TERRITORIAL DISTRIBUTION OF HYDROMETEORS RISK IN DOBRUDJA DURING THE HOT SEASON

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Key words: climatic hazard, hail, pouring rainfall, tornado, Dobrudja

Abstract: The climatic risk phenomena represent the object of vast research due to the specific characteristics they display (seriousness, recurrence, temporality etc) and are thus monitored by international specialized institutions from different countries because of their important economic and ecological impact. This article synthesizes the main risk phenomena from the warm period of the year in Dobrudja, as well as the ecological imbalances and negative economic effects they cause on a territory with a strong development of agriculture (intensive and on large farms), of tourism and the helio-marine therapy, of the naval, air and railroad transport network etc. Among these risk climatic phenomena, torrential rain and hail had the most negative impact between 1965 and 2005, compromising 12303 ha in Constanta County, which represent 43.8% of the total damaged surfaces.

Introduction

The risk factors and climatology aspects in Dobrudja (including the risk of hydrometeors during the hot season) have been researched in papers written by D. Ţâştea et al. (1967), I.F. Mihăilescu (1986, 1999, 2001), Bogdan Octavia (1978, 1996, 1999), S. Chiulache and Nicoleta Ionac (1995), Cr. Păltineanu et al. (2000), M. Lungu (2009).

The analysis of hydrometeors risk during the hot season in Dobrudja is based on the data obtained from observations from ten weather stations between 1965 and 2005. Its purpose is the climatic characterization of the regime, occurrence probability (in the representative landscape points, with relatively complete recordings) and of its territorial distribution.

The different warming degree, either of radiant nature or by the penetration of tropical warm air (continental or marine) constitutes the main cause for the genesis and territorial differentiation of the climatic risks during the warm period. Thus, abundand and torrential rain, hailstorms and other phenomena depend on the intensity of the thermal convection.

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The contribution of warm air, given the continental advections, determine massive heating, and these, associated with thermal convection on the background of a predominantly anticyclonic period, generate episodes of drought (in spring, summer and autumn) It sould be mentioned that there are cases of dryness and drought phenomena regardless of the winter or summer thermal regimen.

1. Material and methods

The monthly and annual average meteorological statistics were recorded at 10 weather stations from different regions of Dobrudja (table 1). The time frame considered was 41 years (1965-2005), except the Chilia Veche station with just 21 years (1985-2005). The database used for the present research consisted of monthly averages for temperature, precipitation and also the measurement altitude.

The reliability of the data set quality was assessed considering that they were recorded in the national network, and standard quality control methods were applied to them. According to a study accomplished by Paltineanu et al. (2006), short-term series of weather data in this country were generally less than about 21 years in length, when both the means and standard deviations calculated for increasing periods became relatively steady for the climatic parameters. If data from short-term stations were significantly correlated with those for long-term stations from the same geographical region, they were extended accordingly to create a more uniform record in space and time.

Table 1. Parameters and conditions for data recording from 10 weather stations.

Cod no.	Weather station	Altitude [m]	Latitude	Longitude	Time frame
1	Sulina	3	45°09'N	29°40'E	1965-2005
2	Sf. Gheorghe	1	44°54'N	29°36'E	1965-2005
3	Constanţa	13	44°13'N	28°38'E	1965-2005
4	Mangalia	6	43°49'N	28°35'E	1965-2005
5	Medgidia	70	44°15'N	28°16'E	1965-2005
6	Gorgova	3	45°11'N	29°12'E	1965-2005
7	Adamclisi	158	44°08'N	28°00'E	1965-2005
8	Tulcea	4	45°11'N	28°49'E	1965-2005
9	Hârşova	38	44°41'N	27°57'E	1965-2005
10	Chilia Veche	5	45°25'N	29°18'E	1985-2005

2. The analysis of risk hydrometeors during the warm period of the year in Dobrudja

2.1. Hail is a form of solid rain, made of transparent or opaque ice particles, having different shapes (spherical or angular), sizes (variable diameter between 0.5 and 50 mm) and weight (from a few grams to over 300 grams), which fall during rain showers, along with tempest phenomena (thunder, lightning) and strong wind.

2.1.1. Average annual number of days with hail in Dobrudja

The average frequency of days with hail in Dobrudja depends on: the thermo-baric contrast between sea and shore/land, the instability of the air masses, the exposure of the relief to the solar rays and the advection of humid air masses, the relief configuration, the altitude etc.

Therefore, the frequency of hail decreases, in general, from the seashore and the Danube floodplain (areas with more humid and unstable air), to the central part (i.e. the warmer and drier area, therefore more stable) Figure 1; therefore, in other words, the days with hail decrease as the continental area increases.

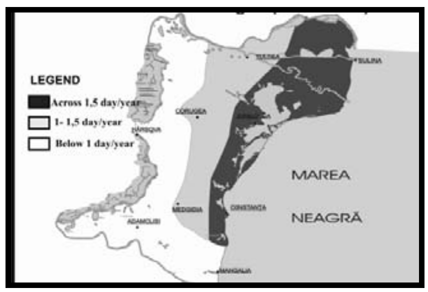

Fig. 1 – Average annual number of days with hail in Dobrudja (1965-2005)

2.1.2. The maximum number of days with hail in Dobrudja

This number has been in all cases 2-3 times higher than the average annual number of days and it did not occur in all areas of the country, highlighting the local and regional characteristic features of the thermo-baric contrasts.

Therefore, in the Danube Delta, the maximum number of days with hail was 3 days/year; at the seaside, the maximum number of days with hail was 4 days/year; in the central and western part of South Dobrudja the maximum number of days with hail was 5-6 days/year.

Among the years with most days with hail we mention: 1967, 1969, 1970, 1975, 1977, 1979, 1982, 1984, 1992, 1999 and 2005.

2.1.3 Duration of hail

The average duration of hail is from a few minutes up to 15 minutes, observing once again, a differentiation of the maximum duration:

in the central and northern part of Dobrudja, around 30% of the cases had a maximum duration of 15 minutes.

- at the seaside, around 65% of the cases had a maximum duration of 5 minutes.

There have also been cases when hail occurred with an exceptional duration, as it happened in May 1974 in Constanta (12 minutes).

During an average year, hail can lead to a total average of 0.3 hours in the higher areas from the north and centre, and 0.1 hours at the seaside.

The maximal duration of hail is 2-3 times longer than the average one.

• 0.6 hours in Constanta and Sulina (at the seaside).

• 0.7 hours in Medgidia and Corugea (in the central and northern part of Dobrogea)

2.2. Torrential rains

Torrential rains fall in the warm period of the year due to increasing activity of the Azores High, and the Atlantic and the Mediterranean cyclone. They generate large amounts of water that fall within a very short time, so they have high intensity and cause large floods (ex. in 20.08.2004) that may have serious consequences on the human settlements and constructions, and accelerate erosion processes on slopes more or less bare of forest vegetation.

Fundamental processes leading to the development of cloudy formations capable of producing large amounts of rainfall are, as known, convection and turbulent exchange of air masses inside.

In Dobrudja, summer season rainfalls are likely frontal and usually occur during the day, having frequently drift character.

Curve correlation between distance from the Black Sea pluviometric points and maximum daily amounts of precipitation (24 hours), fallen in each of the summer months, looks similar to the average amounts of precipitation on the territory of Dobrudja, during a hot year (April-October).

Maximum amounts of rainfall (24 hours) decrease landward, at the distance of 30-35 km, with a tendency to reach the lowest values on the Black Sea. The significant correlation coefficient between distance from the sea and the maximum daily amounts of precipitation (24 hours) confirms their obvious influence on the precipitation distribution in Dobrudja.

In the warm period of the year and especially during the summer months, the longitudinal arrangement of the isohyets, according to the orientation of the sea shore and the rapid growth of their value in inland areas, includes a wider area in southern Dobrudja, where, compared to northern Dobrudja, the landscape is more fragmented. In south Dobrudja, the sea front breezes, which penetrates inland, is poorly disturbed by the steppe plateau because of the low altitude and its relatively reduced fragmentation.

A feature of the territorial distribution of daily maximum rainfall (24 hours) is that, in the summer months, the largest quantities are recorded at a distance of 30-35 km from the Black Sea, i.e. the distance where the increasing of the land isohyet value disappears or is greatly reduced because of the mitigating influence of sea breezes. In the period under consideration the following synoptic situations favorable to their production were identified:

a) Expansion of the Azores High dorsal above Central Europe, separated from the continent's eastern anticyclone by a thalweg that joins the depression area from the polar seas with the one from the south-east of Europe.

b) Retrograde depression in the north-east of Romania, formed in the low-pressure corridor between the Azores High and corridor in north-eastern Europe. The retrograde nature of the depression moving south-west - north-east was determined by the barrier represented by the anticyclone in eastern Europe, which deviated it westward.

c) The existence of a weak anticyclone field extending from the Atlantic Ocean to the Caspian Sea which separates the large Icelandic depression from the less extensive one in southeastern Europe.

High penetration in the anticyclone of the warm and unstable air masses, specific to the low-pressure minimums, and strong insolation at the ground level led to the destabilization of the air, which, pushed by very intense thermo-convective movements followed by those determined by the dynamic convection specific to the highland, favored the development of Cumulonimbus clouds.

d) Mediterranean Cyclones determine torrential rain during spring and winter time.

e) The low-pressure corridor formed between the Icelandic depression and depression in the eastern Mediterranean basin also favors the production of considerable amounts of precipitation. Thus, the contact between the wet and cold polar air and the warm and dry air of tropical origin, generates a very unstable area especially when at altitude, in the the rear of the depression at ground level, cold and wet arctic air penetrates to replace suddenly the hot air.

f) Activation of the polar front in our country.

In conclusion, it was appreciated that torrential rains in the region of Dobrudja are determined by:

-The movement west and northwest;

-Convective heat of summer under a ground-altitude convergence movements;

-Activation and reactivation of the country's polar front;

- Retrograde cyclone related frontal activity which manifests itself however to a lesser extent in this area, reaching only ocluse fronts.

2.2.1. Average intensity of torrential rain

The intensity of torrential rain is its main characteristic. Thus, working with data collected over a period of 41 years (1965-2005), we found that the strongest showers occur in the western city area of Dobrudja and Valu lui Traian (over 10 mm per minute) and the lightest (under 6 mm / minute) occur in the south and the coast of the Dobrudja Plateau.

2.2.2. Duration of torrential rain

In general, there was an inverse relation between the intensity and duration of the shower. If the intensity is higher, the duration is shorter, and vice versa. Thus, heavy rainfalls of frontal origin have the highest duration (over 4 hours), but their intensity drops sharply, below 0.20 mm / min. and even less. As intensity increases, duration decreases as the rainfall intensity is less than 1 mm / min., with a duration of approx. 60 min. Rainfalls between 1 and 2 mm / min. last about 30 minutes.

2.2.3. Water Quantity

During torrential rains, the amount of water fallen is directly proportional to the intensity and duration of rain, and dependents on its genetic conditions. The largest amount of water is registered in the case of the frontal showers, when the thermobaric contrast is very high.

Between 1920 and 2005, the largest quantities of water fallen amounted to over 100 mm rain and lasted up to 60 minutes and were possible in all regions of Dobrudja, Table 2.

Table 2. Maximum amount of rainfall in Dobrudja in 24 hours (1920-2007)

Place	**Amount of rainfall (mm/sm)**		**Place**	**Amount of rainfall (mm/sm)**	
	Maximal value in 24 hours	**Multiannual average**		**Maximal value in 24 hours**	**Multiananual average**
Cogealac	19.3/ 28.08.2004	378.5	Biruinta	222/03.07.2005	399.0
Mangalia	21.9/28.08.2004	412.3	Cernavoda	77.2/28.08.2004	467.7
Aliman	27.8/28.08.2004	470.2	Amzacea	82.6/28.08.2004	406.0
Ostrov	30/28.08.2004	484.0	Saraiu	84.4/28.08.2004	434
Oltina	35/28.08.2004	480.1	Crucea	105/28.08.2004	431
Negureni	37.2/28.08.2004	460.7	Cobadin	106.0/03.07.2005	443.7
Mihai Viteazu	37.8/28.08.2004	325	Mircea Voda	120/28.08.2004	440.5
Silistea	57/28.08.2004	430.3	Lumina	147.7/28.08.2004	390.2
Negru-Voda	59.2/28.08.2004	504.8	Valul lui Traian	151.5/28.08.2004	391.4
Adamclisi	59.8/28.08.2004	472.8	Techirghiol	200.7/03.07.2005	362.1
Independenta	60.2/28.08.2004	460.6	Mamaia-Sat	200/28.08.2004	390
Medgidia	83.4/03.07.2006	435.7	Constanta	205.5/28.08.2004	386.8
Pestera	83/03.07.2006	410.2	Agigea	280.5/28.08.2004	411.0
Harsova	76.6/28.08.2004	407.6	Pantelimon	312/28.08.2004	425.5
Sulina	219.2/29.08.1924	320	Corugea	81.5/06.07.1991	385.5
Tulcea	79.3/06.07.1991	455	Sf. Gheorghe	134.5/27.08.1997	351.7
Jurilovca	80.2/06.07.1991	335	Chilia Veche	83.7/03.08.1997	348.2
Gorgova	79.0/06.07.1991	404.6	C.A. Rosetti	530.6/29.08.1924	345.5

Among these risk climatic phenomena, torrential rain and hail had the most negative impact between 1965 and 2005, compromising 12303 ha in Constanta county, which represent 43.8% of the total damaged surfaces. (Table 3)

Table 3. The size and structure of the compromised surfaces given on risk factors in Constanta county (1965 – 2005)

Locality	**Average Compromised surface (the mean of 41 years)**	**of which:**							
		Hail and torrentia rai		**Floods and water bogging**		**Frost and thaw**		**Other factors**	
		ha	**% of the om promised area**	**ha**	**% of the ompromised**	**Ha.**	**% of the ompromised**	**Ha.**	**% of the compromised area**
Agigea	150	**-**	**-**	-	-	158	100	-	-
Albeşti	620	**241**	**38.2**	-	-	136	21.6	252	40.1
Amzacea	1048	**737**	**70.3**	6	0.6	395	29.1	-	-
Ciocîrlia	630	**99**	**15.7**	-	-	260	41.3	271	43
Stejaru	-	**-**	**-**	-	-	-	-	-	-
Cobadin	192	**144**	**51.6**	-	-	135	48.4	-	-
Mangalia	279	**144**	**51.6**	-	-	135	48.4	-	-
M. Kogălniceanu	1694	**1098**	**64.8**	-	-	507	30.1	89	5.1
Nazarcea	393	**2**	**0.5**	-	-	309	76.6	82	20.9
Negru Vodă	1741	**992**	**57**	-	-	188	10.8	561	32.2
Topraisar	222	**-**	**-**	-	-	222	100	-	-
ZONE I	6986	**3313**	**47.4**	6	0.1	2412	34.5	1255	18
Cogealac	1921	**1509**	**78.5**	13	0.7	599	20.9	-	-
Dorobanţu	1204	**802**	**66.6**	-	-	102	8.5	300	24.9
Murfatlar	695	**8**	**1.2**	-	-	687	98.8	-	-
N. Bălcescu	1164	**772**	**66.3**	-	-	348	29.9	44	3.8
Poarta Alba	591	**331**	**56**	80	13.5	150	25.4	30	5.1
Săcele	832	**334**	**40.1**	-	-	326	39.2	172	20.7
Târguşor	1912	**1003**	**52.5**	197	10.3	697	36.4	15	0.8
Tortomanu	964	**245**	**25.4**	292	30.3	427	44.3	-	-
Vegas	-	**-**	**-**	-	-	-	-	-	-
Medgidia	1391	**247**	**17.8**	-	-	1144	82.2	-	-
ZONE II	10674	**5251**	**49.1**	582	5.5	4280	40.1	561	5
Independenţa	176	**-**	**-**	-	-	-	-	176	100
Peştera	868	**40**	**4.6**	93	10.7	435	50.1	300	34
Pietreni	2227	**1323**	**59.4**	331	14.9	573	25.7	-	-
Stupina	764	**102**	**13.4**	-	-	662	86.6	-	-
Vulture	619	**-**	**-**	-	-	-	-	619	100
Crucea	804	**-**	**-**	-	-	804	100	-	-
Hârşova	463	**463**	**100**	-	-	-	-	-	-

Saraiu	-	**-**	**-**	-	-	-	-	-	-
ZONE III	5921	**1928**	**32.6**	424	7.1	2474	41.8	195	18.5
Adamclisi	209	**-**	**-**	-	-	-	-	209	100
Băneasa	673	**482**	**71.6**	-	-	191	28.4	-	-
Cernavodă	1278	**144**	**11.3**	11.3	0.8	1021	79.8	-	-
Ostrov	2324	**1185**	**51**	7	0.3	1124	48.4	8	0.3
ZONE IV	4484	**1811**	**40.7**	120	2.7	2336	52.1	217	4.8
TOTAL County	28066	**12303**	**43.8**	1132	4.1	11502	41	3128	11.1

2.3. Tornadoes and waterspouts

2. 3.1 Tornadoes. The word "tornado" comes from the Latin "tonare" which means "to roar". The tornadoes are violent atmospheric perturbations, of reduced dimensions, a swirl, in the form of a fast rotating column or a reverse funnel which touches the ground. However, meteorologists do not think it is so easy to define a tornado.

The tornado becomes extremely dangerous when:

-it occurs in high season of vegetation when the trees and the vines are blooming,

-it is accompanied by very powerful winds,

- the duration of the phenomenon is long,

- it occurs in inhabited areas.

In Dobrudja, tornadoes occurred even before the discussed period (1990-2005), but they were not brought to the attention of the public, especially before 1989. Among the most recent tornadoes which caused great damage to the economy in Dobrudja, the following should be mentioned:

-July 30, 2002 in the area of Rahmanu village, in the Danube Delta

-August 12, 2002 in the central – west (also known among specialists as the "tornado from Facaieni"), which will be dealt with in the next case study.

-May 7, 2005 – when no fewer than 9 tornadoes occurred in the area: Harsova (Ciobanu village), Olimp, Cernavoda, Nicolae Balcescu, Topolog.

-April 21, 2008 the Nuclear Plant from Cernavoda was disconnected from the National Energy System on Tuesday night due to a violent storm in the Cernavoda area, which led to anomalies in the system of electric power evacuation.

Dobrudja, alongside the eastern part of the Wallachian Plain, is the most suitable region for tornado occurrence (between 1990 and May 2008, the most affected regions were in the central and western part, the Danube Delta and locally, in the seacoast area – Figure 2), which explains the high frequency of the phenomenon in these areas. Meteorologists consider that the number and intensity of tornadoes will increase due to global warming.

The Regional Meteorological Center from Dobrudja monitors non stop all special meteorological phenomena, using the latest equipment, found only in the

U.S.A. Although the designated area is represented by Dobrudja and the west of the Black Sea, satellites monitor a much vaster area. In spite of all these, tornadoes are phenomena which cannot be foreseen, only guessed. In order to be sure of the existence of a tornado, there should be visual contact. It is easy to mistake a blast for a tornado, which should necessarily contain a vortex.

The warning and monitoring systems for these phenomena do not exist, the inhabitants being left at the mercy of fate. For example, if a tornado were to affect the city of Constanta, people could find refuge in civil shelters. And this if, fortunately, the Inspectorate for Emergency Situations would have time to announce the population. There is, however, the problem of shelters. Most of them are disabled or flooded because of old water pipes from the basements of blocks of flats. Some of the functional ones are used for the storage of pickles and other items belonging to the tenants. Moreover, they are extremely difficult to locate. The Civil Protection marked the blocks where such shelters exist with the letter "A" in white paint. But taking into account the fact that when such disasters strike chaos sets in, it remains to be seen how the shelters will be found, especially because, apart from those who have them in their care, there are very few people who know about the existence of such places, and even fewer who will walk looking at the walls of blocks. At the moment, there are only 56 such shelters in Constanta which can be used in the case of a disaster.

Although it seems a reasonable number, they would accommodate only 23% of the current population. To this percentage we can add a few, taking into account that the Civil Protection also has shelters which can be used and built when necessary.

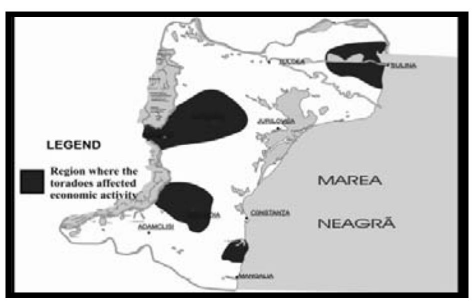

Fig. 2 – The map of the regions affected by tornadoes in Dobrudja, (1990-2008)

2.3.2. Waterspouts

The waterspout represents a phenomenon constituted by a whirlwind made up from a funnel-shaped or tubular portion of a cloud over the ocean or another body of water that, laden with mist and spray, resembles a solid column of water reaching upward to the cloud from which it hangs. In case it reaches the ground it takes up dust particles, sand and different debris or objects lifted up.

This phenomenon is considered a hydrometeor, due to the presence of water particles from the cloud and the sea surface, or any other surfaces it wipes out.

The devastating effect of waterspouts depends both on their intensity and duration. These are amplified by numerous other characteristics of the active surface such as: the presence of vegetation**,** the moment of the year when the shower occurs (if it occurs in summertime when the beaches are full of tourists) etc. In these situations the waterspouts can become climatic hazards, triggering deflation processes, the destruction of the buildings around the beaches having repercussions on the entire sea coast area and also on people's lives and activities.

In the discussed period, 1990-May 2008, three such cases were signaled in the sea coast area:

- July 19, 2002 – Gura Portitei
- May 7, 2005- Olimp
- July 10, 2005 – Neptun

The first case occurred in the summer of 2002, when in July-August, two special hydro-meteorological phenomena were signaled on the Romanian seashore:

a) on the sea moving towards the beach (waterspouts)

b) in Baragan (Wallachian Plain), at Facaieni, having its origin near lake Babadag (northern Dobrogea) moving towards the West (according to statements from the Babadag pluviometric station).

The phenomenon described occurred on July 19, 2002, between 8.10-8.30 a.m., moving from the sea towards the shore. The temperature in those days was between 28-32°C (July 14-18). At the moment of occurrence, the air temperature at the Gura Portitei station was 29°C, an unusually high temperature for a station on the Black Sea coast at that particular hour.

The waterspout noticed at Gura Portitei on July 19, 2002 occurred between 8.10-8.40.

It occurred on days with high temperatures (28-32°C); the air moisture was between 70 and 85%, and the air pressure was between 1010.0 and 1011.5mb. for the period July, 15-19. At the moment it occurred, the few people on the beach panicked, reaching for their belongings and running.

From the testimonies of those present, we may say that the phenomenon started accompanied by a roar followed by a typical whirlwind raising reed, dry grass, leaves and sand from the private beach.

2.4. Massive warming

As Dobrudja is situated in the temperate climatic area and in a continental area with multiple climatic influences, it is crossed by waves of tropical heat which determine high positive variations of air temperature from the normal one, sometimes with unique values or climatic records (Bogdan, 1978, Bogdan, Niculescu, 1992).

Between 1965 and 2005, there have been many situations in Dobrudja when the absolute maximum temperatures exceeded 30°C in the hottest months of the year (July and August) and even between May and September. But not every tropical day can be the result of an accentuated warming. This depends on the persistence of the mass of anticyclonic air which determines the frequency of tropical days and the frequency of warming processes.

In the case of the studied problem, only the absolute maximum temperatures (≥ 30°C) from the meteorological stations in Dobrudja (1965-2005) were taken into account, and they were called massive heating. It is obvious that this calculation ignores a series of values ≥30°C which, although present, did not become absolute maximum during the entire period of observations at each station, being surpassed by other higher values. However this does not mean that they cannot be considered part of massive heating.

Massive heating in summertime has numerous negative effects on the environment, particularly on agriculture (causing plants to die and even compromising the crops – as it happened in the summer of 2000) and on people's activities.

An excessive heat, which surpasses the temperature we are used to, causes adapting reactions of the organism in order to maintain its inner temperature constant. We add to this the fact that these thermal variations are accompanied by certain values of the other climatic components which may amplify stress. An excessively high temperature, as it occurs in Dobrudja in the summer months, especially in July (when the most tropical and scorching days are recorded) and a high solar radiation with very low or very high humidity, amplifies the sensation of drought and stuffiness.

Conclusions

These studies synthesizes the main risk phenomena from the warm period of the year in Dobrudja, as well as the ecological imbalances and negative economic effects they cause on a territory with a strong development of agriculture (intensive and on large farms), of tourism and the helio-marine therapy, of the naval, air and railroad transport network etc.

Among all the risk climatic phenomena described above, torrential rain and hail had the most negative impact between 1965 and 2005, compromising 12303 ha from Constanta county, which represent 43.8% of the total damaged surfaces.

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