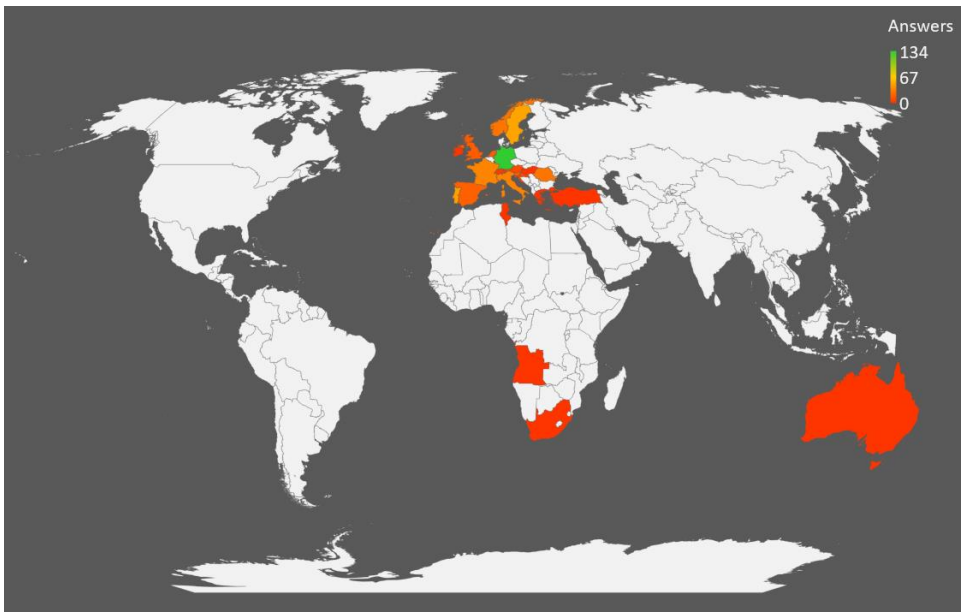
Results of the survey on the significance of climate change impacts on geo-structures across EU countries

Part 1 – Background information

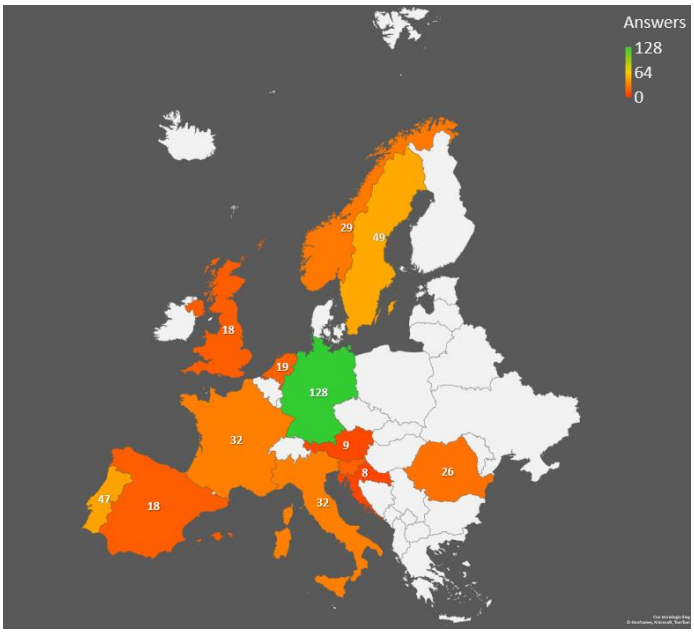
The respective results of the answers are shown after each question.

1. Please indicate for which country you are filling in this questionnaire?

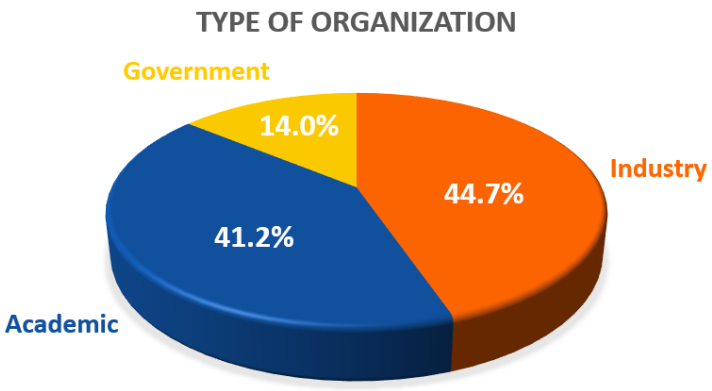
In total we received 474 answers divided between countries, as shown below.



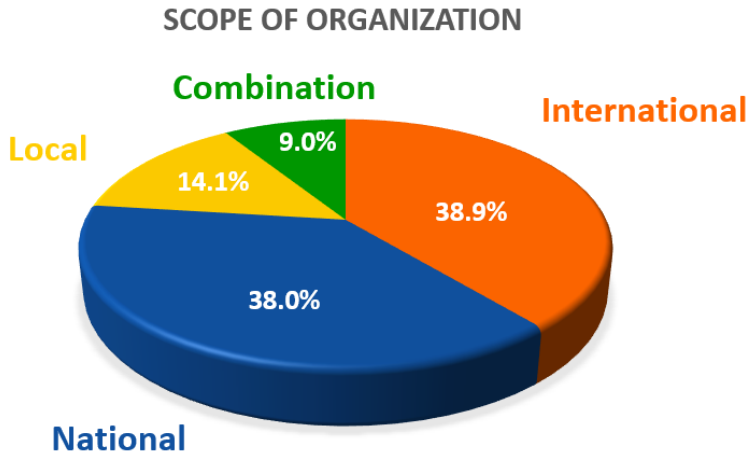
In the following analysis, answers stating no familiarity with climate change nor with its impacts on the engineering geo-structures in the respective country were not considered, reducing the answers to 451. Furthermore, countries with less than six answers were also excluded from the analysis. Hence, the total number of answers taken into account is 434, as illustrated in the following map chart.



2. Type of organization: Academic, Industry, Government?

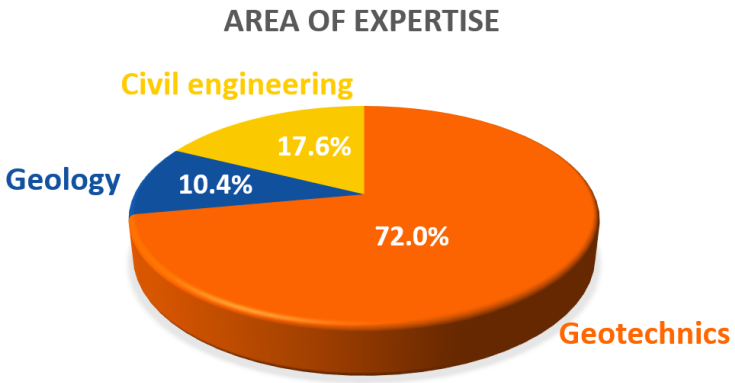


3. Scope of organization: Local, National, International?



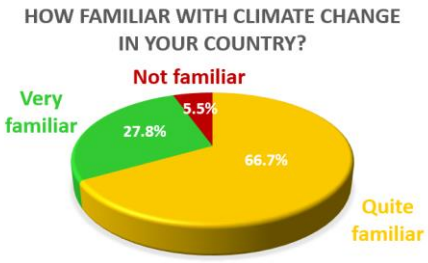
4. Area of expertise?

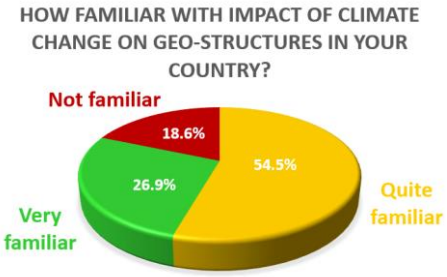
As there were no alternatives, there is a large spread of the answers. Therefore, the major groups are divided as shown below.



5. How familiar are you with the topic of climate change and its effects? (very, quite or not familiar)
6. How familiar are you with the impacts of climate change on the engineering geo-structures in your country? (very, quite or not familiar)

The respondents that answered “not familiar” on both these questions were not considered in the evaluation of results. Here all 474 answers are considered.





Part 2 - Impacts of climate change on geo-structures and their degree of significance in EU countries

The results are shown in the table below. The respective countries are represented by their country codes. Then some of the climate signals with high impact in many countries and the type of impact are shown in maps. Please refer to the following legend for the interpretation of the map charts.

Legend

- No impact or not applicable
- Low impact
- Medium impact
- High impact

Climate Change Signal	Effect on geotechnical/geological properties and processes	Potential Impact on geo-structures	Score												
			AT	DE	ES	FR	GB	HR	IT	NL	NO	PT	RO	SE	SI
A. Increased precipitation[1]	A.1 Degradation of material strength due to increased saturation and physical weathering	Instability of slopes	2	2	2	2	3	2	3	1	3	2	3	3	3
		Instability of embankments	2	2	2	2	2	2	2	2	2	2	2	2	2
	A.2 Increased mineral dissolution due to increased chemical weathering	Instability of other engineered structures	2	2	2	2	2	1	2	2	2	2	2	2	2
	A.3 Increased water erosion	Structure collapse/damage on karstic topography	1	1	1	2	2	1	2	-	1	2	2	1	2
	A.4 Increased surface runoff	Damage/ failure of structure from flooding	2	2	2	2	3	2	2	2	2	2	2	2	3
	A.5 Increased surface and ground water level and flow	Overtopping/breaching of dams and dikes	2	2	2	2	2	2	2	2	1	2	2	2	2
B. Decreased precipitation/increased drought periods[1]	B.1 Degradation of material strength due to shrinkage/desiccation and increased physical weathering	Cracking and instability of slopes	1	2	2	2	2	2	2	1	1	2	2	2	2
		Cracking and instability of embankments	1	2	1	2	2	2	2	2	1	2	2	2	2
	B.2 Decreased surface and ground water level and flow	Cracking and instability of other engineered structure	1	2	1	2	2	1	2	1	1	1	2	1	1
	B.3 Increased wind erosion	Structure settlement/subsidence	1	2	2	2	2	1	2	2	1	2	2	2	2
C. Increased air temperature and periods of warm weather in winter	C.1 Degradation of material strength from increased saturation and physical weathering due to snow and ice melting	Instability of slopes	2	1	1	1	1	1	2	1	2	1	2	2	2
		Instability of embankments	1	1	1	1	1	1	1	1	2	1	2	2	1
	C.2 Changed geotechnical properties of perennially frozen soil/rocks	Instability of other engineered structures	1	1	1	1	1	1	1	1	2	1	2	2	1
	C.3 Increased surface runoff from snow and ice melting	Damage/ failure of structure from flooding	1	1	1	1	1	2	1	1	2	1	2	2	1
	C.4 Increased water erosion	Overtopping/breaching of dams and dikes	1	1	1	1	1	1	1	1	1	1	2	2	1
	C.5 Increased surface and ground water level and flow	Structure collapse/damage on karstic topography	1	1	1	1	1	1	1	-	1	1	2	1	1
	C.6 Increased mineral dissolution due to increased chemical weathering														
D. Increased number of intense rain/drought cycle	D.1 Degradation of material strength due to increased saturation/desiccation and increased weathering	Cracking and Instability of slopes	2	2	2	2	2	2	3	1	2	2	2	2	3
		Cracking and instability of embankments	2	2	2	2	3	2	2	2	2	2	2	2	2
	D.2 Increased shrink-swell behaviour of clay soils	Cracking and instability of other engineered structures	1	2	2	2	2	2	2	2	2	2	2	2	2
	D.3 Increased water and wind erosion														
E. Increased number of frost-thaw cycle	E.1 Degradation of material strength due to increased frost heave/thaw settlement and physical weathering	Cracking and Instability of slopes	2	2	1	2	2	1	2	1	2	1	2	2	2
		Cracking and instability of embankments	2	2	1	1	1	1	2	1	2	1	2	2	2
		Cracking and Instability of other engineered structures	2	2	1	1	2	1	2	1	2	1	2	2	2
F. Increased frequency and intensity of extratropical cyclones and storms	F.1 Degradation of material strength due to increased saturation and physical weathering	Instability of slopes	1	2	2	2	2	1	2	1	1	2	2	1	2
		Instability of embankments	1	2	2	1	2	2	2	1	1	2	2	1	2
	F.2 Increased mineral dissolution due to increased chemical weathering	Instability of other engineered structures	1	2	1	2	2	1	2	1	1	2	2	1	2
	F.3 Increased surface runoff	Structure collapse/damage on karstic topography	-	1	1	1	1	1	1	-	1	1	1	1	1
	F.4 Increased surface and ground water level and flow	Damage/ failure of structure from flooding and/or strong wave action	1	2	2	2	2	1	2	2	2	2	1	2	2
	F.5 Frequent and higher sea water rise from storm surges														
	F.6 Increased loading due to strong wind and wave action	Overtopping/breaching of dams and dikes	1	2	1	2	2	1	2	2	1	2	1	2	2
	F.7 Increased water and wind erosion	Damage/failure of tall structure foundation from strong wind action	1	1	1	2	2	1	2	1	1	2	1	2	1
G. Sea level rise	G.1 Degradation of material strength due to increased saturation and increased weathering	Instability of coastal slopes	-	2	2	2	3	2	2	2	2	3	2	2	2
		Instability of coastal embankments	-	2	2	2	2	2	2	2	2	2	2	2	2
	G.2 Increased water erosion	Instability of other engineered coastal structures	-	2	2	2	3	2	2	2	2	2	2	2	2
	G.3 Landward encroachment of the sea	Damage/failure of engineered coastal structures from flooding	-	2	2	2	3	1	2	2	2	2	2	2	2
		Overtopping/breaching of dykes and levees	-	2	2	2	2	2	2	3	1	2	2	2	2
H. Increased wind speed	H.1 Increased wind erosion	Instability of slopes	1	1	1	-	1	1	1	1	1	1	1	1	1
	H.2 Increased dynamic load	Instability of embankments	-	1	1	-	1	1	1	1	1	1	1	1	1
		Instability of other engineered structures	1	1	1	1	1	1	1	1	2	2	1	2	2
		Damage/failure of tall structure foundation	1	1	2	2	1	1	2	1	2	2	1	2	2

[1]In terms of duration, frequency and/or intensity

Note that ISO-2 alpha codes are used for referring to the countries.

A. Increased precipitation

Instability of slopes

Instability of embankments

Instability of other engineered structures

Damage/ failure of structure from flooding

Overtopping/breaching of dams and dikes

B. Decreased precipitation/increased drought periods

Structure settlement/subsidence

D. Increased number of intense rain/drought cycle

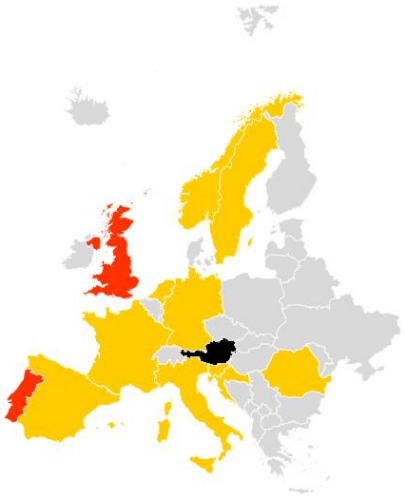
Cracking and instability of slopes

Cracking and instability of embankments

Cracking and instability of other engineered structures

G. Sea level rise

Instability of coastal slopes



Instability of coastal embankments

Instability of other engineered coastal structures

Damage/failure of engineered coastal structures from flooding

Overtopping/breaching of dykes and levees