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HUMAN POPULATION PRESSURE, NATURAL AND ECOLOGICAL HAZARDS ALONG THE BULGARIAN BLACK SEA COAST

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1. Introduction

Coastal zone, as a boundary between sea and land, is the most dynamical and sensitive area, which comprises the greater variety of natural ecosystems and resources. This fact predetermines the attractiveness of the littoral both for settlement and for realization of different human activities, like tourism, recreation activities etc. As all over the world thus in Bulgaria the temps of population increasing in the zones, close to the sea are much higher in comparison with the inland. The coastal population raise is a consequence of natural growth and as well as of migration. The motive for migration to littoral is determined of better economic conditions of life, possibilities for good jobs and education, the higher living standard and favorable climate. Ironically, the qualities that make the coastal zone so desirable are the same ones that have led to its endangerment.

The population growth in the littoral has caused rapid coast urbanization, development of infrastructures, transport system and so on. As a result the coastal ecosystems are pressured by population gain, leaving them vulnerable to pollution, habitat degradation and loss, overfishing and increased coastal hazards (WRI, 2000; Hinrichsen, 1998; National Safety Council, 1998). The presence of vast sand beaches at Bulgarian Black Sea coast, in combination with favorable temperate-continental climate and clean sea waters, are the precious preconditions for tourist industry development. However, the accelerated tourist development during the recent years is an additional risk factor for coastal zone. Both local residents and tourists causes pressure to the ecosystem and the population along the seacoast is used as pressure indicator for Integrated Coastal Management. On the other hand, the established infrastructure along lowland coastal areas (where the widest beaches are located), the most part of which is especially built for tourist industry (hotels, restaurants and so on) is being at risk during the extremal natural events. In addition, as a result of global climate changes and accelerated sea level rising the socio-economical consequences will be the most severe for coastal infrastructures, ports and harbors, historical and cultural heritages, agriculture, tourism and fishery industry.

The goal of present investigation is to assess evolution of human population along the Bulgarian Black Sea coast as a common indicator for the anthropogenic pressure to the Black Sea ecosystem. Both natural and ecological hazards are analyzed in the context of human population pressure along the seacoast which is used as pressure indicator for Integrated Coastal Management. Applying Geographic Information Systems (GIS) the evaluation of the most hazard-prone zones along Bulgarian coast is performed taking into account the number of population in the lowland areas.

2. General presentation

The Bulgarian Black Sea coast, situated in the Western part of the Black Sea, has coastal line 378 km long (Popov, Mishev, 1974), 140 km of which are occupied by 78 beaches (Dachev et al., 2005).

Fourteen of 262 municipalities, which are the smallest administrative-territorial units in Bulgaria (Kopralev, 2004), have outlet on the Black sea and are included in Bulgarian Black Sea coastal zone (Fig. 1). The total land area of Bulgaria is 110 842 km^2, as all 14 Black sea municipalities are 5 769.9 km^2 or 5.21 % from the entire territory of the country, which hosted 8.85 % of the nation's population.

Figure 1. Locator map

According to Klein and Nicholls, (1999) as the most vulnerable are considered such systems with highest sensitivity and lowest adaptability to the climate changes effects, including lowland shoreline territories, sandy coasts, dunes, marshlands, lagoons, firths, estuaries etc., all being under subsidence processes. At the same time the mentioned areas are the most attractive both for settlements and for tourist industry development due to their characteristics: possibilities for better livelihoods, easy access to the sea, wide and vast beaches and so on.

Along the Bulgarian Black Sea coast the most intensive negative movements are observed in the firths and lagoons depressions of the south coast, as the values of subsidence increases from 0.8 mm/y at the Hadgijska river firth to -3 mm/y at the firths of Diavolska and Ropotamo rivers, but in the region of the Burgas lakes this value reaches to 5 mm/y (Keremedchiev, Stancheva, 2005).

3. Data and methods

In the present paper the basic data for population in municipalities and settlements are obtained of the official statistics, collected from various censuses for the years 1934, 1946, 1956, 1965, 1975, 1985, 1992 and 2001 are used. Tourist spate data are based on official statistics, provided by Territorial Statistical Bureau (TSB – Varna,) to the National Statistical Institute (NSI) of Republic of Bulgaria, and contains information for means of accommodation, number of tourist beds, number of realized night spending and number of accommodated people for the period 1999-2004. For international tourist arrivals during 2000-2004 for entire country are used the data from the source: http://www.mi.government.bg/tourism/stat/. Population trends and tourist dynamics in the coastal municipalities are investigated with the help of ArcInfo Geographic Information Systems (GIS).

To identify the most vulnerable lowland coastal territories along the Bulgarian coast the topographical maps in scale 1:50 000 were proceed. The basic criterion for the extent of inundation is the altitude. All sites, including cities, villages and resorts, fallen into partly or entirely in lowland coastal areas are also defined. Using the data from NSI of Republic of Bulgaria the assessment is done of number of sites and their population to risks of flooding in case of storm surges.

4. Population trends in Bulgarian Black Sea municipalities

4.1. National level

During all censuses in the period 1934-1985 the Bulgarian population had positive gain, but after 1985 between two sequential censuses the population decreasing had been registered (table 1). Totally for the period 1985-2001 the population had been decreased with 1 015 665, as 679 141 of this value are the losses from outside emigration. The trend shows that the significant population growth in near future is slightly expectable. Due to political and economic reforms in Bulgaria in the early 90's of the past century the significant inside migration has been noted – many people, remaining without livelihoods and jobs, have directed to the areas where the better living and realization opportunities exist. Ones of such attractive areas are the biggest coastal towns.

Census data	Number of population per years							
	1934	1946	1956	1965	1975	1985	1992	2001
Entire country	6077939	7029349	7613709	8227866	8727771	8948649	8487317	7928901

Table 1. Population trend in Bulgaria

4.2 Bulgarian Black Sea municipalities - number of population

Bulgarian Black Sea coastal zone is one of the most rapidly growing and developed areas in national scale. The authors define a municipality as coastal if it has direct outlet at the Black Sea coast. After statistical processing of the censuses data for different periods the following results for coastal population number were obtained. Among 14 Bulgarian Black Sea coastal municipalities during the period 1934-2001 in 5 of them the population number has decreased, while in the rest 9 municipalities – has increased (table 2).

Bulgarian Black Sea municipalities	Number of population per years								Alteration of population 1934-2001 (%)
	1934	1946	1956	1965	1975	1985	1992	2001	
Avren	16976	17686	15842	12934	11269	9109	8817	8714	-48.67
Biala	5445	5260	5461	4976	4346	4019	3787	3413	-37.32
Shabla	8627	10413	11116	10650	9261	8464	7508	6380	-26.05
Sozopol	16645	18447	20417	17813	15886	15765	14971	14277	-14.23
Aksakovo	19752	18662	16741	14743	17182	16534	17994	19118	-3.21
Primorsko	3637	4873	4832	3980	4003	4666	4143	4079	12.15
Dolni Chiflik	17324	19293	21607	20791	20535	20782	20944	20217	16.7
Tzarevo	8256	9902	10990	10634	9610	9726	10634	10229	23.9
Kavarna	13419	15571	18554	19375	19709	19109	18044	16688	24.36
Balchik	15475	17805	22092	23538	24254	23990	22367	22354	44.45
Pomorie	17994	19744	20800	23157	25612	27416	27746	27370	52.11
Nessebar	11838	13526	13803	14276	16542	18186	18871	19113	61.45
Burgas	53778	65677	95535	135201	180715	210670	212410	209417	289.41
Varna	76664	83845	127160	188047	258613	309875	315336	320464	318.01
Total:	**285830**	**320704**	**404950**	**500115**	**617537**	**698311**	**703572**	**701833**	**145.54**

Table 2. Population trend in Bulgarian Black Sea municipalities

As it is clearly evident from the table the municipalities Varna and Burgas have the biggest population growth, respectively with 318.01 % and 289.41 %, while the municipalities Avren and Biala remark the highest population decreasing – 49.67 % and 37.32 % respectively (Fig. 2). Total coastal population during 1934-2001 has been increased with 416 003 people or 145.54 %, while the averaged rate for the rest part of the country has been increased by 1 439 042 people or 24.85 %. This comparison shows the population growth in coastal areas is almost six times higher than in the entire country.

In 2001 the permanent residents in the coastal municipalities are 701 833 or 8.85 % of the nation's population, but only 5 769. 9 km2 or 5.2 % of Bulgaria land area. Considering that the coastal zone is limited land area and very vulnerable, as a boundary between land and sea, this enormous population increasing is a hazard factor for coastal zone sustainability.

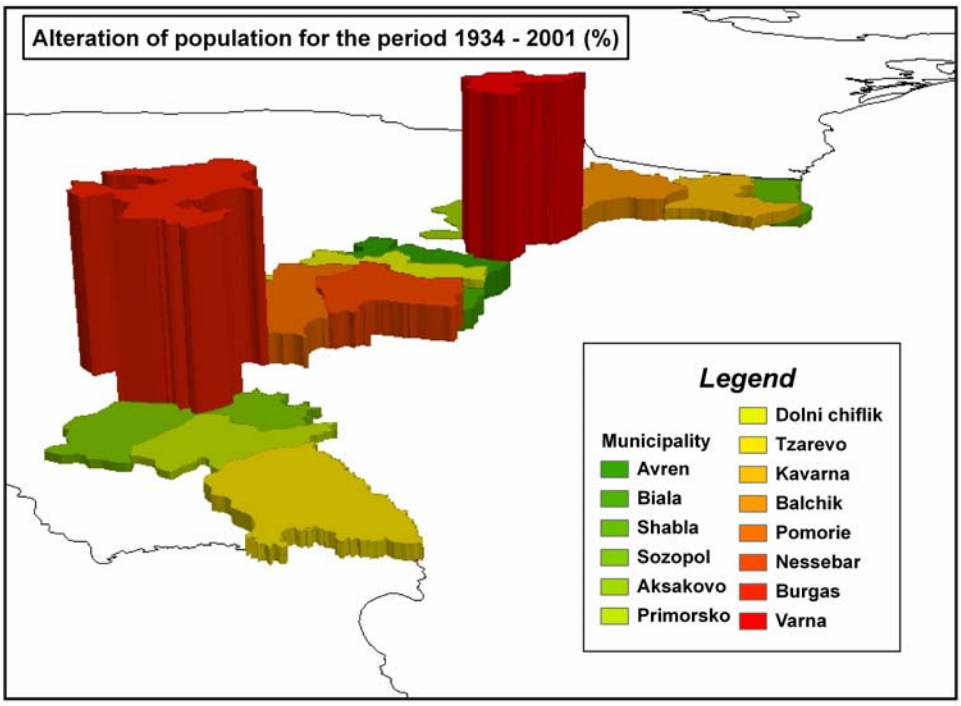

Figure 2. Alteration of population

4.3. Bulgarian Black Sea municipalities - population density

In 2001 the averaged population density for entire country is 71.57 people per square kilometers, whereas in all Bulgarian Black Sea municipalities the averaged value is 121.64 people per square kilometers. This means that the coastal municipalities are twice more densely populated. From 262 municipalities two coastal are the most densely populated: Varna municipality hold the second place with 1349.32 people per square kilometers and Burgas municipality is at seventh place with 408.86 people per square kilometers. The municipalities Primorsko, Tzarevo and Shabla have less than 20 people per square kilometers. From 1934 to 2001 (table 3) the average population density for all Black Sea municipalities have increased with 72.1 people per square kilometers or 144 %, while the average value for the entire country is 16.74 people per square kilometers or 30.53 %.

Municipality	**Population density (people/km^2)**							
	1934	**1946**	**1956**	**1965**	**1975**	**1985**	**1992**	**2001**
Aksakovo	42.89	40.53	36.35	32.02	37.31	35.90	39.07	41.52
Avren	47.98	49.99	44.78	36.56	31.85	25.75	24.92	24.63
Balchik	29.52	33.97	42.14	44.90	46.27	45.76	42.67	42.64
Biala	33.65	32.51	33.75	30.75	26.86	24.84	23.41	21.09
Burgas	104.99	128.23	186.52	263.96	352.82	411.30	414.70	408.86
Dolni chiflik	35.71	39.77	44.54	42.86	42.33	42.84	43.17	41.68
Kavarna	27.87	32.35	38.54	40.25	40.94	39.69	37.48	34.67
Nessebar	28.16	32.17	32.83	33.96	39.35	43.26	44.89	45.46
Pomorie	43.57	47.81	50.36	56.07	62.01	66.38	67.18	66.27
Primorsko	13.37	17.92	17.76	14.63	14.72	17.15	15.23	15.00
Shabla	26.17	31.59	33.73	32.31	28.10	25.68	22.78	19.36
Sozopol	28.31	31.37	34.72	30.29	27.02	26.81	25.46	24.28
Tzarevo	15.57	18.67	20.72	20.05	18.12	18.34	20.05	19.29
Varna	322.80	353.03	535.41	791.78	1088.90	1304.74	1327.73	1349.32
Total	**49.54**	**55.58**	**70.18**	**86.68**	**107.03**	**121.03**	**121.94**	**121.64**

Table 3. Population density in Bulgarian Black Sea municipalities

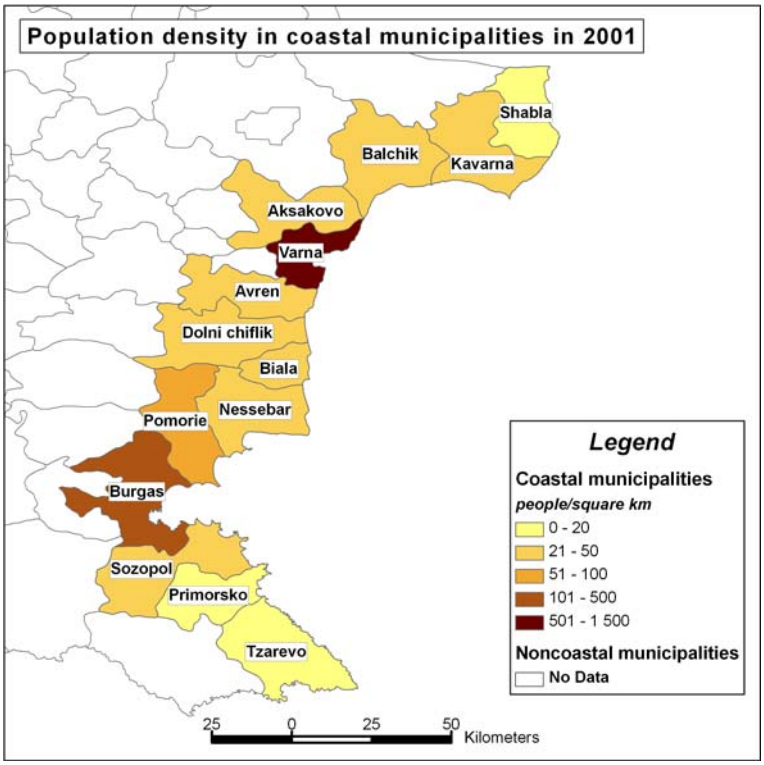

Figure 3. Population density in Bulgarian Black Sea coastal municipalities

4.4. Impact of tourism development

The situation with tourists' abundance is completely different. The tourism and partially the coastal tourism is one of the fastest developing world industry sectors (Hall, 2001) and Bulgaria is also included in this tendency. Data for tourist international arrivals for Bulgaria during the period 2000 - 2004 are presented in table 4. Between 2000-2004 the number of tourists had been continuously increased: from 2 354 052 in 2000 to 4 010 326 in 2004 or the gain is more than 70 %. (http://www.mi.government.bg/tourism/stat).

Year	Number	Years	Increasing (%)
2000	2354052	2000/1999	12.92
2001	2755717	2001/2000	17.06
2002	2992590	2002/2001	8.6
2003	3531567	2003/2002	18.01
2004	4010326	2004/2003	13.56

Table 4. Tourist international arrivals data for entire country

In table 5, data for number of hotels in coastal municipalities for the period 1999-2004 are shown. In the period 1999-2004 it was found that the number of hotels for had been increased from 322 to 640 or almost 100 %. The highest increasing is considered in municipalities Varna, Nessebar and Balchik: in 2004 there are 488 hotels or 76.25 % from all hotels in the Bulgarian Black Sea municipalities (Fig. 4). Exactly at the territories of these 3 municipalities the most famous Bulgarian Black Sea resorts are placed – Golden sands, Sunny beach and Albena resorts. At the same time in Aksakovo municipality in 2004 there is nonworking hotel.

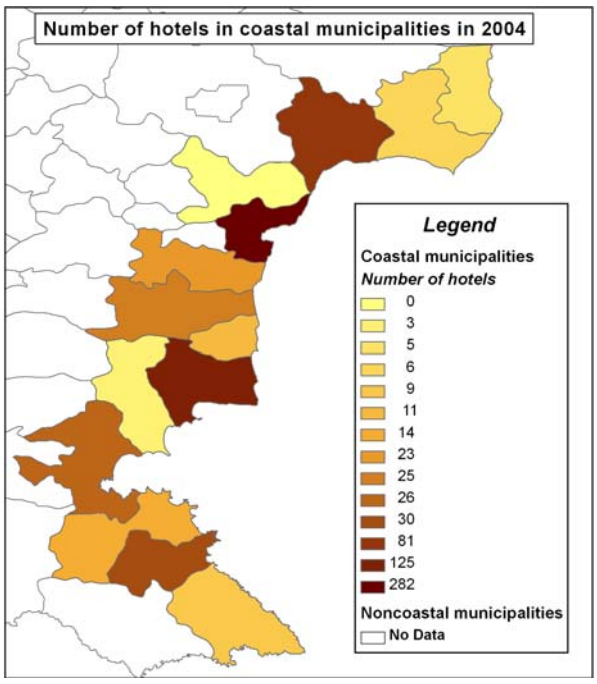

Figure 4. Number of hotels

Bulgarian Black Sea municipalities	Number of hotels					
	1999	2000	2001	2002	2003	2004
Aksakovo	0	0	0	1	0	0
Pomorie	1	3	3	3	1	3
Shabla	4	4	5	5	5	5
Kavarna	3	3	4	5	6	6
Tzarevo	4	7	7	6	7	9
Biala	2	2	5	3	8	11
Sozopol	7	15	10	12	15	14
Avren	4	6	3	3	0	23
Dolni chiflik	3	3	2	3	2	25
Burgas	11	30	21	20	15	26
Primorsko	6	15	13	9	21	30
Balchik	50	58	64	63	63	81
Nessebar	97	58	42	59	101	125
Varna	130	167	146	159	210	282
Total	322	371	325	351	454	640

Table 5. Data for number of hotels

Situation about number of tourist beds is the similar. During the period 1999-2004 the beds number had been increased from 74 277 to 135 784 or with 82.8 % (table 6). In the 3 above mentioned municipalities their number is 114 304 or 84.18 % from all beds (Fig. 5).

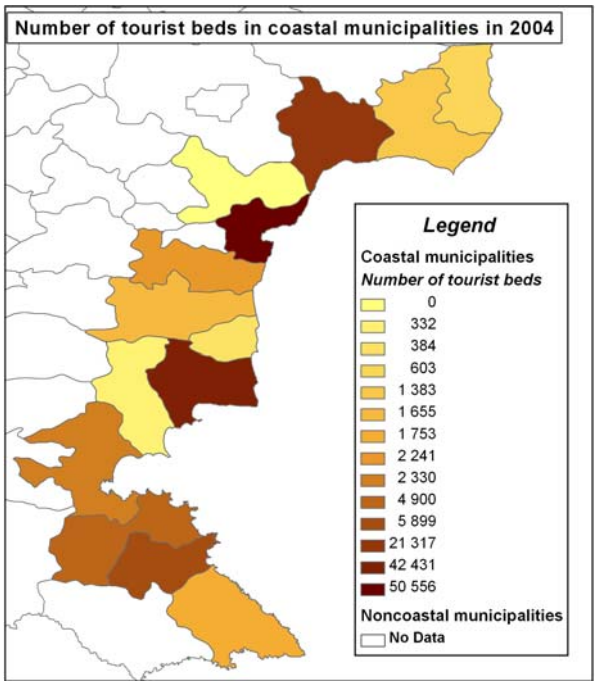

Figure 5. Number of tourist beds

Bulgarian Black Sea municipalities	Tourist beds					
	1999	2000	2001	2002	2003	2004
Aksakovo	0	0	0	10	0	0
Pomorie	212	582	510	485	270	332
Biala	163	163	757	257	373	384
Shabla	918	680	737	573	588	603
Kavarna	922	922	1231	1485	1577	1383
Dolni chiflik	120	177	154	220	134	1655
Tzarevo	771	2012	1663	1148	901	1753
Avren	953	1000	980	834	0	2241
Burgas	1537	5956	3263	2872	1798	2330
Sozopol	2408	2393	2850	2857	4332	4900
Primorsko	2512	3343	3366	1586	5243	5899
Balchik	15602	17274	19147	18966	18151	21317
Nessebar	25117	15599	12602	19602	32913	42431
Varna	23042	30640	27628	37324	40691	50556
Total	74277	80741	74888	88219	106971	135784

Table 6. Data for number of tourist beds

For the same period the numbers of nights spending had grown from 4 852 775 to 10 312 204 or 112 % (Fig.6). In 2004 in municipalities of Varna, Nessebar and Balchik they counted 9109161 or 88.33 % of all spending (table 7). There is also a high disproportion between these 3 municipalities and the rest 11.

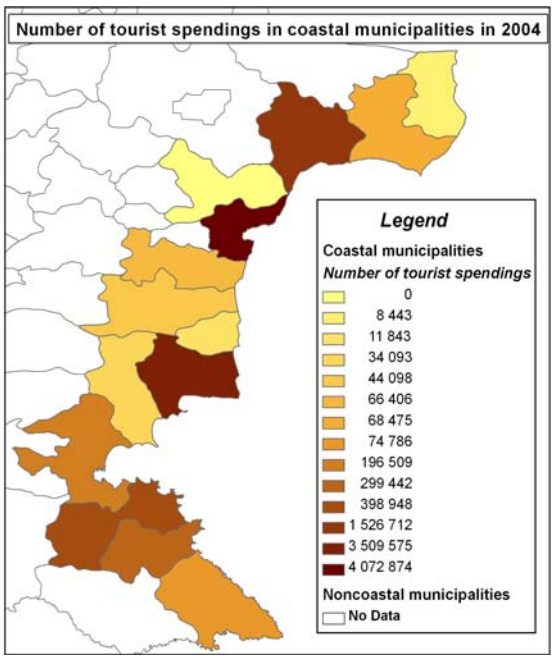

Figure 6. Number of tourist spending

Bulgarian Black Sea municipalities	Number of spending					
	1999	2000	2001	2002	2003	2004
Aksakovo	0	0	0	20	0	0
Shabla	5694	4035	6025	9438	7171	8443
Biala	8046	9821	64512	16688	18180	11843
Pomorie	19794	34442	32628	29345	23538	34093
Dolni chiflik	1898	3142	2750	2438	1827	44098
Avren	43849	25670	30703	28347	0	66406
Kavarna	11877	19282	71432	88006	92548	68475
Tzarevo	27153	47072	43787	16060	23287	74786
Burgas	153098	344543	229513	199940	155765	196509
Primorsko	84004	173830	209081	86914	324061	299442
Sozopol	156073	181917	238283	299611	373026	398948
Balchik	1355323	1685746	2066486	2163553	1618002	1526712
Nessebar	1361289	958404	937416	1127047	2596312	3509575
Varna	1624677	1958176	2386860	2860871	3650624	4072874
Total	**4852775**	**5446080**	**6319476**	**6928278**	**8884341**	**10312204**

Table 7. Data for number of tourist spending

Number of tourists, who prefer to have a rest at the seacoast, is increasing continuously too. For the period 1999-2004 they had been increased with 118 % and the total number had reached 1 450 188, or more than twice of local coastal population (table 8). Again in the municipalities of Varna, Nessebar and Balchik in 2004 the number of tourists was 1 241 127 or 85.58 % from all tourists resting at the Bulgarian Black Sea coastal municipalities (Fig. 7). Every tourist spends 7 days in average, but they are not uniformly spatially and at the time distributed. During the year the most crowded months are July and August and the most crowded places are the big resorts. In these months, total coastal population of the Bulgarian Black Sea coast could be increased with approximately 20%, but at the some resorts more than 200%. The trends show that we can expect at leas 10% yearly tourists' growth for the next few years.

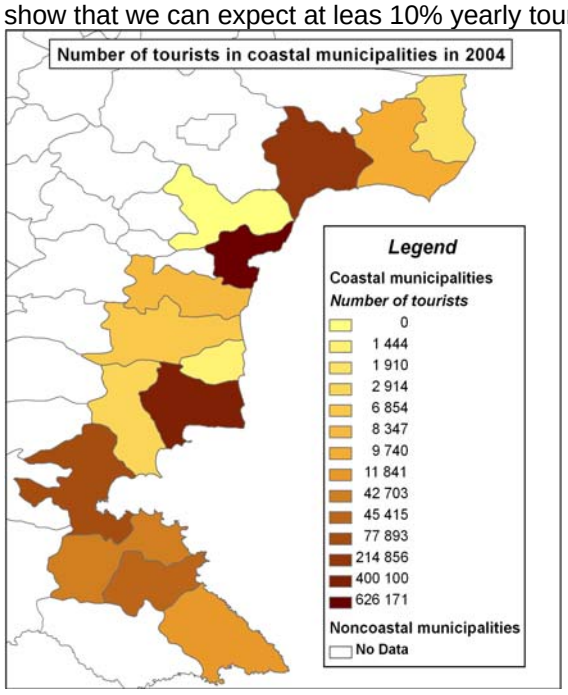

Figure 7. Number of tourists

Bulgarian Black Sea municipalities	Number of tourists					
	1999	2000	2001	2002	2003	2004
Aksakovo	0	0	0	20	0	0
Biala	424	431	8046	1333	1706	1444
Shabla	1257	1015	1849	3015	1915	1910
Pomorie	2426	3587	3589	2565	2014	2914
Dolni chiflik	1367	1528	1942	1307	1184	6854
Avren	7810	4724	4995	3405	0	8347
Kavarna	3709	3996	7367	9503	10096	9740
Tzarevo	4048	7815	5570	3261	3847	11841
Sozopol	24326	22480	27184	33605	40688	42703
Primorsko	11709	20060	17871	11901	34071	45415
Burgas	77828	90156	74393	84018	64764	77893
Balchik	149360	207347	214784	232849	236094	214856
Nessebar	134535	97604	94098	120019	284854	400100
Varna	245043	287343	344832	406972	516773	626171
Total	**663842**	**748086**	**806520**	**913773**	**1198006**	**1450188**

Table 8. Data for number of tourists

4.5. Lowland hazard-prone zones identified along the Bulgarian Black Sea coast. Number of population potentially affected by extremal events.

As a consequence of global climate change it has been projected that the frequency of extremal meteorological events can increase, including strong storms, intensive pouring rainfalls and surge waves (IPCC, 1998).

On the base of topographical maps in scale 1:50 000 the coastal territories, being potentially at risk of flooding, are determined and represented on the following map (Fig.8).

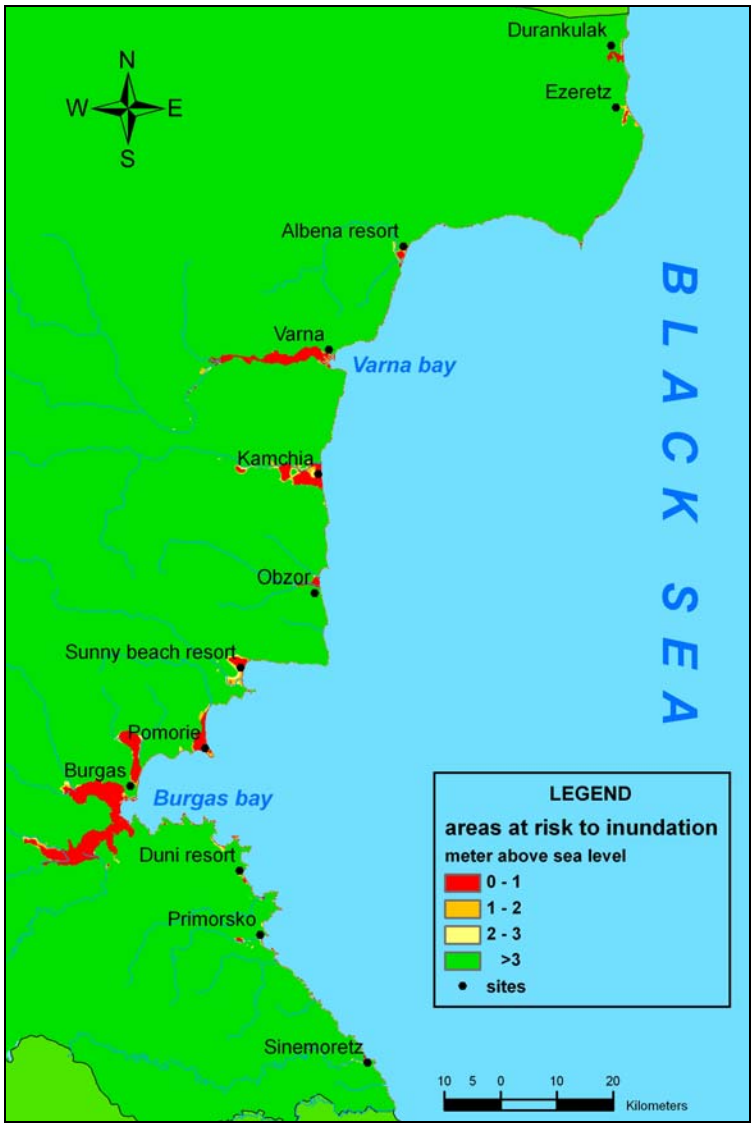

Figure 8.Map of vulnerable lowland coastal territories

The most vulnerable lowland territories along the Bulgarian coast with altitude to 1 m are represented at the map (Fig.8) with red color. On the base of performed analysis the main conclusion could be drawn: in the lowland areas partly or entirely get into 8 cities, 10 villages and 8 famous Bulgarian Black Sea resorts, including 2 regional and 7 municipal centers. As the most risks zones are defined the territories around of Varna town, region of Kamchia river, resort Sunny beach, towns of Pomorie and Burgas. The total number of local population in the mentioned sites in 2001 is 549 765.

The risk of flooding is especially high in summer months, when a great number of tourists having a rest at the sea resorts. Such dangerous flood was happened in the beginning of July 2006, when the very strong storm, accompanied with pouring rains, caused the inundation of part of Sunny beach resort. In the place of Irakli the situation was similar, but because there is not built infrastructure, the damages were the less.

The risks of flooding in the context of biophysical impacts can include the following:

- Increased coastal erosion and reducing of natural beaches
- Landward intrusion of seawater in estuaries and aquifers
- Changes in groundwater characteristics

Related socioeconomic impacts can include the following:

- Increased potential loss of life
- Damage to coastal protection works and other infrastructure
- Increased disease risk
- Loss of renewable and subsistence resources
- Loss of tourism, recreation, and transportation functions
- Loss of nonmonetary cultural resources and values
- Impacts on agriculture and aquaculture through decline in soil and water quality. Increased loss of property and coastal habitats

5. Conclusions:

As a result of the study the next conclusions could be drawn: Analyzing the human population pressure on the coastal ecosystem we could assume total population, which consists of local residents and tourists. Last twenty years there is no significant population growth of the local residents of Bulgarian coastal zone. The existing and continuously improved infrastructure has capability to meet and reduce anthropogenic impact on the ecosystem caused by local population growth. Tourist spate towards Bulgarian Black Sea coast dramatically increases last five years will continue to growth at least few years. The existing facilities in some municipalities could not be able to met this increasing additional pressure and to reduce adequately anthropogenic impact to the marine ecosystems. Considering that the coastal zone is limited land area and very vulnerable, as a boundary between land and sea, this enormous population increasing is the hazard factor for coastal zone sustainability. Although population increasing and coastal development give rise to numerous economic benefits, they also may result in the loss of critical habitat, green space, and biodiversity. Public policymakers and coastal managers are now confronted with the daily task of finding a balance between benefiting from economic growth while mitigating the effects of this growth on coastal environments. This task is becoming ever more challenging as the total coastal population continues to grow in a limited space.

In conditions of global sea level rising and increased extremal natural events the lowland coastal territories are facing a growing number of problems because of developed infrastructure and high population growth in coastal zone. In consequence, functions and human activities, associated with coastal areas have been degraded, and public safety and economy have been impacted.

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