Analysing last century's occurrence and impacts of technological and complex environmental hazards

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Abstract
The purpose of the paper is to present the occurrence and fatalities of the technological and complex environmental hazards and draw an initial picture of concentration if there is any. For that reason, aggregate regional tables are used as well as map visualizations created in R-studio. As it is shown, there appears to be a space concentration on the natural environmental hazards that need to be deeply examined with the use of advanced econometric techniques.

Keywords: Risk; technological - environmental hazards; disaster; economic damage.

JEL codes: C63; D62; H12; I31: Q50.

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1. Introduction

Technology is a controversial topic of discussion. Based on Weisaeth (1994), the first technological attainment that turned from an innovation to a "disaster" was the Dedalus and Icarus example. The ancient Greek inventor created the initial attempt for air transport, when his son Icarus decided to exceed the allowed limits of use, an action which led him to plummeting into the sea. The adverse result of this "technological" invention was caused by man's recklessness. And this is not the only example in the history.

The purpose of this paper is to present the graphical and statistical results based on technological environmental hazards occurred over the last 117 years (1900-2016) as they have been recored by the EM-DAT (2017). The graphical representation includes map visualizations techniques while the numerical representation includes regional aggregated values over the last century. The main purpose of the paper is not focused on the extended literature review on the topic of technological environmental hazards due to the fact that this work will be a supplementary guide to future publications of the authors on this specific field of research. Section 2 presents the full list of natural environmental hazards as it is given by the EM-DAT (2017). while section 3 analyzes the methodology used in order to obtain the resulats that are discussed in section 4. Finally. section 5 gives the general conclusion and proposals for further research.

2. List of Technological and Complex Environmental Hazards

When the field of research is so complicated a great variety of terms and definitions are created. based on the specific impact we investigate. The scientific field of environmental hazards, either natural or technological, contains a detailed list of terms and definitions. Although each term has a specific and detailed explanation for each precise meaning the majority of people tend to be confused and not use the appropriate term.

The case of technological environmental hazards is divided into 3 subgroups: industrial, miscellaneous, transport. Another subgroup of analysis is the case of complex environmental hazards which included famine events. Each subgroup is then divided into types and subtypes based on the common factors of occurrence. Table 1 presents all different subtypes of technological and complex environmental hazards that are listed under the appropriate type and subgroup[1].

Table 1: Natural Hazard Classification (based on CRED – EM-DAT)

	Subgroup		Type		Subtype
Industrial Environmental Hazards					
1	Industrial	1	Industrial	1	---[2]
				2	Chemical Spill
				3	Collapse
				4	Explosion
				5	Fire
				6	Gas Leak
				7	Oil Spill
				8	Poisoning
				9	Radiation
				10	Other
2	Miscellaneous	2	Miscellaneous	11	---
				12	Collapse
				13	Explosion
				14	Fire
				15	Other
3	Transport	3	Transport	16	Air
				17	Rail
				18	Road
				19	Water
Complex Environmental Hazards					
1	Complex	1	Complex	1	---
				2	Famine

[1] For relevant information on environmental natural hazards see Halkos and Zisiadou (2018b) and for relating environmental performance with socioeconomic and cultural factors see Halkos and Zisiadou (2018c)

[2] ---: unidentified cause

3. Methodology and Data

The main attempt of this discussion paper is to establish the high-and-low frequency areas regarding the technological hazards over the last century. More specifically, based on the dataset derived by EMDAT (2017), a full list of information for all technological hazards types is selected. The occurrence information as well as the fatalities and economic damage will, once again, be analyzed following the same procedure as in Halkos and Zisiadou (2018a).

Regarding the national level of analysis, all variables included have been calculated by using the summations of all 117 years of examination. Moreover, for the map visualization procedure, the variables deaths, injured, affected, homeless, total affected, and economic damage have been weighted using the national occurrence level. More specifically, the formula used for the weightings is the following:

$$Reported\ deaths = \frac{Actual\ number\ of\ deaths}{Number\ of\ occurence}$$

R-studio software has been used once again, as in Halkos and Zisiadou (2018), in order to extract the global maps per variable. The packages used for the map visualization procedure are: "rworldmap", "RColorBrewer", "ncdf.tools", "classInt". The weighted variables were finally inserted in the R-studio software environment. Initially, the packages were loaded in the R-studio software environment as shown in the following routine:

```
> library(readxl)
> data <- read_excel("File/data.xlsx")
View(data)
> library("rworldmap".
lib.loc="/Library/Frameworks/R.framework/Versions/3.3/Resources/library")
>library("RColorBrewer".
lib.loc="/Library/Frameworks/R.framework/Versions/3.3/Resources/library")
> library("ncdf.tools".
lib.loc="/Library/Frameworks/R.framework/Versions/3.3/Resources/library")
> library("classInt". lib.loc="/Library/Frameworks/R.framework/Versions/3.3/Resources/library")
> attach(data)
> data<-data
```

Source: Halkos and Zisiadou (2018a)

The creation of the group of analysis is the process presented below which will afterwards lead us to the map process. The ISO coding system is the identification method per country of origin for each event, while the colour palette chosen is the “heat map colour” reporting the low values with yellow and the high values with red colour. Missing or non-affected countries are reported with grey colour.

The following routine presents the group of analysis procedure as well as the map visualization process:

```
> group<-joinCountryData2Map(data.joinCode = "ISO3".nameJoinColumn =
"ISO".mapResolution = "coarse".verbose = TRUE)
> map<-mapCountryData(group.nameColumnToPlot = "Occurrence".catMethod =
"fixedWidth".numCats = 200.addLegend = TRUE.colourPalette = "heat".oceanCol =
"lightblue".missingCountryCol = "grey".mapTitle = "Industrial Occurrence")
> map<-mapCountryData(group.nameColumnToPlot = "Total_deaths".catMethod =
"fixedWidth".numCats = 200.addLegend = TRUE.colourPalette = "heat".oceanCol =
"lightblue".missingCountryCol = "grey".mapTitle = "Industrial Total Deaths")
> map<-mapCountryData(group.nameColumnToPlot = "Injured".catMethod =
"fixedWidth".numCats = 200.addLegend = TRUE.colourPalette = "heat".oceanCol =
"lightblue".missingCountryCol = "grey".mapTitle = "Industrial Injured")
> map<-mapCountryData(group.nameColumnToPlot = "Affected".catMethod =
"fixedWidth".numCats = 200.addLegend = TRUE.colourPalette = "heat".oceanCol =
"lightblue".missingCountryCol = "grey".mapTitle = "Industrial Affected")
> map<-mapCountryData(group.nameColumnToPlot = "Homeless".catMethod =
"fixedWidth".numCats = 200.addLegend = TRUE.colourPalette = "heat".oceanCol =
"lightblue".missingCountryCol = "grey".mapTitle = "Industrial Homeless")
> map<-mapCountryData(group.nameColumnToPlot = "Total_affected".catMethod =
"fixedWidth".numCats = 200.addLegend = TRUE.colourPalette = "heat".oceanCol =
"lightblue".missingCountryCol = "grey".mapTitle = "Industrial Total Affected")
> map<-mapCountryData(group.nameColumnToPlot = "Total_damage".catMethod =
"fixedWidth".numCats = 200.addLegend = TRUE.colourPalette = "heat".oceanCol =
"lightblue".missingCountryCol = "grey".mapTitle = "Industrial Total Damage ('000$)")
```

Source: Modified from Halkos and Zisiadou (2018a)

The same procedure is followed for all three technological environmental hazards, while the complex subgroup has been excluded due to limited observations.

4. Results and Discussion

4.1 Industrial Hazards

Moving forward, we are going to present the regional results for industrial hazards which are presented in Appendix I (Tables 1 and 5). Based both on the tables in Appendix I (1 and 5) and map representations in Appendix II (1-6), the industrial accidents are space concentrated, while at the same time the cause the highest economic damage compared to the other two technological cases. However, the positive aspect is that they are not the most often case of hazards regarding the technological category.

4.2 Miscellaneous Hazards

Moving forward, to the miscellaneous hazards, the regional occurrence and fatality tables are presented in Appendix I (Tables 2 and 6). Based both on the tables in Appendix I (2 and 6) and map representations in Appendix II (7-12), the miscellaneous hazards are space concentrated with fire being the most common case of miscellaneous accidents. Still the positive aspect is the low frequency compared to industrial and transport-related accidents.

4.3 Transport Hazards

The next subgroup is transport hazards. where the regional occurrence and fatality tables are presented in Appendix I (Tables 3 and 7). Based both on the tables in Appendix I (3 and 7) and map representations in Appendix II (13-18), the hypotheses for transport-related accidents cannot be accepted or rejected. What is known though and expected based on literature review is that transport accidents are the most often technological accident with air travel being the safest case, while road travel is the most common accident-related case (Cox et al. 1992).

4.4 Complex Hazards

The next environmental hazard is the complex hazards, where the regional occurrence and fatality tables are presented in Appendix I (Tables 4 and 8). The lack of evidence reduces the ability of representation and visualization which actually leads us to a point where we cannot accept or reject any hypothesis based on this current analysis.

5. Conclusions

The purpose of this paper is to describe the technological and complex environmental hazards occurred over the last 117 years (1900-2016) as they have been recorded by the EM-DAT (2017) by using graphical and statistical methods. As it has been seen, in most cases there is a space concentration regarding the technological environmental hazards. Although we cannot rely on graphical and statistical representations in order to draw research conclusions, we can propose further research based on the advanced econometric approaches proposed by literature review. Moreover, as it has already been mentioned, this work will be used as a supplementary guide to further research.

Reference

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R-studio Package Guides

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ncdf.tools: https://cran.r-project.org/web/packages/ncdf.tools/ncdf.tools.pdf

RColorBrewer: https://cran.r-project.org/web/packages/RColorBrewer/RColorBrewer.pdf

rworldmap: https://cran.r-project.org/web/packages/rworldmap/rworldmap.pdf

Appendix I

Table 1: Industrial Hazards – Most suffered countries

	Country's Name	Occurrence		Country's Name	Total Deaths		Country's Name	Injured		Country's Name	Affected
1	China	525	**1**	Iraq	411	**1**	Iraq	2,055	**1**	Maldives	107,500
2	India	98	**2**	Colombia	178	**2**	Spain	1,571.2	**2**	Panama	80,743
3	USA	80	**3**	Hong Kong	135	**3**	India	1,063.6	**3**	Soviet Union	48,818.2
4	Mexico	39	**4**	Bangladesh	122.9	**4**	Japan	1,021.5	**4**	Cote d' Ivoire	47,465.5
5	Russian Federation	37	**5**	Soviet Union	112.7	**5**	Morocco	670.7	**5**	Brazil	39,303.1
6	Belgium	34	**6**	Korea [3]	110	**6**	Kyrgyzstan	600	**6**	Canada	12,377.5
7	Nigeria	33	**7**	Yugoslavia	100	**7**	Nicaragua	400	**7**	Nicaragua	11,500
8	Turkey	26	**8**	Ethiopia	100	**8**	Korea[4]	378.9	**8**	Venezuela	6,666.7
9	Ukraine	25	**9**	Nigeria	88.2	**9**	Venezuela	267.2	**9**	Guatemala	6,008.5
10	Pakistan	24	**10**	France	87.35	**10**	Egypt	263	**10**	USA	4,506
	Country's Name	**Homeless**		**Country's Name**	**Total Affected**		**Country's Name**	**Economic Damage ('000)**			
1	Italy	31,666.7	**1**	Maldives	107,500	**1**	Algeria	800,000			
2	Japan	24,615.4	**2**	Panama	80,743	**2**	Spain	775,415.9			
3	Hungary	2,373.3	**3**	Soviet Union	48,985.1	**3**	USA	269,593.75			
4	Sudan	2,000	**4**	Cote d' Ivoire	47,500	**4**	Soviet Union	254,545.45			
5	Indonesia	1,800	**5**	Brazil	39,377.3	**5**	United Kingdom	82,193.75			
6	Nicaragua	1,250	**6**	Italy	33,733.8	**6**	Hungary	54,333.3			
7	Mexico	529.7	**7**	Japan	26,726	**7**	Mexico	46,956.4			
8	Thailand	277.8	**8**	Nicaragua	13,150	**8**	Russian Federation	35,675.7			
9	Ecuador	150	**9**	Canada	12,378.6	**9**	Netherlands	34,775			
10	Senegal	125	**10**	Venezuela	6,933.8	**10**	Ukraine	34,680			

[3] (the Democratic People's Republic of)
[4] (the Republic of)

Table 2: Miscellaneous Hazards – Most suffered countries

	Country's Name	Occurrence		Country's Name	Total Deaths		Country's Name	Injured		Country's Name	Affected
1	China	129	**1**	Paraguay	390	**1**	Congo (the)	1,638.5	**1**	El Salvador	247,500
2	India	127	**2**	Japan	306.8	**2**	Paraguay	300	**2**	Guyana	62,620.25
3	Philippines	105	**3**	Guyana	225.25	**3**	Albania	300	**3**	Gambia	43,000
4	USA	82	**4**	Saudi Arabia	223.8	**4**	Jordan	250	**4**	Haiti	37,358.2
5	Russian Federation	57	**5**	Congo (the)	214	**5**	Mozambique	244.5	**5**	Sri Lanka	20,000
6	Pakistan	33	**6**	South Sudan	203	**6**	Netherlands	239	**6**	Palau	12,000
7	Nigeria	29	**7**	Jamaica	187	**7**	Burkina Faso	200	**7**	Albania	10,000
8	Egypt	28	**8**	Iraq	168.6	**8**	Saudi Arabia	174.88	**8**	Myanmar	9,060.7
9	Brazil	27	**9**	Turkey	167.4	**9**	Sweden	162	**9**	Uzbekistan	6,766. 7
10	Indonesia	27	**10**	Cambodia	100.2	**10**	Canada	159.9	**10**	Congo (the)	5,023
	Country's Name	**Homeless**		**Country's Name**	**Total Affected**		**Country's Name**	**Economic Damage ('000)**			
1	Ethiopia	6,643.75	**1**	El Salvador	247,522.75	**1**	Portugal	83,333.3			
2	Uganda	4,571.4	**2**	Guyana	62,620.25	**2**	Netherlands	62,920			
3	Sri Lanka	4,000	**3**	Gambia	43,000	**3**	Germany	52,942.8			
4	Cambodia	4,000	**4**	Haiti	37,435.6	**4**	Turkey	18,533.3			
5	Uzbekistan	2,353.3	**5**	Sri Lanka	24,027	**5**	Barbados	15,000			
6	Kenya	2,353	**6**	Palau	12,004	**6**	Ecuador	12,533.5			
7	Hong Kong	1,992.8	**7**	Myanmar	10,588.8	**7**	Myanmar	11,258.5			
8	Benin	1,877.5	**8**	Albania	10,300	**8**	Iran [5]	9,375			
9	Bangladesh	1,710.5	**9**	Uzbekistan	9,172.7	**9**	Trinidad & Tobago	8,500			
10	Mali	1,666.7	**10**	Congo (the)	6,661.5	**10**	Puerto Rico	6,050			

[5] (Islamic Republic of)

Table 3: Transport Hazards – Most suffered countries

	Country's Name	Occurrence		Country's Name	Total Deaths		Country's Name	Injured		Country's Name	Affected
1	India	493	**1**	Estonia	912	**1**	Korea [6]	252.3	**1**	Korea [7]	5,291.7
2	Nigeria	270	**2**	Guam	228	**2**	Canada	180.5	**2**	Mozambique	2,277.6
3	China	265	**3**	Jamaica	175	**3**	Singapore	117	**3**	Estonia	140
4	USA	180	**4**	Japan	111.4	**4**	Costa Rica	81.7	**4**	Macao	133
5	Indonesia	177	**5**	Canary Is	108.4	**5**	Canary Is	70.4	**5**	Bahamas (the)	106.4
6	Bangladesh	160	**6**	Ireland	104.5	**6**	Argentina	65.4	**6**	Tonga	54
7	Egypt	155	**7**	Philippines	101.1	**7**	UK	62.6	**7**	Turks & Caicos Is	50
8	Pakistan	153	**8**	Libya	101	**8**	Japan	60.1	**8**	Maldives	50
9	South Africa	146	**9**	Canada	98.8	**9**	Lesotho	60	**9**	Philippines	46.17
10	Peru	143	**10**	Haiti	85.9	**10**	Hong Kong	58.1	**10**	Canada	38.1
	Country's Name	**Homeless**		**Country's Name**	**Total Affected**		**Country's Name**	**Economic Damage ('000)**			
1	Korea [8]	1,541. 7	**1**	Korea [9]	7,085. 7	**1**	Korea [10]	68,000			
2	Canada	1,13.2	**2**	Mozambique	2,304.8	**2**	Austria	17,142.8			
3	Soviet Union	5.2	**3**	Canada	331.8	**3**	Canada	4,433.9			
4	Italy	1.5	**4**	Estonia	140	**4**	Spain	3,035.4			
5	Mozambique	0	**5**	Macao	133	**5**	Comoros	2,500			
6	Estonia	0	**6**	Singapore	117	**6**	Korea [11]	1,163.6			
7	Macao	0	**7**	Bahamas (the)	116.4	**7**	Japan	445.9			
8	Bahamas (the)	0	**8**	UK	94.1	**8**	Peru	433.6			
9	Tonga	0	**9**	Costa Rica	81.7	**9**	USA	127.8			
10	Turks & Caicos Is	0	**10**	Canary Is	74	**10**	India	77.1			

[6] (the Democratic People's Republic of)
[7] (the Democratic People's Republic of)
[8] (the Democratic People's Republic of)
[9] (the Democratic People's Republic of)
[10] (the Democratic People's Republic of)
[11] (the Republic of)

Table 4: Complex Hazards – Most suffered countries

	Country Name	Occurrence		Country Name	Total Deaths		Country Name	Affected
1	Armenia	1	**1**	Soviet Union	5,000,000	**1**	Korea[12]	8,000,000
2	Bangladesh	1	**2**	Korea [13]	610,000	**2**	Armenia	3,500,000
3	Burundi	1	**3**	Armenia	0	**3**	Sudan	2,600,000
4	Cambodia	1	**4**	Bangladesh	0	**4**	Burundi	2,000,000
5	Central African Republic	1	**5**	Burundi	0	**5**	Yemen	1,437,214
6	Comoros	1	**6**	Cambodia	0	**6**	Cambodia	900,000
7	India	1	**7**	Central African Republic	0	**7**	India	710,000
8	Korea [14]	1	**8**	Comoros	0	**8**	Comoros	300,000
9	Nicaragua	1	**9**	India	0	**9**	Bangladesh	128,400
10	Panama	1	**10**	Nicaragua	0	**10**	Togo	50,000
11	Sudan	1	**11**	Panama	0	**11**	Central African Republic	45,000
12	Togo	1	**12**	Sudan	0	**12**	Nicaragua	12,500
13	Yemen	1	**13**	Togo	0	**13**	Panama	3,000
14	Soviet Union	1	**14**	Yemen	0	**14**	Soviet Union	0

[12] (the Democratic People's Republic of)
[13] (the Democratic People's Republic of)
[14] (the Democratic People's Republic of)

Table 5: Industrial Hazards – Real Values and Percentages

	Occurrence	Deaths	Injured	Affected	Homeless	Total Affected	Economic Damage (‘000)
---	3	133	10	0	0	10	0
Chemical Spill	108	610	8,773	636,778	7,430	652,981	1,198,954
Collapse	141	5,657	2,218	133	637	2,988	1,335,000
Explosion	730	35,225	33,236	293,078	226,557	552,871	25,098,674
Fire	198	4,748	4,749	455,435	4,485	464,669	2,608,005
Gas Leak	53	2,818	115,468	397,652	0	513,120	30,000
Oil Spill	8	1	120	29,017	0	29,137	30,000
Poisoning	75	3,565	54,442	594,080	0	648,522	0
Radiation	9	86	1,909	742,243	320,000	1,064,152	2,800,000
Other	109	4,776	1,434	98,190	36,000	135,624	9,960,407
	1,434	**57,619**	**222,359**	**3,246,606**	**595,109**	**4,064,074**	**43,061,040**

Table 6: Miscellaneous Hazards – Real Values and Percentages

	Occurrence	Deaths	Injures	Affected	Homeless	Total Affected	Economic Damage (‘000)
---	2	22	0	10	600	610	0
Collapse	270	13,565	11,483	274,231	19,929	305,643	283,800
Explosion	197	6,811	17,375	77,704	16,592	111,671	619,100
Fire	682	33,803	17,917	663,617	523,905	1,205,439	1,727,470
Other	234	12,976	30,245	1,839,086	300	1,869,631	0
	1,385	**67,177**	**77,020**	**2,854,648**	**561,326**	**3,492,994**	**2,630,370**

Table 7: Transport Hazards – Real Values and Percentages

	Occurrence	Deaths	Injures	Affected	Homeless	Total Affected	Economic Damage (‘000)
Air	1,027	48,321	7,215	1,226	0	8,441	144,100
Rail	605	27,215	56,942	38,159	9,550	104,651	903,000
Road	2,510	60,834	43,206	2,338	0	45,544	7,700
Water	1,349	100,630	12,683	73,342	6,000	92,025	92,900
	5,491	**237,000**	**120,046**	**115,065**	**15,550**	**250,661**	**1,147,700**

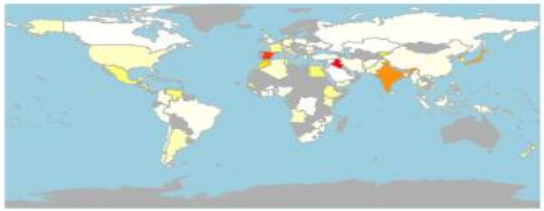
Table 8: Complex Hazards – Real Values and Percentages

	Occurrence	Deaths	Injures	Affected	Homeless	Total Affected	Economic Damage (‘000)
---	6	500,0000	0	2,333,114	0	2,333,114	0
Famine	8	61,0000	0	17,353,000	0	17,353,000	0
	14	**5,610,000**	**0**	**19,686,114**	**0**	**19,686,114**	**0**

Appendix II

1 **Industrial Total Deaths**

2 **Industrial Injured**



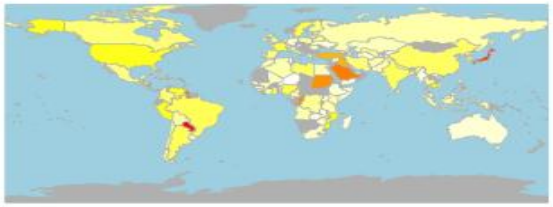
3 **Industrial Affected**

4 **Industrial Homeless**

5 **Industrial Total Affected**

6 **ndustrial Economic Damage ('000$)**

7 **Miscellaneous Total Deaths**



8 **Miscellaneous Injured**

9 **Miscellaneous Affected**

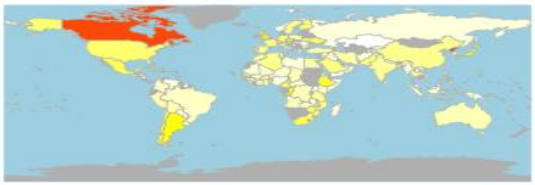
10 **Miscellaneous Homeless**

11 **Miscellaneous Total Affected**

12 **Miscellaneous Economic Damage ('000$)**

13 **Transport Total Deaths**

14 **Transport Injured**



15 **Transport Affected**

16 **Transport Homeless**

17 **Transport Total Affected**

18 **Transport Economic Damage ('000$)**