over 5 degrees, and 37 were devastating with a magnitude of over 7 Mw degrees on the Richter scale. The year in which the most earthquakes were recorded was 2015 with 2152 events, and the month in which the highest frequency was recorded was October, respectively, the 22^{nd} day. The trend of the evolution of maximum intensity earthquakes starting with the year 984 is linear in the form $\hat{Y}_t = -0.0081t + 6.5818$

A strong correlation (0.86) was recorded between the depth of the epicentre and the intensity of the earthquake. The specificity of the statistical distribution was tested for the depth of the focus, for the distribution of earthquakes of 5+, respectively, those of 6-7 degrees, for which purpose three tests (Kolmogorov-Smirnov, Andersen-Darling, Chi-Squared) were used, then finally choosing the result where the agreement between the obtained results was the highest.

Simulations were carried out regarding the modification of the statistical indicators of the distribution of destructive earthquakes (over 6 Mw) depending on different values of the *x* variable. At intervals of 50 years each, 322 events were recorded starting with the year 984 throughout the entire analysis interval, the chances of recording less than three events are about 40%, between one and ten 82%, and more than ten only 29%.

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