European
Commission

JRC TECHNICAL REPORT

M7.8 and M7.5 Earthquakes in Türkiye and Syria

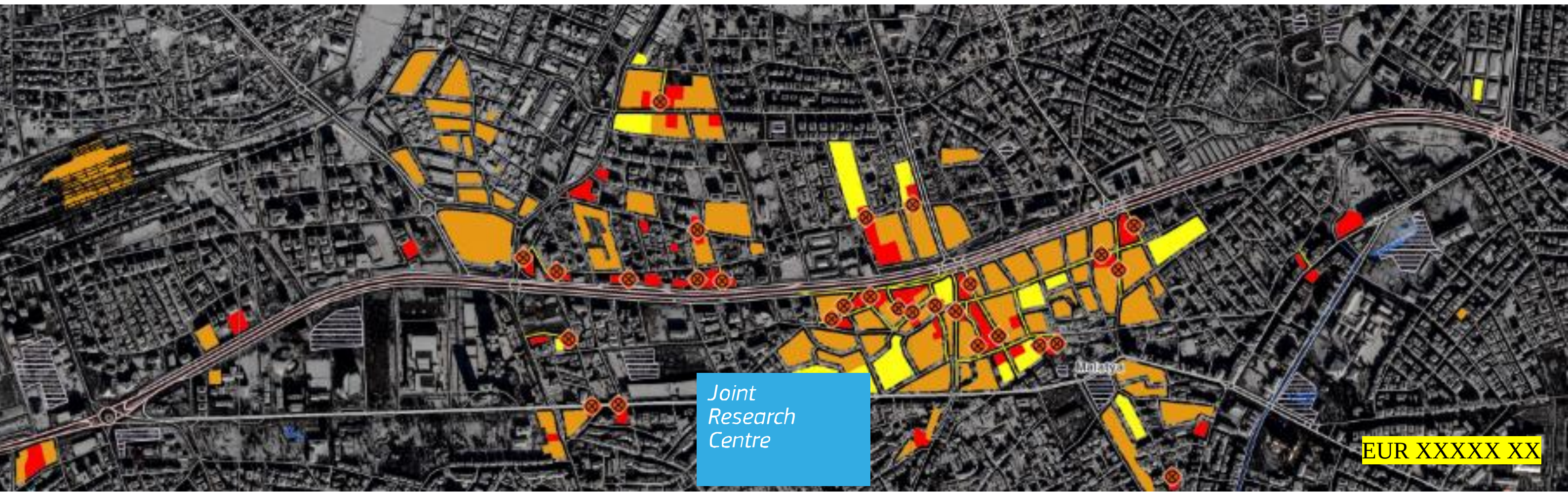
Update of the EC-JRC Scientific Analysis – Report #6 as of 27 February 2023 at 14:00 UTC

GDACS RED ALERT
M7.8 in Türkiye on 06 Feb 2023 01:17 UTC – 04:17 local time

GDACS ORANGE ALERT
M7.5 in Türkiye 06 Feb 2023 10:24 UTC – 13:24 local time

Santini M., Abad Perez J., Proietti C., Necmioglu O., Bavera D., Caravaggi I., Ceccato P., De Girolamo L., Duta A-M., Gerhardinger A., Joubert-Boitat I., Lentini A., Mari Rivero I., Mastronunzio M., Osato F., Rosales Sanchez C., Salvitti V., Spagnolo L., Spruyt P., Tucci M., De Groeve T.

2023



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Contents

Abstract

This is the sixth JRC emergency report on the ongoing earthquake crisis in Türkiye and Syria started 06 Feb 2023 at 01:17 UTC – 04:17 local time (previous reports published on 06, 07, 08, 10 and 17 February, respectively). Please note that this report is complementary to the previous ones, i.e., it does not necessarily include information already shared. Previous reports are available here.

This update focuses on the earthquake **impact on buildings**, providing a commentary on the damage estimation and the preliminary damage assessment from the field, performed by Turkish authorities. These has then been compared with 2 different damage estimation methodologies, to get a reasonable level of uncertainty for the latter, for future calculations of the reconstruction needs of the area. An **estimation of the volume of debris** was attempted, based on the Global Human Settlement Layer (GHSL) database and a methodology defined by JRC, it was inconclusive and will be updated in future reports.

The reports provide also a situation analysis of the **earthquake-related floods and possible earthquake-affected dams** both in Türkiye and in Syria, as well as of the impact of the earthquake on the **cultural heritage** of both countries.

Other information included are about the **monitoring of Persons of Concern in Syria**; the **drought situation** and possible impact on agriculture and other important sectors, with consequences on the viable risk reduction strategies; the available **products** -and those planned in the coming days- **from the satellite mapping systems activated**; the monitoring of **health system capacity and health related issues**, as well as of the epidemiological situation. An annex has been dedicated to a non-exhaustive **inventory of relevant data and information** available from multiple sources and **organized by key sector** of the UNDP Türkiye Earthquake Recovery and Reconstruction Assessment Concept Note (21 February 2023).

Acknowledgements

The authors wish to thank the many colleagues who contributed to this report in record time.

Authors

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Executive summary

- With the scope of providing evidence to a preliminary **Post Disaster Needs Assessment (PDNA)** process, two different building damage estimation models have been performed and compared to field damage assessment data. Taken together, they also provide a measure of the uncertainty in the reported damage data. **The preliminary results for Türkiye allow to confirm the order of magnitude of the building damages reported by the National Authorities.** The most affected province is Hatay, with a calculated mean value of destroyed building estimation of 27%, compared to a reported value of 19%. A general overestimation of the "no damage" category compared to the damage reports has been detected. This can be due to the preliminary assessments which started, as common practice in post-earthquake field surveys, from the most damaged buildings.
- Turkish media has reported an estimated 50-230 million tons of debris. An attempt by the JRC to corroborate this information was inconclusive and will be updated in future reports.
- Monitoring of earthquake-related floods and earthquake-affected dams both in Türkiye and in Syria is performed. Namely, the four monitored structures are: the **Orontes/Asi River overflow (Syria, Türkiye), Atatürk Dam (Türkiye), Sultansuyu Dam (Türkiye) and Maydanki-Afrin Dam (Syria).** The **Copernicus Risk and Recovery Mapping** has also been activated to simulate a potential **dam break of the Maydanki (Afrin) Dam**. The results of this activation are considered sensitive and are not publicly available.
- A **severe lack of precipitation affects both Türkiye and Syria** with impacts on soil moisture and rivers' flow. The compound effects of the catastrophic earthquakes of February 2023 and the drought may exacerbate impacts on water availability for human, agricultural and energy use.
- **Cultural heritage** has been damaged by the ongoing earthquake crisis in both countries. A list and map of reported damaged sites is provided for Türkiye. Preliminary considerations about the impact of the seismic crisis on cultural heritage in Syria are also shared.
- Public health authorities expressed concerns about a high risk of new or exacerbated outbreaks of food and waterborne disease, respiratory and vaccine-preventable infections in both countries. In this report we share information on the **observed increased number of cholera infections in northwestern Syria** and the **detected case of chickenpox and increased number of acute intestinal infections in Türkiye**. Actions recommended by ECDC are also summarised.
- As of today, **Copernicus Emergency Management Service - Rapid Mapping made available 64 satellite-based damage maps (949 km2)**, with preliminary damage assessment information and light loss assessment. All links to available products and a summary of the relevant outcomes are provided in this report.
- The ECHO-ERCC, on behalf of United Nations Development Programme/UNDP, requested an activation to facilitate **the response/early recovery phase** of the affected areas in Syria, specifically in 14 urban areas, where UNDP plans to facilitate aid. More specifically to verify and highlight detailed damage assessment using various sources, **IDP camps** and informal settlement's **location, volume of debris** from destroyed/partially destroyed buildings and direct and indirect **economic loss assessments**. This activation is about to start and the results will be available within 10 calendar days.

1 Introduction

Following the main shocks, as of 26 February 2023, 17:30 UTC, 9 205 aftershocks occurred along both fault systems, with 437 aftershocks of M>4. On 20 February 2023 at 17:04, another earthquake with M6.3 occurred in Hatay, in the most southern part of the rupture zone of the first (M7.8 earthquake). A scientific discussion on the overall crustal stress change resulting from both earthquakes is provided in this report. The M6.3 earthquake on 20 February was in line with the concerns reflected in this discussion. The possibility of aftershocks with M>6 still cannot be excluded.

Türkiye

The Disaster and Emergency Management Presidency of Türkiye (AFAD) reports, in the last bulletin of 27 February at 14:00 UTC, **44 375 fatalities** in 11 Provinces (Kahramanmaras, Gaziantep, Sanliurfa, Diyarbakir, Adana, Adiyaman, Osmaniye, Hatay, Kilis, Malatya, and Elazig) across southern Türkiye. In addition, AFAD reports a total of **448 010 evacuated people** to other Provinces. Several media reports quoting government authorities stated the number of fatalities as **44 375** as of 27 February. The number of **injured people** as of 27 February is **108 178**. Furthermore, AFAD reports, as of 21 February at 6:00 UTC, **6 fatalities** and **294 injured people** due to the M6.3 occurred in Hatay on 20 February.

On 6 February the UCPM was activated by the Republic of Türkiye and the Emergency Response Coordination Centre (ERCC) is coordinating the mobilization.

A **three-month State of Emergency** (please refer to Annex I for further details) **has been declared in Kahramanmaraş, Kilis, Diyarbakır, Adana, Osmaniye, Gaziantep, Şanlıurfa, Adıyaman, Malatya and Hatay, a total of 10 provinces**. On 15 February 2023, a spokesman of the ruling part AKP announced that Elazığ will also be included among the earthquake impacted region as the 11th province ([1]). By the time of the release of this report, there was no presidential decree yet on this in Türkiye, but an official press release of the Elazığ Governorship confirmed Elazığ's status as disaster but was not added to the areas under State of Emergency ([2]).

Syria

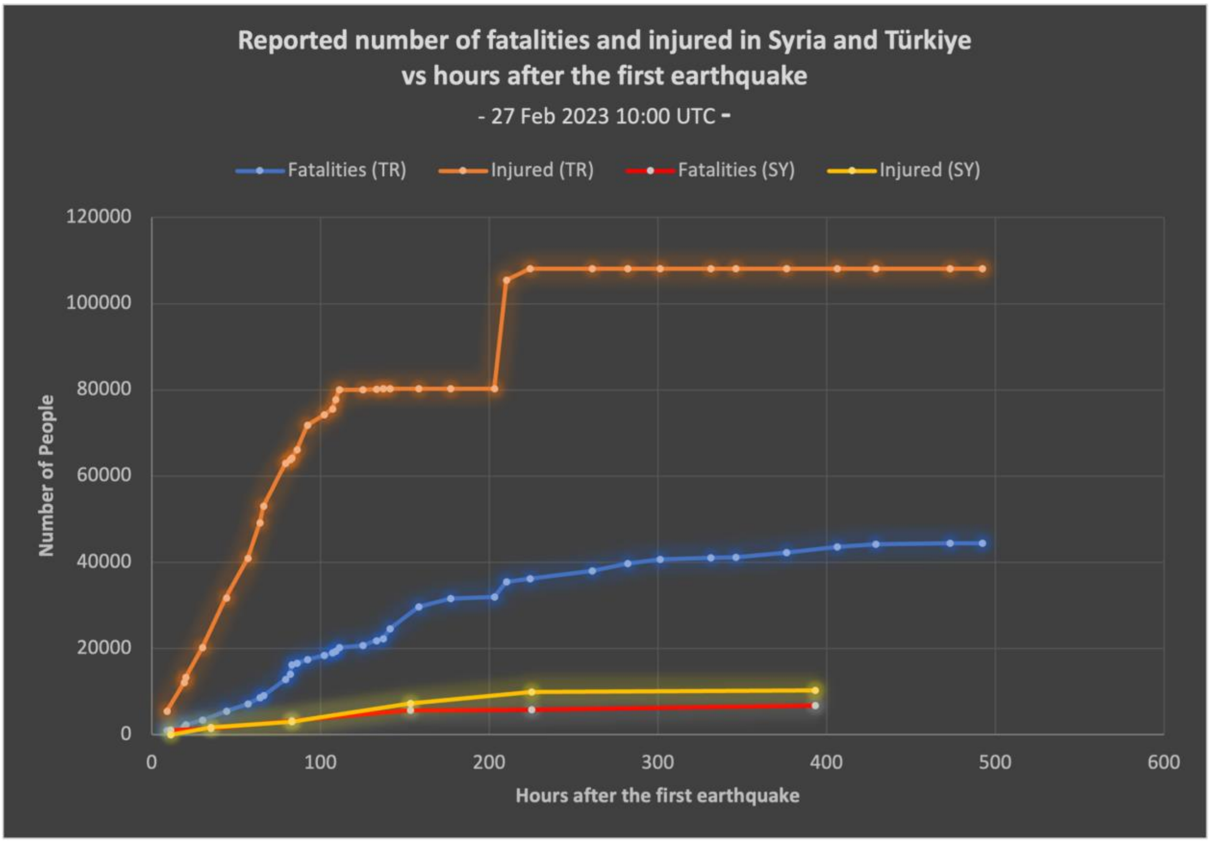
In Syria, the Syrian Observatory for Human Rights (SOHR), reports, as at 22 February, **6 747 fatalities** (of which 4 521 in non-government controlled areas and 2 226 across the government controlled area), around **14 500 injured people** and approximately **100 000 homeless families**. Furthermore, SOHR reports, as of 21 February, **5 fatalities** and more than **500 injured people** due to the M6.3 occurred in Hatay on 20 February.

On 08 February, **the Syrian government requested assistance through the EU civil protection mechanism** for search and rescue teams and equipment, shelter items and medicines. An additional request arrived on 09 February from the World Food Programme (WFP) for search and rescue equipment, shelter and non-food items, medical equipment and medicines.

In areas controlled by the government of Syria, more than 300 buildings have collapsed. As of 15 February, the rapid structural assessment undertaken in Aleppo classified 169 buildings as 'high risk of collapse' and 644 as 'medium risk of collapse.' In north-west Syria more than 8 900 buildings have been completely or partially destroyed leaving at least 11 00 people homeless. A cursory check of the pre-disaster situation in built-up environment in Syria shows that most small settlements fall inside the "informal settlement" typology and therefore presenting a number of structural vulnerability factors that exacerbate earthquake damage. Many buildings in Syria have been also exposed to impacts from the conflict, reducing their ability to withstand the shock of an earthquake, which may be the decisive factor.

[1] https://t24.com.tr/haber/elazig-da-afet-bolgesi-ilan-edildi,1092565
[2] http://www.elazig.gov.tr/basin-aciklamasi-2023-9

Figure 1. Number of fatalities and injured in Syria and Türkiye vs hours after the first earthquake as of 26 February 2023 15:00 UTC (sources: media and AFAD bulletins for Türkiye, media and ECHO Daily Flash for Syria)



2 Earthquake impact

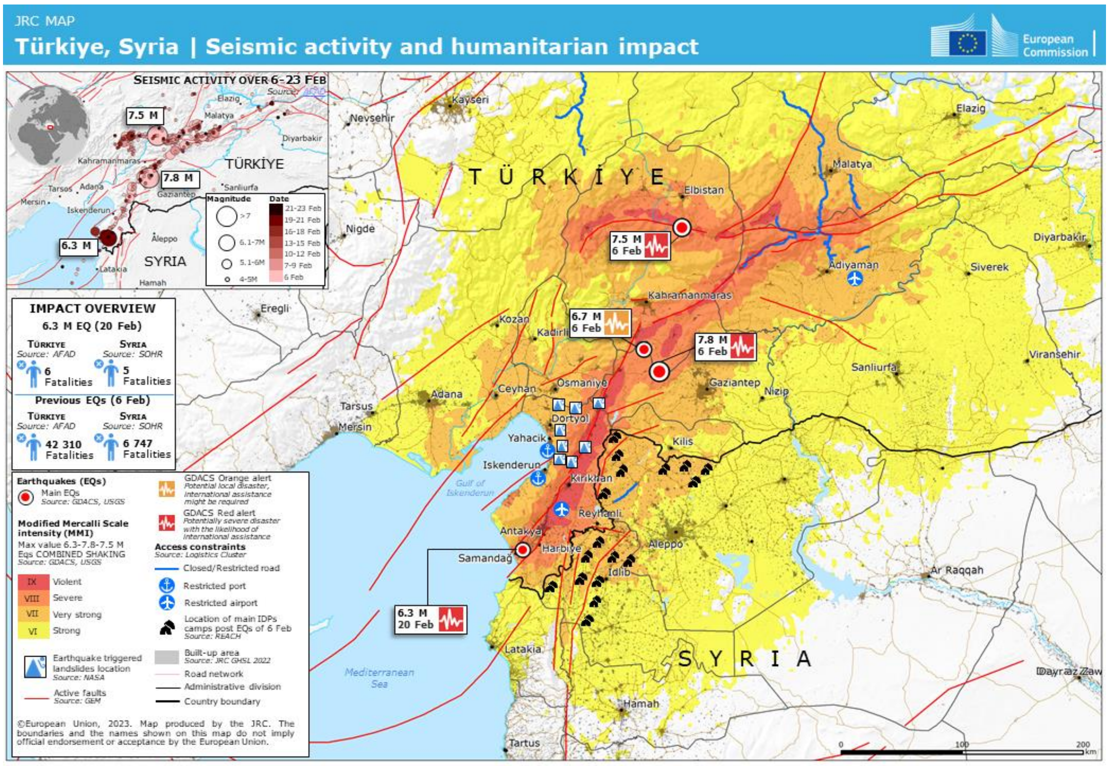
2.1 Seismic analysis and assessment

A series of earthquakes started on 06 February 2023 with a strong earthquake of M7.8 (M7.7 as reported by Disaster and Emergency Management Presidency of Türkiye-AFAD) at a depth of 18 km occurred at 1:17 UTC (4:17 local time) in southern Türkiye (epicentral coordinates: 37.174°N 37.032°E), close to the border with northern Syria. The epicenter was located in Atalar town (Gaziantep Province, Southeastern Anatolia Region), and about 45 km north of the northern border of Aleppo Governorate in Syria.

A second event with a M7.5 and 10 km depth occurred at 10:24 UTC at a distance of about 100 km from the first event (epicentral coordinates: 38.024°N 37.203°E), likely worsening the impact and the ongoing Search & Rescue operations.

On 20 February 2023 at 17:04, another earthquake with M6.3 occurred in Hatay, in the most southern part of the rupture zone of the first (M7.8 earthquake). 1 person died, 69 injured due to the M5.2 earthquake in Malatya-Türkiye on 27 February during which 29 buildings have collapsed.

Figure 2. JRC map for the seismic activity and the humanitarian impact in Türkiye and Syria

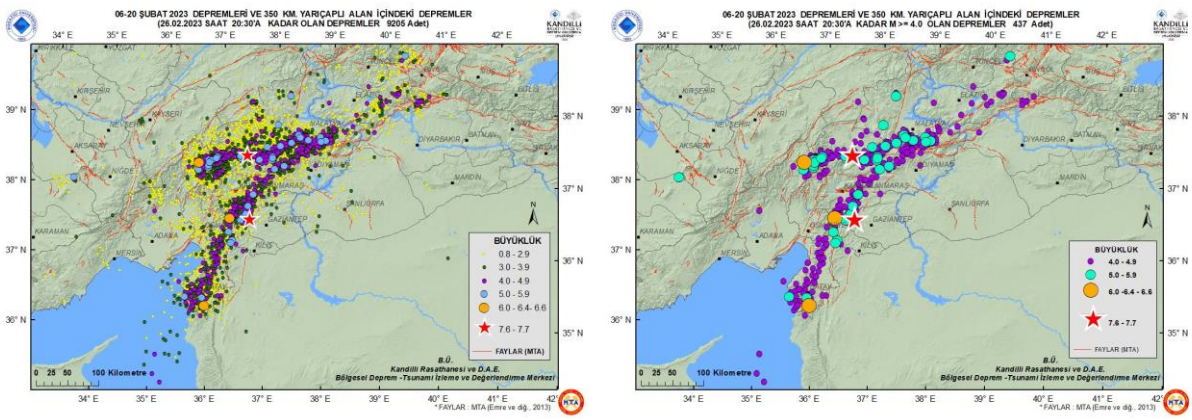


Following the main shocks, as of 26 February 2023, 17:30 UTC, 9 205 aftershocks occurred along both fault systems, with 437 aftershocks of M>4. The possibility of aftershocks with M>6 still cannot be excluded.

During a press conference on 15 February, the Director of AFAD's Earthquake and Risk Reduction section stated that “according to the observations obtained so far in the earth's crust as a result of these two earthquakes, we know that a surface rupture over 400 km has occurred... This earthquake is the biggest earthquake that Anatolia has experienced in the past 2 000 years." ([3])

Figure 3. Surface ruptures in Türkiye generated from the 1st earthquake with M7.8 and 2nd earthquake with M7.5. (top-left) Kahramanmaraş-Şekeroba (top-left 4 and top-centre [5]), Hatay (top-right [6]), Kahramanmaraş-Tevekkeli (bottom-left [7]), Kahramanmaraş-Türkoğlu (bottom-centre [8]) and along Sürgü-Çardak fault (second earthquake) (bottom-right [9]).

Figure 4. Main shock and aftershocks (left-all aftershocks, right aftershocks with M>4) of 06 February 2023 earthquakes in Türkiye as of 26 February 2023 17:30 UTC (source: KOERI). Locations of the earthquakes with lower magnitudes (<3) may be subject to revision in the future based on improved seismological analysis.



The earthquakes in Türkiye on 06 February 2023 occurred on the East Anatolian Fault (EAF), which is a major transform type tectonic boundary between the Anatolian Plate and the northward-moving Arabian Plate accommodated mainly by strike-slip faults, starting from the Maras Triple Junction (MTJ) at the northern end of the Dead Sea Transform (DST) and ending at the Karlıova Triple Junction (KTJ) where it meets the North Anatolian Fault (NAF) (Figure below). Aftershocks of the first

[3] https://t24.com.tr/haber/afad-bu-deprem-anadolu-cografyasinin-son-2-bin-yilda-yasadigi-en-buyuk-deprem,1092505

[4] https://twitter.com/CengizZabci/status/1623236454926229504/photo/1
[5] https://twitter.com/akyuz24/status/1623455630676860928/photo/1
[6] https://twitter.com/onediocom/status/1624075046430842881/photo/1
[7] https://www.hurriyet.com.tr/gundem/depremin-buyuklugunu-gozler-onune-seren-goruntu-kahramanmarastaki-fay-kirigi-goruntulendi-kilometrelerce-uzaniyor-42217908
[8] https://twitter.com/CengizZabci/status/1623236487687929857/photo/1
[9] https://twitter.com/tsancar/status/1623698495730339840/photo/1

earthquake with M7.8 extended also into the northern section of the DSF to the southern parts of Antakya region. While M>7 earthquakes on the EAF are extremely rare, both NAF and DSF experienced catastrophic events with M>7 in their past, such as 1939 M7.7 Erzincan, 1943 M7.6 Ladik-Tosya, 1999 M7.6 Izmit on the NAFZ and 525-528 M7 and 1872 M7.3 earthquakes in Antakya, 1202 M7.6 in Damascus.

Figure 5. Main tectonic structures of Anatolia and Middle East. North Anatolian Fault (NAF), East Anatolian Fault (EAF), Dead Sea Transform (DST), Bitlis-Zagros Fold and Thrust Belt (BZFTB), together with the two main earthquakes, two major aftershocks and the administrative regions along the DAF and EAF in Türkiye.

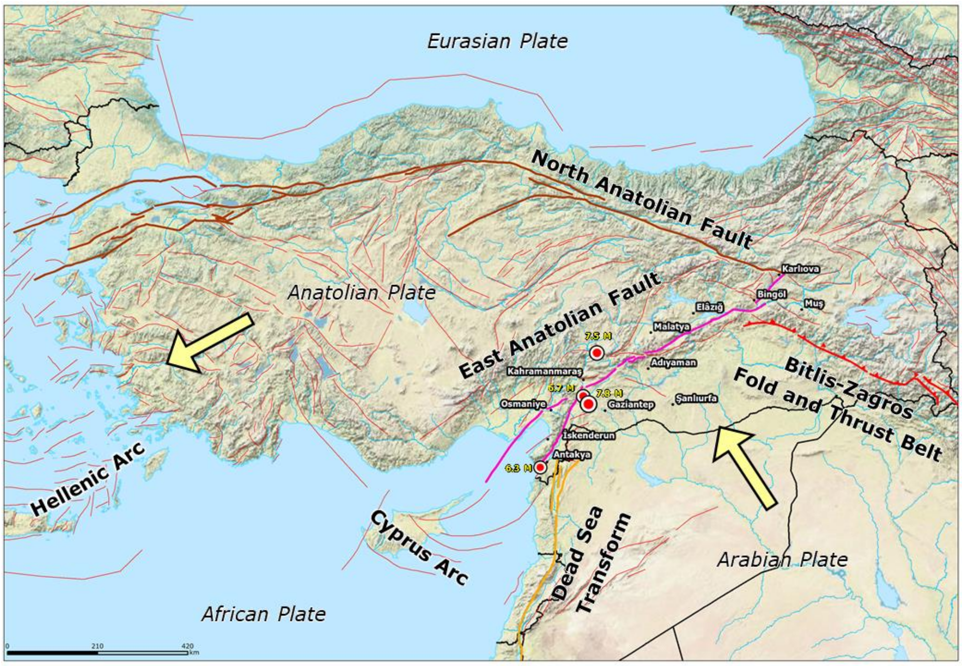
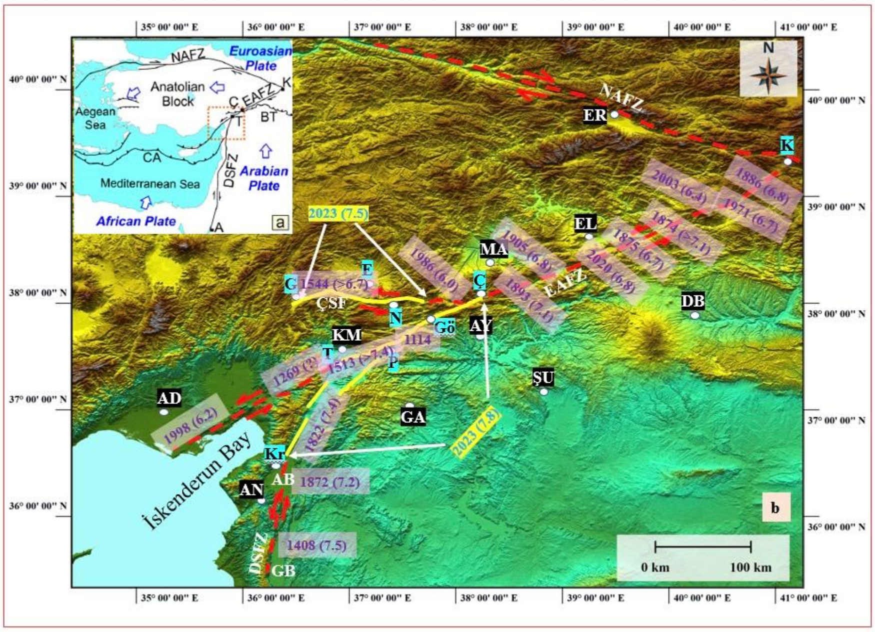


Figure 6. Historical earthquakes on the East Anatolian Fault (EAF) and the northern section of the Dead Sea Fault[10].



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[10] Erdik, M., Tümsa, M. B. D., Pınar, A., Altunel, E., and Zülfikar, A. C. 2023, A preliminary report on the February 6, 2023 Earthquake in Türkiye, http://doi.org/10.32858/temblor.297

The 1st earthquake with M7.8 is composed of two ruptures with approximately 230 km rupture on the EAF and approximately 60 km rupture on its southern branch that runs parallel to DSF (Figure 4 – left). *The peak ground acceleration values and the peak ground velocity values are much higher in the Hatay Province to the southwest, likely a result of basin amplification effects, as well as directivity effects (Erdik et al., 2023).*

Figure 7. (left) USGS finite fault model for the 1st earthquake with M7.8 (11). (right) Instrumental intensity as recorded by the KOERI and AFAD networks in Türkiye (12).

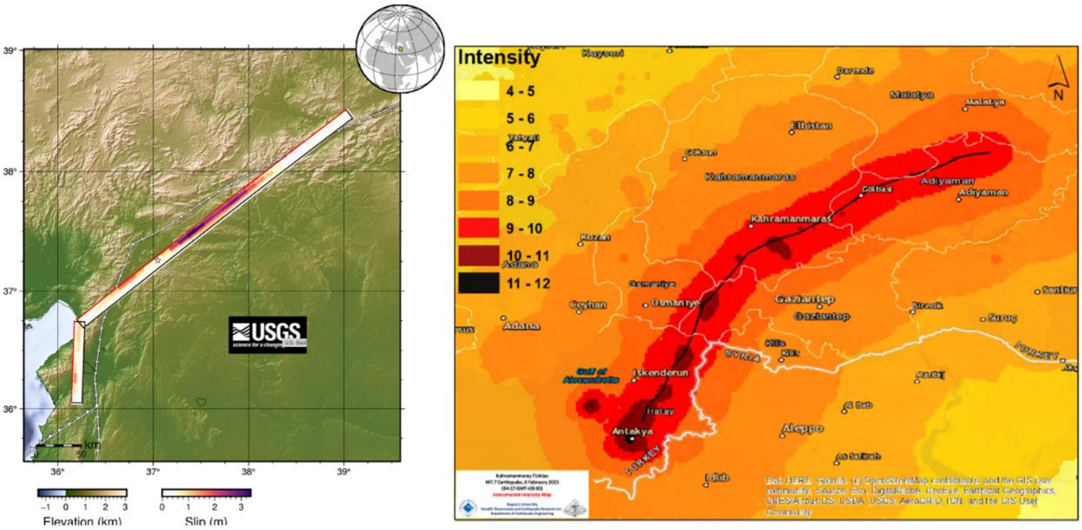
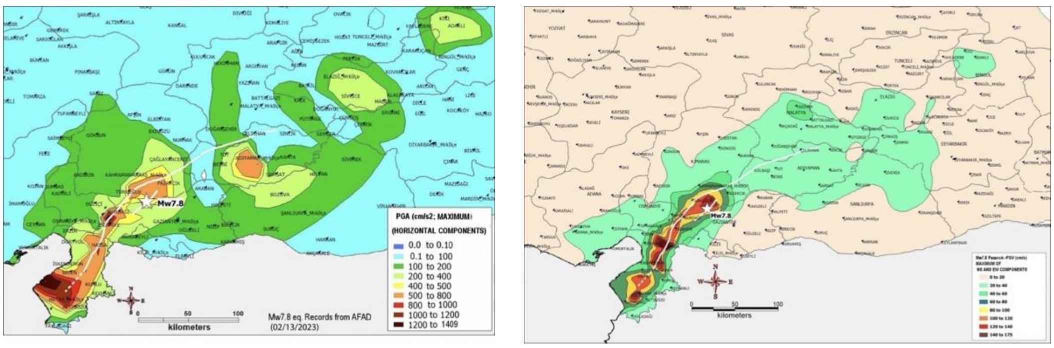


Figure 8: Contour map of the peak ground acceleration (left) and velocity (right) (in units of centimetres per second squared; maximum values of north-south and east-west horizontal components) associated with the magnitude-7.8 earthquake[13].



[11] https://earthquake.usgs.gov/earthquakes/eventpage/us6000jllz/finite-fault

[12] Hancılar, U., Şeşetyan, K., Çaktı, E., Yenihayat, N., Süleyman, H., Açıkgöz, N., Dede, Ş., Acar, Ş. (2023) Kahramanmaraş - Gaziantep Türkiye M7.7 Earthquake, 6 February 2023 (04:17 GMT+03:00) Strong Ground Motion and Building Damage Estimations Preliminary Report (v6), Boğaziçi University - Kandilli Observatory and Earthquake Research Institute - Department of Earthquake Engineering

[13] Erdik, M., Tümsa, M. B. D., Pınar, A., Altunel, E., and Zülfikar, A. C. 2023, A preliminary report on the February 6, 2023 Earthquake in Türkiye, http://doi.org/10.32858/temblor.297

Figure 9: Contour map of the peak ground acceleration (left) and velocity (right) (in units of centimeters per second squared; maximum values of north-south and east-west horizontal components) associated with the magnitude-7.5 earthquake[14].

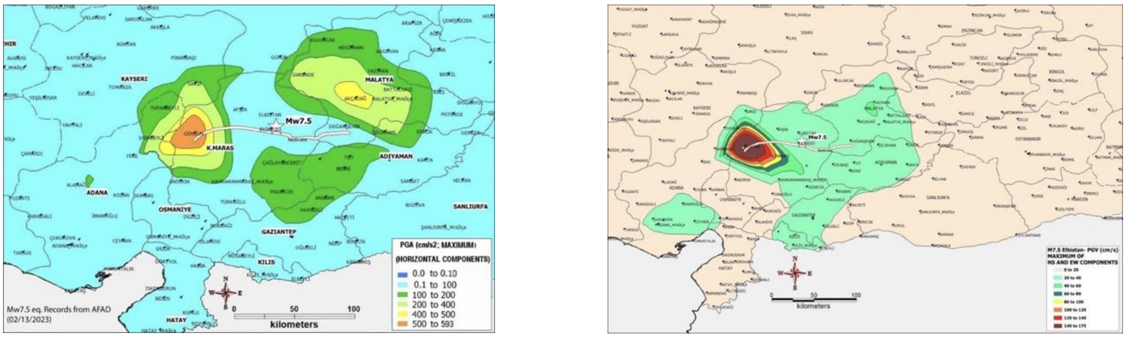
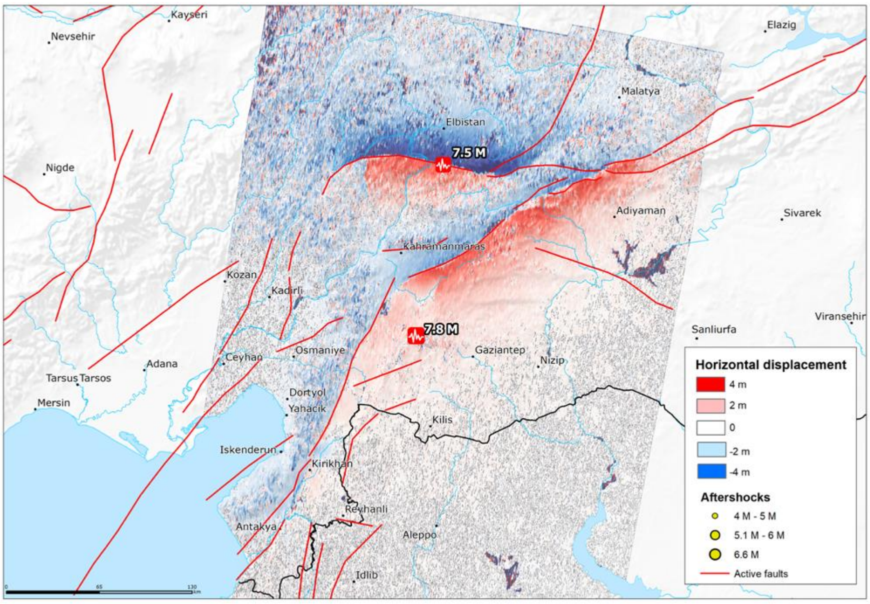


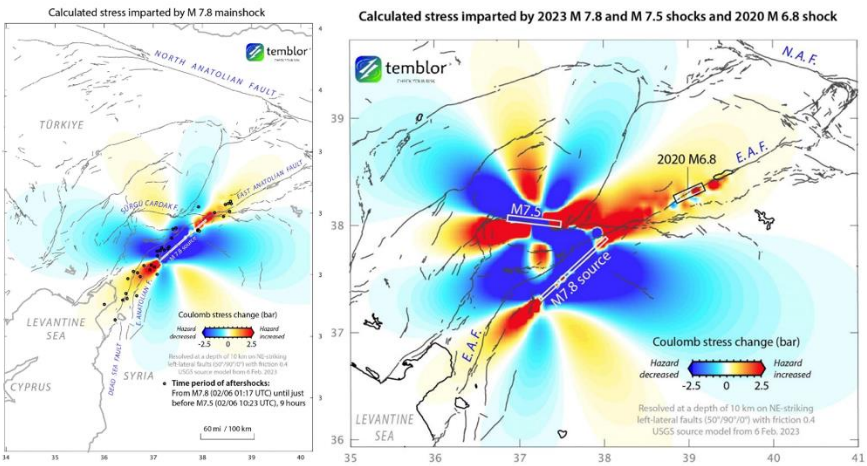
Figure 10. Map produced by the JRC showing the ground displacement caused by the two earthquakes. The red gradient colours describe the movement of the land towards the satellite while the blue colours represent the movement away from the satellite since it last flew over the area.



The horizontal displacement in the Figure above has been processed and created by the Advanced Rapid Imaging and Analysis (ARIA) team at NASA's Jet Propulsion Laboratory and California Institute of Technology. The interferogram (available at this link), has been produced from synthetic aperture radar (SAR) images from the Copernicus Sentinel-1 satellites, operated by the European Space Agency (ESA). It derives from the interferometric difference between the post-event image acquired on 10 February 2023, with a pre-event image acquired on 29 January 2023. The interferogram provides information on the rupture length and variations in the amount of slip along the faults, which helps to estimate the slip at depth and the change in stress on nearby faults, providing information on the areas where aftershocks are more likely. This map also helped to confirm assumptions from initial seismic readings that the earthquakes originated from ruptures in both the East Anatolian Fault and the Dead Sea Fault systems. The rupture of these two faults may have greatly increased the area impacted by these earthquakes. (*Jacob Reed and Gabriella Lewis, NASA Disasters*).

[14] Erdik, M., Tümsa, M. B. D., Pınar, A., Altunel, E., and Zülfikar, A. C. 2023, A preliminary report on the February 6, 2023 Earthquake in Türkiye, http://doi.org/10.32858/temblor.297

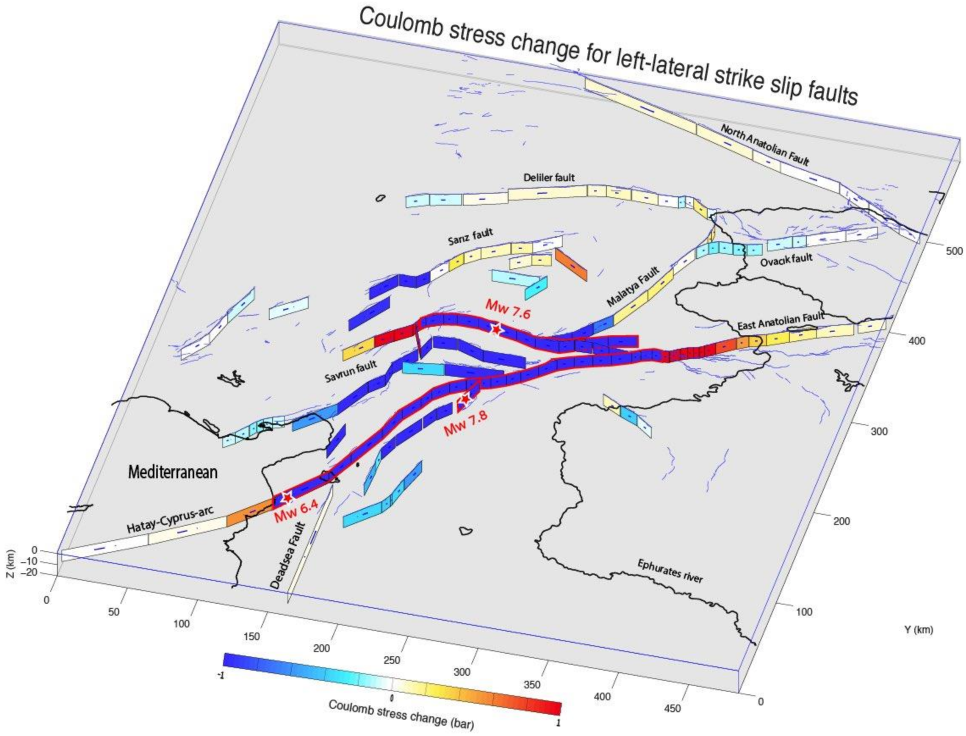
Figure 11. (left) Coulomb stress change calculations for the main segment of the 1st earthquake. (right) Overall stress change resulting from both earthquakes (15).



Coulomb stress change calculations show that the 2nd earthquake with M7.5 may be triggered by the stress change resulted from the main segment of the 1st earthquake with M7.8 on the East Anatolian Fault (Figure 10 – left) ([5]). The same calculations also indicate a stress change on the DSF component of the total rupture zone (Hatay region), which provides a plausible explanation on the activation of this segment during the 1st earthquake. Overall stress change resulting from both earthquakes (Figure 10 – right) show stress loading in the north-eastern section of the EAF between Malatya and Bingöl (also visible in Figure 11), where in 2020 an earthquake with M6.7 occurred ([16]). Some prominent experts argue that the region between Bingöl and Karlıova is a source of "concern" for possible "future" earthquakes ([17]), without making any reference to its possible magnitude or occurrence time. A relatively lower level of aftershock activity in this section (Figure 1) of the EAF further contributes to this concern. In the previous report, similar concerns were also mentioned by some scientist for the north-eastern section of the Cyprus Arc offshore İskenderun/Syria ([18]). The M6.3 earthquake in Hatay on 20 February 2023 at 17:04 could be considered as an initial confirmation of these concerns, subject to verification through detailed scientific studies.

[15] https://temblor.net/earthquake-insights/stress-calculation-clues-aftershocks-turkey-earthquakes-2023-14952/
[16] https://earthquake.usgs.gov/earthquakes/eventpage/us60007ewc/executive
[17] https://tr.euronews.com/2023/02/09/prof-naci-gorur-iki-fay-enerjisini-bosaltti-endise-ettigimiz-yer-bingol-ile-karliova-arasi
[18] https://twitter.com/Paleosismolog/status/1626317482561503233/photo/1

Figure 12. Coulomb stress change calculations on the main faults in the region[19].



It is worth noting that less than 3 months after the M7.6 Izmit earthquake in Türkiye in 1999 with more than 18 000 fatalities ([20]), an earthquake in the same fault system in Düzce with M7.2 ([21]) caused around 1000 fatalities. Several scientific studies argued that the M7.2 Duzce earthquake was triggered because of the stress change resulted by the M7.6 Izmit earthquake ([22,23]).

In terms of potential amplification due to site effects, the area can be of divided in two main categories (see figure below):

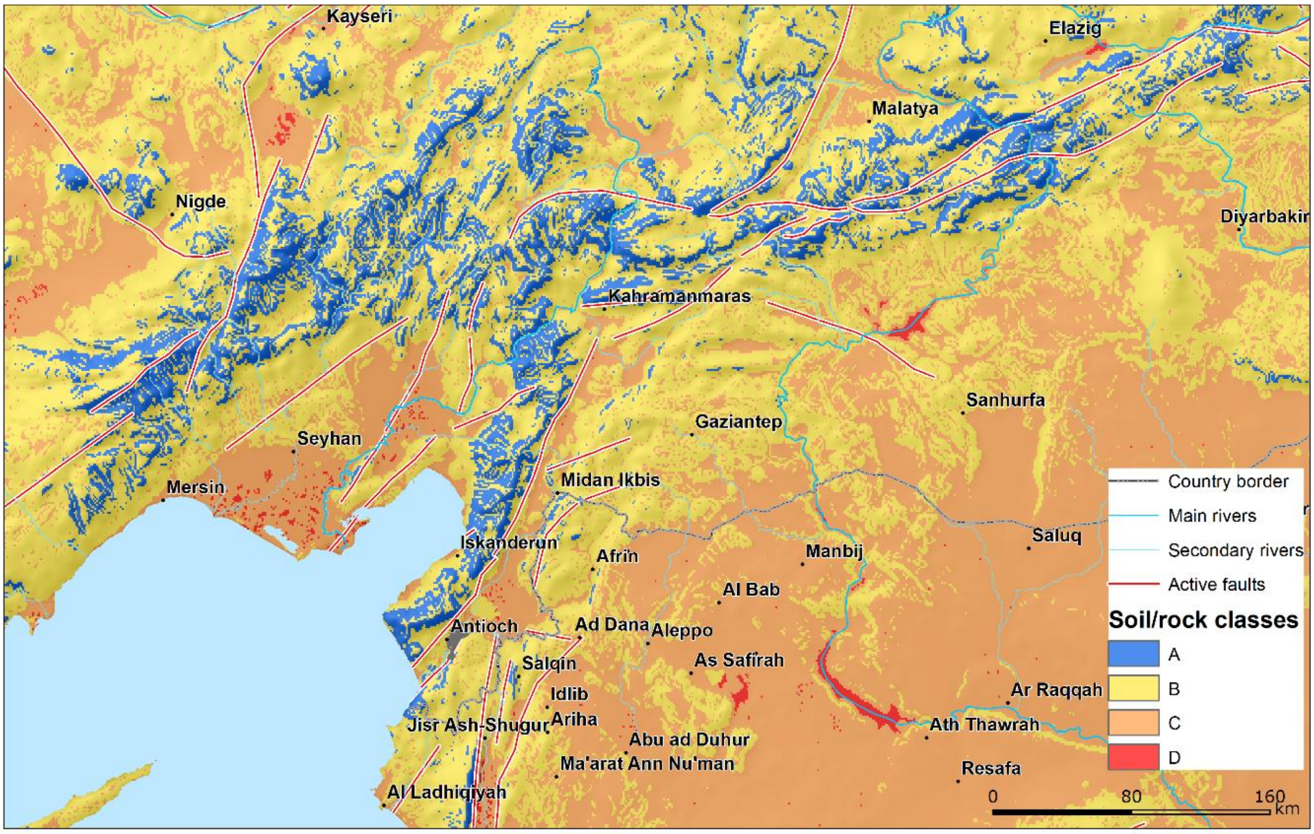
Stable zones: areas which present the speed of the S* waves: Vs30>800 m/s (**Tab. 1**): *class A* (in deep blue in the figure).

Zones with lithological amplification: lithology which present the speed Vs30<800 m/s, further divided in other 3 *classes B, C, D* (the worst soil condition, for the seismic effects, is the class D, **Tab.1**). These are areas where damage is likely to be higher due to the local surface geology.

In-depth commentary of site effects can be found in Annex 5.

[19] https://twitter.com/ziyadin/status/1629039070696378369/photo/1
[20] https://en.wikipedia.org/wiki/1999_%C4%B0zmit_earthquake
[21] https://en.wikipedia.org/wiki/1999_D%C3%BCzce_earthquake
[22] https://www.sciencedirect.com/science/article/abs/pii/S1251805001016767
[23] https://academic.oup.com/gji/article/153/1/229/621117

Figure 13. zones with/without potential amplification due to site effects.



[1] U.S. ***Geological Survey*** https://usgs.github.io/shakemap/manual4_0/sg_installation.html#downloading-and-configuring-vs30-and-topography

[2] GEM Global SEISMIC HAZARD MAP v 2019.1 globalquakemodel.org

2.2 Impact on buildings

The General Directorate of Construction Affairs of the Ministry of Environment, Urbanization and Climate Change in Türkiye continues to work in earthquake zones with a team of 7 328 experts, including 400 professors and associate professors from more than 20 universities. Many volunteer civil engineers from different institutions and organizations who want to take part in damage assessment studies are evaluated and are sent to the regions determined according to the needs after a short training. As of 19 February 2023, the results of the damage assessment in 3 273 605 independent units in 830 783 buildings in the earthquake affected regions were as follows:

- immediate demolition required: 384 545 individual units in 105 794 buildings
- moderately damaged: 133 575 individual units in 24 464 buildings
- slightly damaged: 1 091 720 individual units in 205 086 buildings with minor damage
- undamaged: 1 409 654 individual units in 407 786 buildings

254 111 individual units in 87 653 buildings could not be controlled because of inability to access. A total of 71 052 units in 20 662 buildings in Adana, Adıyaman, Diyarbakır, Elazığ, Gaziantep, Kahramanmaraş, Malatya, Hatay, Kilis, Osmaniye and Şanlıurfa have collapsed.

On 24 February 2023, the Ministry of Environment, Urbanization and Climate Change in Türkiye announced[24] that the damage assessment performed in Türkiye included the examination of 1 316 000 buildings. The assessment showed that 173 000 of these buildings were collapsed/heavily damaged/to be demolished immediately.

Table 1. Damage status of building and individual units in Türkiye as reported on 19 February 2023 by the Ministry of Environment, Urbanization and Climate Change

as of 19.02.2023	# of assessed buildings					# of assessed individual units				
Administrative Division	heavily damaged / collapsed	moderately damaged	slightly damaged	undamaged	total	heavily damaged / collapsed	moderately damaged	slightly damaged	undamaged	total
ADANA	97	462	2568	9396	13141	1715	10667	53986	113890	183448
ADIYAMAN	13730	4338	19410	18598	63452	44817	17489	63737	40037	190693
DİYARBAKIR	1110	1044	10977	27334	45149	8284	12106	109784	226953	373947
ELAZIĞ	1036	174	2176	1266	4810	5193	1027	21911	15401	44536
GAZİANTEP	15008	5662	42945	135809	228272	36620	22829	252089	461926	842811
HATAY	30112	7281	36112	77107	158112	123349	33351	117588	169711	465813
KAHRAMANMARAŞ	22113	2208	33664	45395	117801	84059	12975	139406	98242	374218
KİLİS	1261	307	4746	7918	15387	1921	1629	24044	25301	55029
MALATYA	16870	1694	17745	17333	64883	62547	12098	88763	54180	257762
OSMANİYE	3794	465	11830	36666	56371	12505	3472	54959	80097	158241
ŞANLIURFA	663	829	22913	30964	63428	3535	5932	165453	123916	327130
TOTAL	*105794*	*24464*	*205086*	*407786*	*830806*	*384545*	*133575*	*1091720*	*1409654*	*3273628*
https://csb.gov.tr/deprem-bolgelerinde-830-bin-783-binadaki-3-milyon-273-bin-605-bagimsiz-birimde-hasar-tespit-calismasi-yapildi-bakanlik-faaliyetleri-38439										

<u>Analysis of the published survey results:</u>

The survey results are currently the best available measure of damage to the built environment in the area and should be the basis for future calculations of the reconstruction needs of the area.

The following comments can be made to help the interpretation of the survey numbers:

- No clear definition (e.g. with photographic examples) has been found of the different damage categories by the authors of this report, meaning they are subject to interpretation. This type of rapid survey is usually focused on establishing the habitability of buildings, that is, on identifying which buildings are unsafe for the occupants to remain.
- The number of buildings in the "moderately damaged" category is proportionally small when compared to the "slightly damaged" and "heavily damaged/collapsed" category". This could indicate that the engineers on the field are exercising caution and classifying more buildings as "heavily damaged" (or "unsafe to remain in", under the hypothesis that habitability is being evaluated). It is therefore unclear if all of these buildings will truly be demolished, even though the damage is undeniably widespread.
- When compared to the number of households per province listed in the Turkish building census, published in 2021, it appears that the survey has been thorough, as can be seen in the table below. In fact, the number of households indicated in the survey slightly exceeds those of the census. The observed mismatches should be within the margins of error of a national census, with the exception of Gaziantep, where the mismatch could not be explained (mismatches of this order of magnitude can be the result of, for example, touristic areas

[24] https://t24.com.tr/haber/deprem-bolgesinde-173-bin-bina-yikik-ya-da-agir-hasarli,1094313

where second homes are common, generating more dwellings than households, but this does not appear to be the case for Gaziantep).

- The number of "heavily damaged/collapsed" buildings in the province of Elazig seem at this point disproportionately large for the level of shaking intensity expected in this area. A priori, this would indicate that other risk factors may have affected this area (either local hazards, such as liquefaction, or local vulnerabilities in construction styles). This is especially notable since the survey in Elazig is one of the most incomplete ones (see table below), meaning the number could still increase (although it is likely that the surveyors prioritized areas where damage was known).

Table 2. Comparison of the number of the survey and 2021 census data

Provinces	Total households	Surveyed units	Percentage
Total	**3 478 573**	3 273 628	94%
Adana	**632 875**	183 448	29%
Adıyaman	**155 300**	190 693	123%
Diyarbakır	**394 867**	373 947	95%
Elazığ	**173 836**	44 536	26%
Gaziantep	**522 947**	842 811	161%
Hatay	**449 151**	465 813	104%
Kahramanmaraş	**311 458**	374 218	120%
Kilis	**40 020**	55 029	138%
Malatya	**230 499**	257 762	112%
Osmaniye	**156 199**	158 241	101%
Şanlıurfa	**411 421**	327 130	80%

2.2.1 Building damage estimation

As indicated above, the survey information should be the main source for considering the damage in the area. However, the information it provides may not be enough for post-disaster management needs (for example, housing needs for evacuees or debris estimation). Until the Turkish authorities measure and publish these ancillary numbers, building damage modelling can be useful to supplement it, especially if calibrated using the survey data. In the following paragraphs, two different modelling approaches are presented. These are not the only models available, as the scientific community has been very active in providing modelling as well, notably the Kandilli University team has been publishing modelling results since the beginning[25]. Indeed, Turkey has some of the world's most renowned experts in the field of seismology and earthquake engineering, and any damage assessment efforts should include their expertise.

To perform a comparison among the damage estimation and the preliminary damage assessment from the field, 2 different damage estimation methodologies have been applied. Taken together, they also provide a measure of the uncertainty in the reported damage data.

With the scope to provide a plausibility check among the building damage data coming from the field surveys, two different building damage estimation models have been performed and compared. In a

[25] Hancılar, U., Şeşetyan, K., Çaktı, E., Yenihayat, N., Süleyman, H., Açıkgöz, N., Dede, Ş., Acar, Ş. (2023) Kahramanmaraş - Gaziantep Türkiye M7.7 Earthquake, 6 February 2023 (04:17 GMT+03:00) Strong Ground Motion and Building Damage Estimations Preliminary Report (v6), Boğaziçi University - Kandilli Observatory and Earthquake Research Institute - Department of Earthquake Engineering

short timeframe, with limited information on the vulnerability of the buildings, this comparison would provide an uncertainty range of damage ratio, to give the opportunity to reasoning on the order of magnitude of the field damage assessment data.

The building damage estimation methodologies are the following:

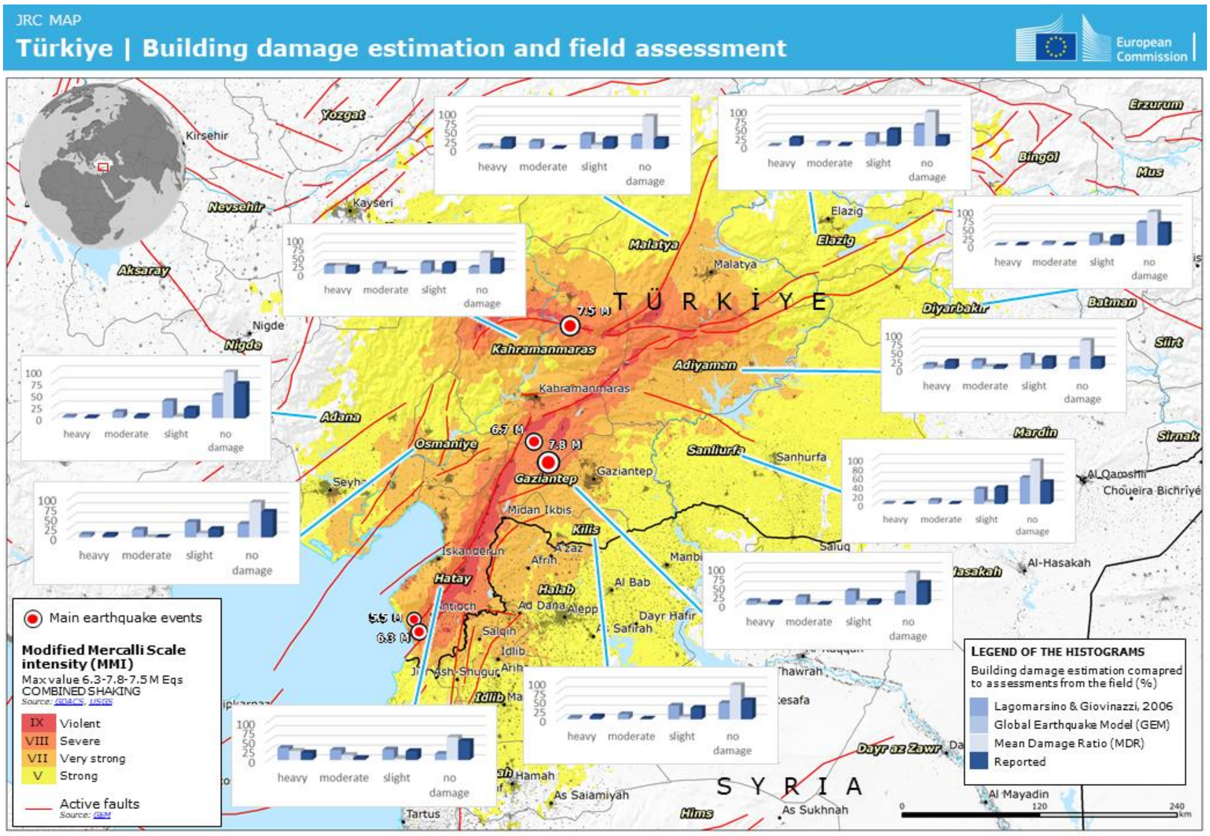
- Mean Damage Ratio (Annex 2)
- Lagomarsino & Giovinazzi, 2006 (Annex 3)

This analysis has been performed at province level, to keep the consistency with the field damages reported by the National Authorities. Results can be consulted in Annex 4.

The preliminary results from this comparison are the following:

- The order of magnitude of the reported damages can be confirmed by the damage estimation methodologies. The most affected province is Hatay, with an estimated mean value of destroyed building of 27%, compared to a reported value of 19%.
- There is a general overestimation of the "no damage" category compared to the damage reports. This can be due to the preliminary assessments which started, as common during post-earthquake field surveys, from the most damaged buildings. It should be noted that the sum of the percentages of damage reported from the field surveys are not the 100% of the buildings.

Figure 14. Building damage estimation and field assessment.



This damage ratio is also confirmed by analysis performed by the National insurance sector "*Basic earthquake insurance premium rates (TDV, 2018; TDV, 2010) use the loss ratio of buildings, which is the cost of retrofit relative to the cost of construction of the building prior to earthquake damage. The average building loss ratio under exposure to 475-year (DD-2) and 2,475-year (DD-1) ground motions in the four hardest-hit cities are 16% and 37%, respectively (TDV, 2018). In other words, the government expected to lose 16% of its buildings in earthquakes that occur about every 500 years, and 37% of its buildings in earthquakes that occur about every 2,500 years. With an approximately*

20% loss of buildings in the Feb. 6 events, that is what happened." (source: https://temblor.net/temblor/preliminary-report-2023-turkey-earthquakes-15027/)

Figure 15: Pancake collapsed buildings in Hatay (Credit: IMO[26])

2.2.2 Estimation of the debris associated to building damage

One of the applications of a damage estimate is the estimation of debris that needs to be cleared as part of the reconstruction process. Building materials are valuable resources, some of which can be recycled, and estimates of rubble can also contribute to anticipate this work.

Turkish media has reported an estimated 50-230 million tons of debris[27,28]:

Referring to the information contained in the Damage Assessment Study of the Ministry of Environment, Urbanization and Climate Change dated February 13, 2023, Öner said, *"It has been determined that 153,506 independent units in 33 thousand 143 buildings are in need of urgent demolition, are heavily damaged and are in ruins. Each residence means approximately 75 cubic meters of concrete debris. When the furniture and other equipment inside the house are taken into account, approximately 750 cubic meters of excavation emerges for each house. With the most optimistic estimate, there is 115 million cubic meters of domestic Debris. This does not include debris from industries and workplaces. The density of domestic debris is close to 2 tons per cubic metre. In other words, there is 230 million tons of debris the size of Mount Erciyes."*

An attempt to corroborate these figures using the HAZUS methodology for earthquake debris estimation was carried out by the JRC but its results were inconclusive. The study was not included in the present report in order to avoid confusion but can be communicated upon request. An update is planned to be included in a future version of this report.

[26] https://www.imo.org.tr/TR,146861/insaat-muhendisleri-odasi-6-subat-2023-kahramanmaras-pazarcik-ve-elbistan-depremleri-on-degerlendirme-raporu.html
[27] https://www.yenisafak.com/gundem/724-moloz-tasiyorlar-enkaz-hafriyatlari-tek-tek-ayrisacak-4509027
[28] https://www.hurriyet.com.tr/gundem/enkazin-agirligi-erciyes-dagini-asti-230-milyon-ton-tasinacak-42219974

2.3 Situation of dams and river infrastructures in Türkiye and Syria

Additional information about possible earthquake-related floods and possible earthquake-affected dams both in Türkiye and in Syria are emerging from the affected areas. Namely, the four dams of concerns are: the Orontes/Asi River overflow (Syria, Türkiye), Atatürk Dam (Türkiye), Sultansuyu Dam (Türkiye) and Maydanki-Afrin Dam (Syria).

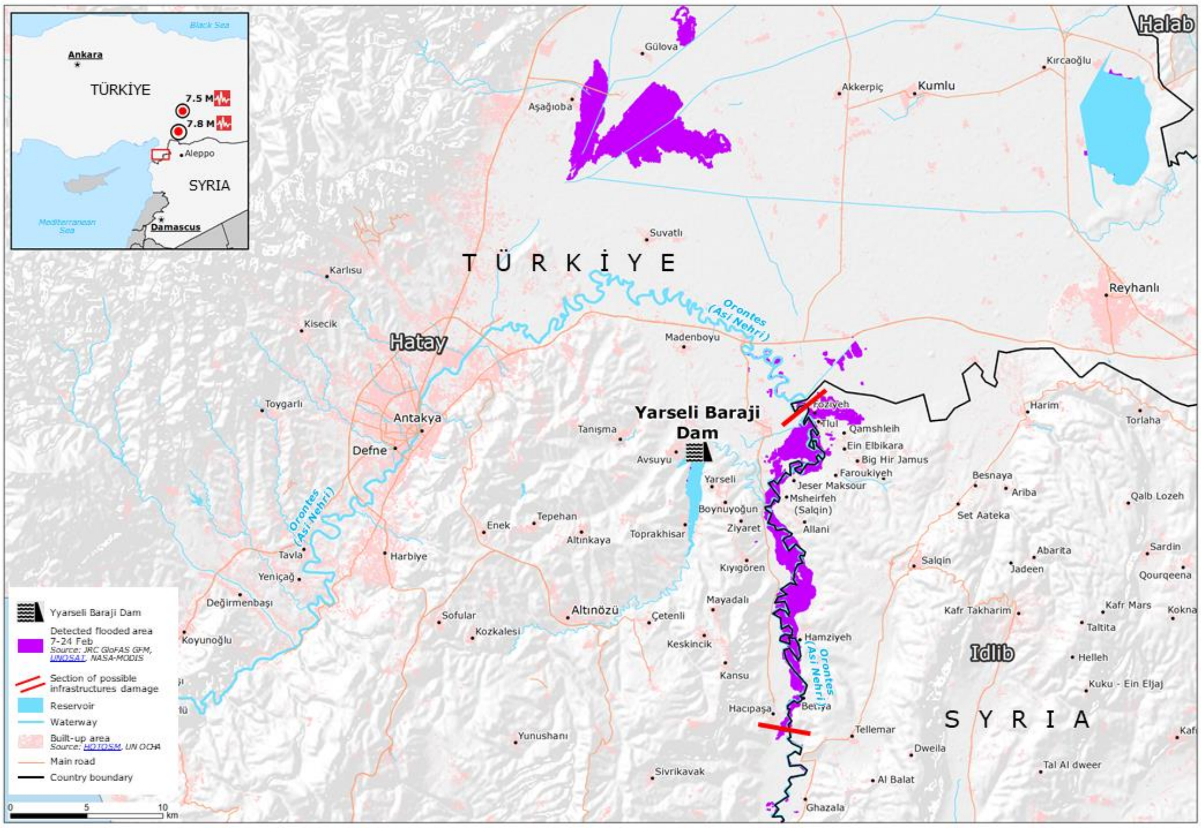
Orontes/Asi River (Türkiye/Syria) and nearby Yarseli Dam (Türkiye)

Regarding the Orontes/Asi River and the nearby Yarseli Dam (located in southern Türkiye near the border with Syria, very close to the Avsuyu village, eastern Hatay Province), UN OCHA reports as of 12 February (source: https://reliefweb.int/report/syrian-arab-republic/north-west-syria-situation-report-11-february-2023-enar), that the water level of the Orontes/Asi River was reportedly risen and submerged a number of houses in the aftermath of the earthquakes of 06 February. The dam generates a tributary of the mentioned Orontes/Asi River.

The flooding was detected by different sources (JRC GloFAS GFM, UN OCHA, UNOSAT, NASA-MODIS) over the period from 7 to 24 February and occurred on both side of the border area between the Hatay Province (southern Türkiye) and Idlib Governorate (north-west Syria). In this latter, due to the presence of more settlements along the river valley, the floods led to population displacements (around 30 000 people) from several villages, in particular: Al-Talul, Dergoush, Al-Jameiyah, Hardana, Delbiya, Jakara, and Hamziyeh. The flooding affected approximately 1 000 houses across the aforementioned villages.

Figure 16. Image of the flooded area in the along Al-Taloul village, along the Orontes/Asi River, in Syria.

Figure 17. Map produced by the JRC with the location of the Yarseli Dam in Türkiye and detected flooded areas, over the period 7-24 February, in Syria and Türkiye.



This map illustrates satellite-detected flooded area from the JRC GloFAS Global Flood Monitoring (GFM) over the period 7-16 February, form NASA-MODIS over 17-24 February and from UNOSAT-UNITAR on 9 February and on 13 February. The floods may have been likely triggered by damage also induced to certain water infrastructures (e.g. levees) along this river by the shaking due to the earthquakes and the large number of aftershocks. Currently, no hypotheses can be formulated regarding damages of the Yarseli Dam, due also to the fact the reservoir level is increased to not worsen the downstream situation, already affected by floods (image below).

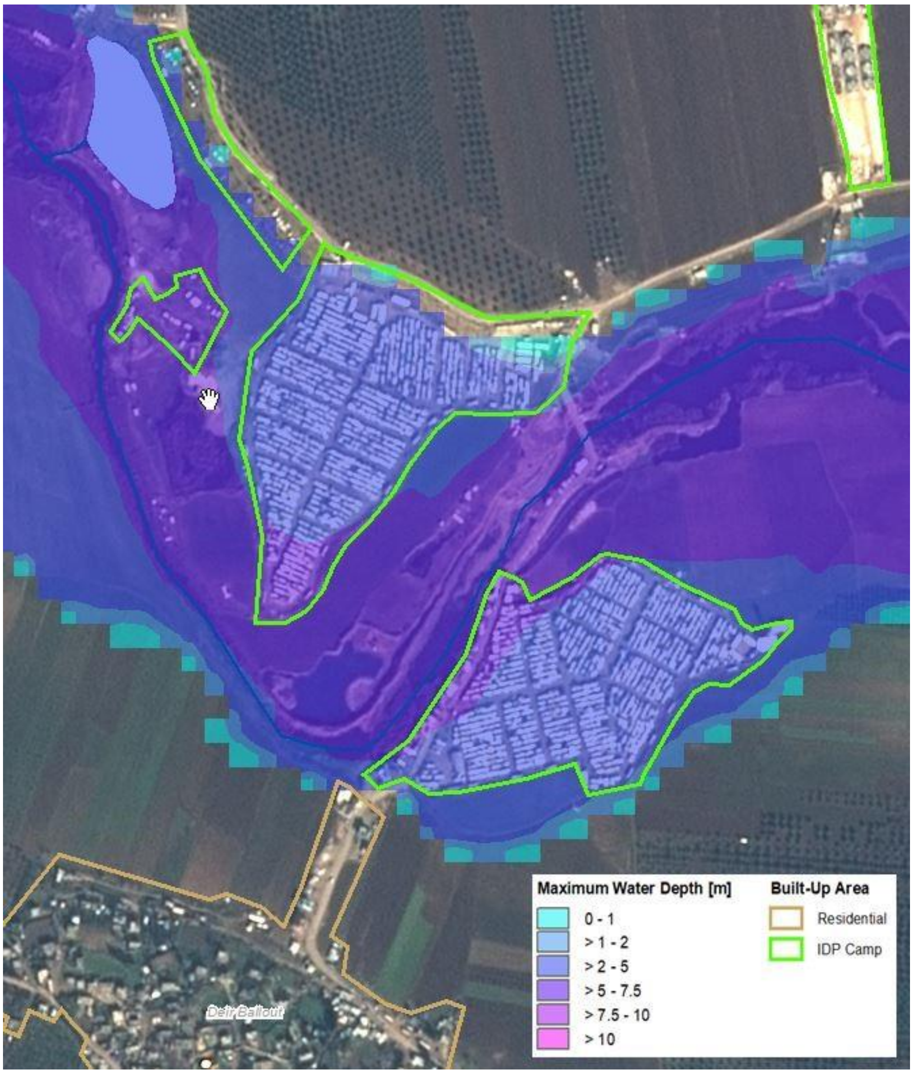
Figure 18. Multi temporal comparison of water basin level. A significant increase can be observed.

Maydanki-Afrin Dam (Syria), exposed to MMI VII

The Maydanki-Afrin Dam has been damaged by the earthquakes. Several longitudinal cracks have been reported on the crest of the infrastructure. The Copernicus Risk and Recovery Mapping has been activated to simulate a potential dam break of the Maydanki-Afrin Dam, located in northwest Syria, 12 km north of the town of Afrin, and 70 km from the city of Aleppo. The analyses included in the activation EMSN145 are the following:

- Reference dataset, most up-to-date pre-event reference information focused on built-up areas and identification of IDP camps, derived from visual interpretation of very high-resolution satellite imagery and complemented with data from public datasets.
- Hydraulic modelling of a potential dam break and following flood inundation of the downstream areas providing information on inundation extent, water height, and time of arrival downstream. Two scenarios were modelled: worst-case scenario (complete collapse of the dam wall); medium risk level scenario (50% break of the dam wall).
- Exposure assessment for the two scenarios analysed, worst-case and medium risk level, focusing on transportation, population including IDP camps.

Figure 19. Modelled maximum water depth for the worst-case scenario (southwest of the AOI).



The results of this activation (EMSN145) are considered sensitive and will not be publicly available.

Sultansuyu Dam (Türkiye), exposed to MMI VII

For the Sultansuyu Dam, which was affected by the earthquake in the Pazarcık District of Kahramanmaraş. The severe shacking caused longitudinal cracks along the structure. The Malatya Governorate announced the gradual discharge of the reservoir as a precaution measure and that the downstream population should have been cautious. The level of the reservoir, some days after the two earthquakes (7.8 M and 7.5 M) of 6 February, has reached 1.5 m due to the controlled discharge. The satellite images pre- and post-event shows confirms that the reservoir level is significantly decreased due to the discharge.

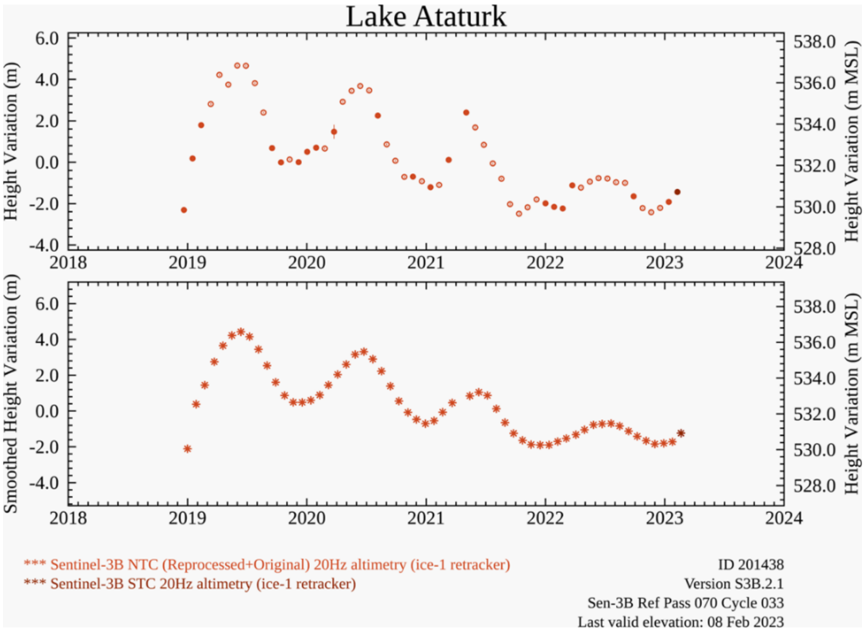
Figure 20. Longitudinal cracks on the Sultansuyu Dam.

Atatürk Dam (Türkiye), exposed to MMI VI

The Atatürk Dam is located on the Euphrates River at a distance of 62 km from Şanlıurfa and 48 km from Adıyaman, and is the most important and largest power plant in Türkiye. A statement of the Minister of Agriculture and Forestry of Türkiye has been reported, concerning the status of the dam: "No concerns in dams and hydroelectric power plants in Türkiye" even though "some cracks have been identified in Ataturk Dam which does not pose any threat or risk":

Due to the unavailability of near-real time river gauges data, altimetry data have been considered to look at the reservoir level time series. The reservoir level has a decreasing trend that can be detected from the beginning of the measurements, with a seasonal trend. The last measurement is only 2 days after the event, so it does not provide sufficient information on the trend after the earthquakes.

Figure 21. Altimetry data to monitor the level of the *Atatürk Dam (source: G-REALM)*.



2.4 Impact on cultural heritage

2.4.1 Situation in Turkiye

The following cultural heritage in Türkiye has been reported[29] as

- **collapsed / heavily damaged**:
  - Ulu Mosque[30] in Antakya (16th century)
  - Parliament Building of the Hatay State[31] (1938-1939)
  - Ulu Mosque[32] in Adıyaman (14th Century - restorations in 1863 and 1902)
  - Habib-i Najjar Mosque[33] in Antakya (7th century, rebuilt in 1852 after the 1853 earthquake)
  - Saint Georgios Antioch Greek Orthodox Church[34] in Hatay-Antakya (14th century, damaged heavily during the 1872 earthquake, opened again in 1900)

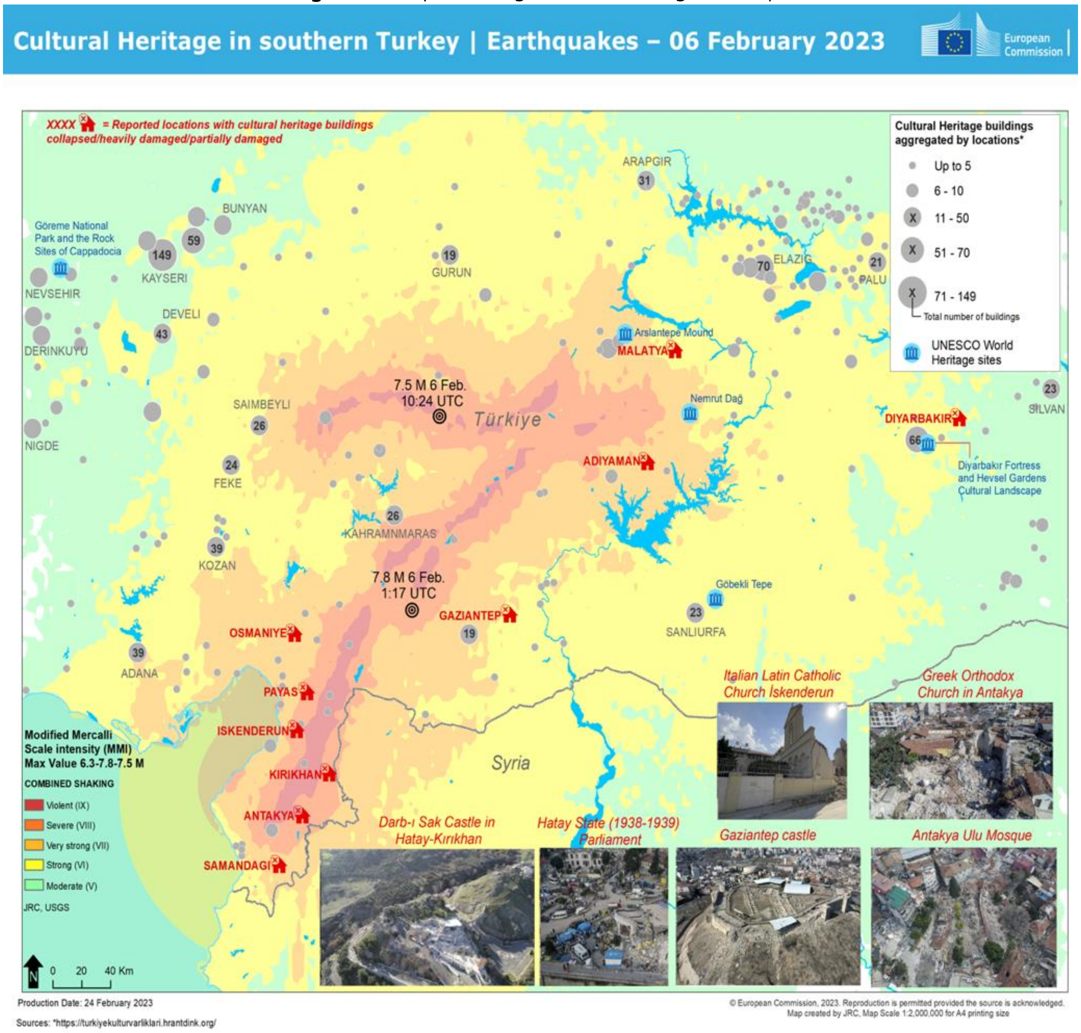
[29] https://www.ntv.com.tr/galeri/n-life/kultur-ve-sanat/depremler-tarihi-yapilara-da-buyuk-zarar-verdi,c4aJq0kl0kKx8Zo_88VQrQ/jlVVo1HtQkSIzYTgPX4zRQ
[30] https://tr.wikipedia.org/wiki/Antakya_Ulu_Camii
[31] https://en.wikipedia.org/wiki/Hatay_State
[32] https://www.kulturportali.gov.tr/turkiye/adiyaman/gezilecekyer/ulu-cami553357
[33] https://tr.wikipedia.org/wiki/Habib-i_Neccar_Camii
[34] https://www.ortodokslartoplulugu.org/kutsal-mekanlar/antakya-ortodoks-kilisesi/

- Italian Latin Catholic Church[35] in Hatay-İskenderun (19th century)
- Antakya Synagogue[36] (19th century)

- **partially damaged:**
  - Envar-ül Hamit Mosque[37] in Osmaniye (19th century)
  - Gaziantep Castle[38] (2nd century)
  - Hacı Yusuf Taş Mosque[39] in Malatya (20th century)
  - Sarımıye Mosque[40] in Antakya (16th century)
  - Virgin Mary Armenian Church[41] in Samandağ-Hatay
  - Eagle-topped column of the Karakush Tumulus[42] (1st century BC)
  - Darb-ı Sak Castle[43] in Hatay-Kırıkhan (11th century)
  - Sarı Selim Mosque[44] in Hatay-Payas (16th century)
  - Kahta Castle[45] in Adıyaman (13th Century)
  - Diyarbakır Walls[46]

[35] https://en.wikipedia.org/wiki/Cathedral_of_the_Annunciation,_%C4%B0skenderun
[36] https://serbestiyet.com/haberler/sinagog-yikildi-cemaat-baskani-ve-esi-depremde-hayatini-kaybetti-ve-antakyadaki-2500-yillik-yahudi-hayati-son-buldu-118350/
[37] https://osmaniye.ktb.gov.tr/TR-60833/envar-ul-hamit-camii.html
[38] https://en.wikipedia.org/wiki/Gaziantep_Castle
[39] https://www.kulturportali.gov.tr/turkiye/malatya/kulturenvanteri/yen-cam-haci-yusuf-tas-cam
[40] https://www.antakya.com/bilgi-42-sarimiye-camii
[41] https://www.aa.com.tr/tr/asrin-felaketi/hatay-merkezli-deprem-meryem-ana-kilisesindeki-hasari-artirdi/2826625
[42] https://en.wikipedia.org/wiki/Karaku%C5%9F_Tumulus
[43] https://hataytarihii.wordpress.com/5-gezilecek-yerler/darb-i-sak-kalesibayezid-i-bistami/
[44] https://www.payas.bel.tr/sayfa.php?idno=15
[45] http://adiyaman.gov.tr/eski-kahta-kalesi
[46] https://diyarbakir.ktb.gov.tr/TR-56899/surlar.html

Figure 22. Map of damaged cultural heritage in Türkiye.



2.4.2 Situation in Syria

The earthquake of 06 February 2023 caused extensive damage also to cultural heritage and ancient sites in Syria, which have already been affected by the conflict.

UNESCO (United Nations Educational, Scientific and Cultural Organization) expressed its concerns about the situation in the Ancient city of Aleppo, inscribed on the UNESCO World Heritage Sites List as well as on the List of World Heritage in Danger. The earthquake of 06 February caused considerable damage to the Old Citadel's walls and towers: the western tower of the Antakya Gate has collapsed; several other buildings, among which the old Souks al-Hamediyya, al-Mahamas, and al-Haddin, have been partially damaged; the façade of the National Museum has cracked. The Great Mosque of Aleppo also reported damage, with parts of the dome falling off[47]. The citadel is thought to have been built around the 3rd millennium BC.

According to UNESCO officials, visible cracks appeared on the walls of the Crac des Chevaliers, a Crusader fortress in Homs governorate which is also on UNESCO's World Heritage Sites List[48].

[47] https://whc.unesco.org/en/news/2521
https://www.euronews.com/culture/2023/02/21/how-can-cultural-sites-be-saved-after-the-turkiye-syria-earthquakes
https://www.gulftoday.ae/opinion/2023/02/16/destruction-upon-destruction
[48] https://www.euronews.com/culture/2023/02/21/how-can-cultural-sites-be-saved-after-the-turkiye-syria-earthquakes

Several cultural and archaeological sites in Tartous governorate were affected[49]. Most notably, the Al-Marqab castle, located in Baniyas, was heavily damaged by the earthquake, which caused the partial or complete collapse of several parts of the structure[50], while a circular tower in the Tartous Citadel of the Crusaders collapsed[51].

In Hama, the 12th century Norias, massive wooden waterwheels, have collapsed[52].

In the ancient city of Maarat al Numan, Idlib governorate, the museum and the Ottoman Khan were impacted[53].

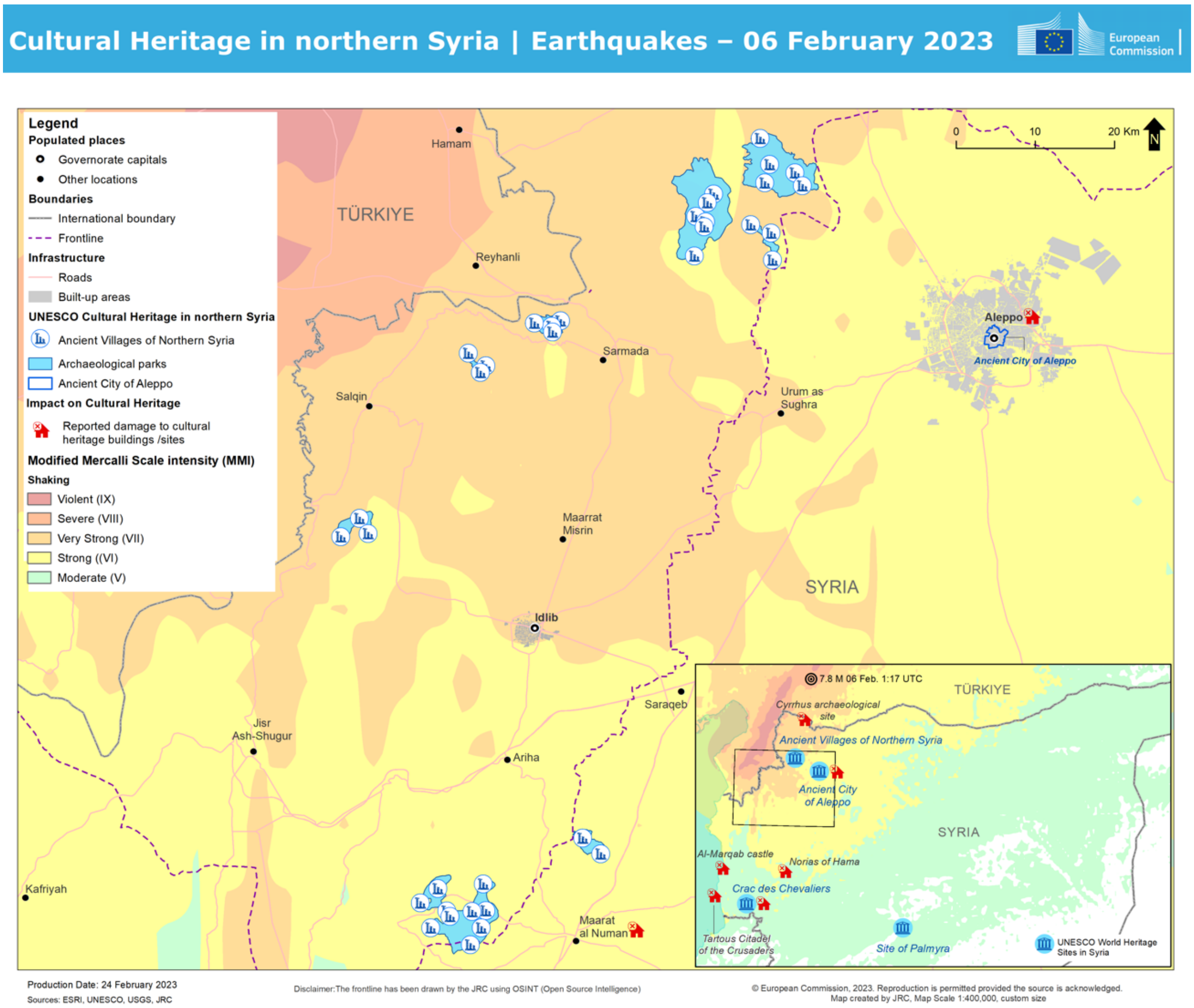
Possible damage was reported over other cultural and archaeological sites, including the Roman amphitheatre of Cyrrhus in Aleppo governorate.

Figure 23. Images of earthquake impact on the Great Mosque of Aleppo in the Old Citadel Aleppo Old Citadel (left) and Al-Marqab castle (right) in Syria.

Additionally, several of UNESCO Ancient Villages in Northern Syria can be found in the earthquake impacted areas, already under pressure due to the long-lasting conflict, and might have been subject to structural stress. Although no damage to the archaeological ruins was yet reported, many modern villages and towns in that same area were heavily affected[54].

[49] https://www.sana.sy/en/?p=301043
[50] https://www.euronews.com/culture/2023/02/21/how-can-cultural-sites-be-saved-after-the-turkiye-syria-earthquakes
[51] https://unosat.org/products/3500
[52] https://www.gulftoday.ae/opinion/2023/02/16/destruction-upon-destruction
[53] https://www.gulftoday.ae/opinion/2023/02/16/destruction-upon-destruction
[54] https://www.gulftoday.ae/opinion/2023/02/16/destruction-upon-destruction

Figure 24. Map of Cultural Heritage damage in Syria.



3 Monitoring of Persons of Concern in Syria

<u>Government controlled area</u>

The local authorities continue the provision of emergency relief in the 200 collective shelters still open in Aleppo. According to IFRC, 293 000 people have been displaced. 6.5 million people in 5 governorates are affected or at risk.

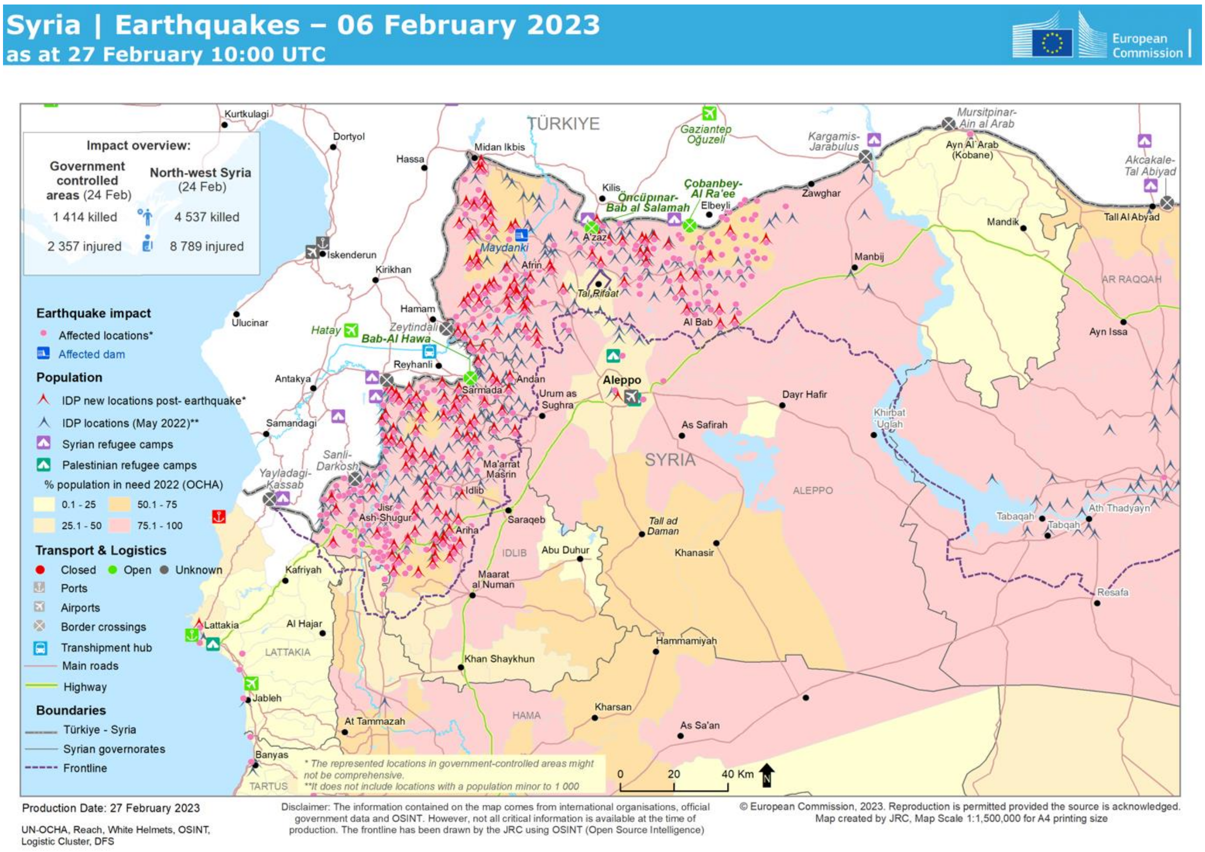
<u>North-west Syria</u>

Analysis provided by Global Camp Coordination and Camp Management Cluster (CCCM) and IOM shows that almost 2.6 million people are internally displaced in north-west Syria, including almost 90 000 recently displaced. 1.9 million people were living in IDP camps. Jandairis, Salqin and Harim have seen the highest number of departures while Dana, Salqin and Idleb have seen the highest number of IDP arrivals.

A Rapid Monitoring Assessment of IDP sites was launched by CCCM and should be completed by 28 February.

UNHCR's Flash Update of 23 February mentions that 50 000 people still need emergency shelter and 440 000 people need core relief items.

Figure 25. Earthquake impact in Syria



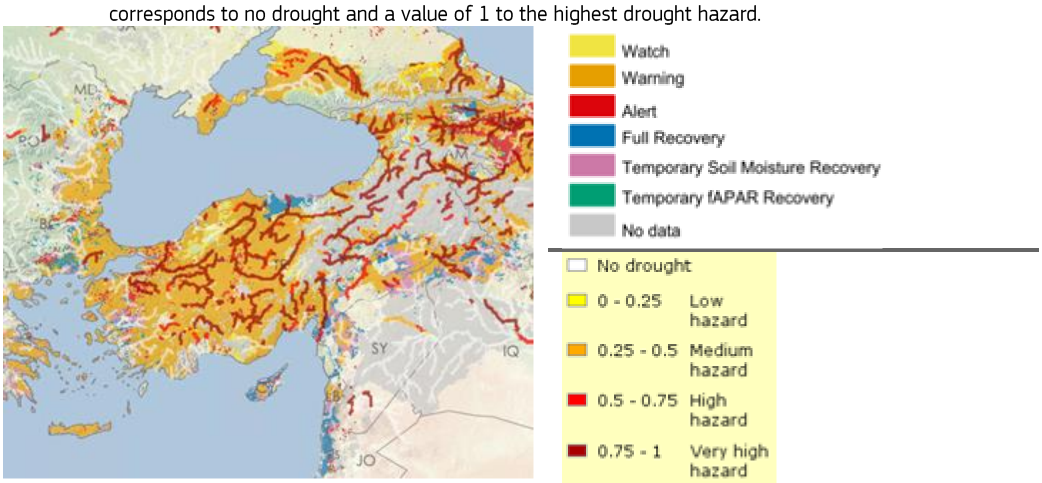
4 Drought situation and impact on agriculture

A severe lack of precipitation affects both Türkiye and Syria with impacts on soil moisture and rivers' flow.

The compound effects of the catastrophic earthquakes of February 2023 and the drought may exacerbate impacts on water availability for human, agricultural and energy use.

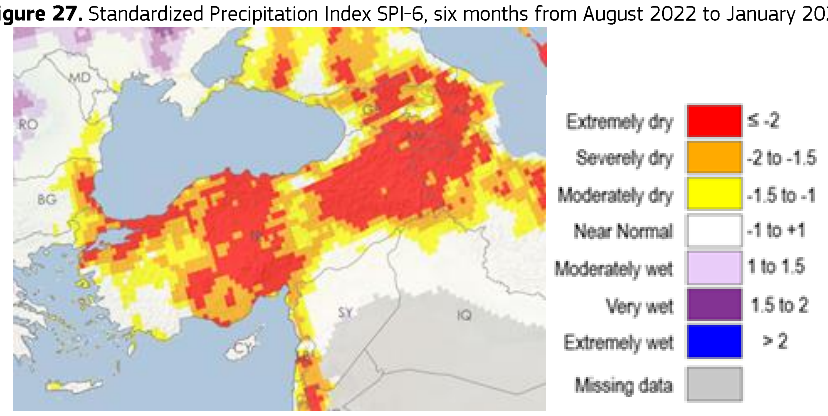
Türkiye and Syria remain extensively under warning conditions according to the Combined Drought Indicator (CDI). This reflects a severe lack of precipitation in the last months and drier than normal soil moisture conditions. The crop season has not started yet, but the current situation raises concerns for its potential impacts and risks. It has been reported about one month delay of the sowing dates, but monitoring the evolution of the drought is important to estimate potential impacts and support risk reduction strategies.[1] The Low-Flow Index (LFI) shows critical values over most of Türkiye. Higher risk is detected in western Türkiye, Caucasus and southern Syria. Recovery is detected only for local spots (Fig. 1).

Figure 26. Combined Drought Indicator (CDI) and Low-Flow Index (LFI) at the beginning of February 2023. A Low-Flow Index of 0 corresponds to no drought and a value of 1 to the highest drought hazard.



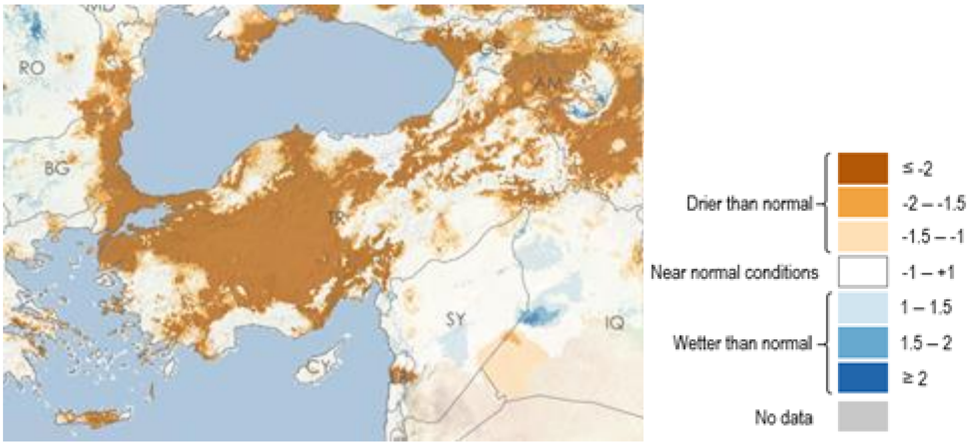
Türkiye has been affected by negative precipitation anomalies from August 2022 to January 2023. The highest negative anomalies are detected in central and north-eastern Türkiye. In Syria, according to the available data, precipitation is generally near normal values except for the western regions. (SPI-6, Fig. 2).

Figure 27. Standardized Precipitation Index SPI-6, six months from August 2022 to January 2023.



The soil moisture anomaly remains markedly negative in most of Türkiye, in particular in the central and western regions due to the long-lasting lack of precipitation and the warm-spell at the beginning of the winter 2022-23. In eastern Türkiye and in northern Syria some partial and local improvements have been detected, but a longer monitoring is required. Data are coherent with the negative SPI pattern.

Figure 28. Soil Moisture Anomaly – beginning of February 2023.



[1] For more details on impacts please refer to the GDO Analytical Report: Drought in the Maghreb and Türkiye February 2023 – in press.

5 Update on the satellite mapping activations

5.1 Copernicus EMS Rapid Mapping activation in Türkiye (EMSR648)

The European Commission's Copernicus emergency satellite mapping system was activated by the Emergency Response Coordination Centre (ERCC) on 06 February at 04:43 UTC to support damage assessment (less than 4 hours after the M7.8. earthquake). The JRC Copernicus Mapping Team is providing technical support to the activity. All information and maps related to this activation are available here:

https://emergency.copernicus.eu/mapping/list-of-components/EMSR648

Optical satellite images of very high resolution (less than 1 meter) were acquired between 07 and 12 February over 20 areas of interest (AOIs) located near the epicentres of the earthquakes. These areas, covering a total of 949 km^2, are home to an estimated population of 4 279 646 people.

Due to cloud coverage, it was necessary to order numerous satellite images in order to cover all areas. As of 09 February, 100% of the area covered by the 20 AOIs have been analysed (32% on 08 February). In total 64 maps (in 37 products) were published showing a total of 1 161 building blocks, 3 361 buildings and 84 km of roads as possibly damaged, damaged or destroyed. In addition, 644 temporary or spontaneous camps and 46 ha for larger camps were identified on the satellite images.

Figure 29. Results of the damage assessments as performed by the Copernicus EMS Rapid Mapping team in the context of the EMSR648 activation. Situation as of 12 February at 10:00 CET.

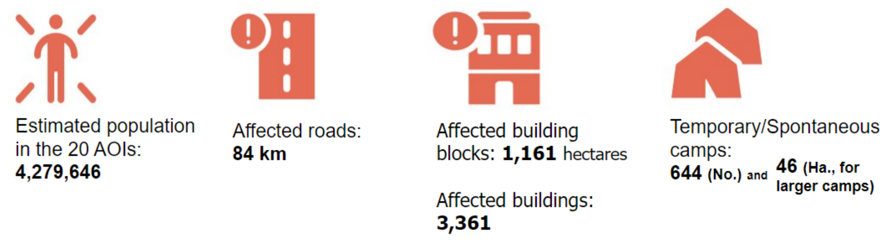
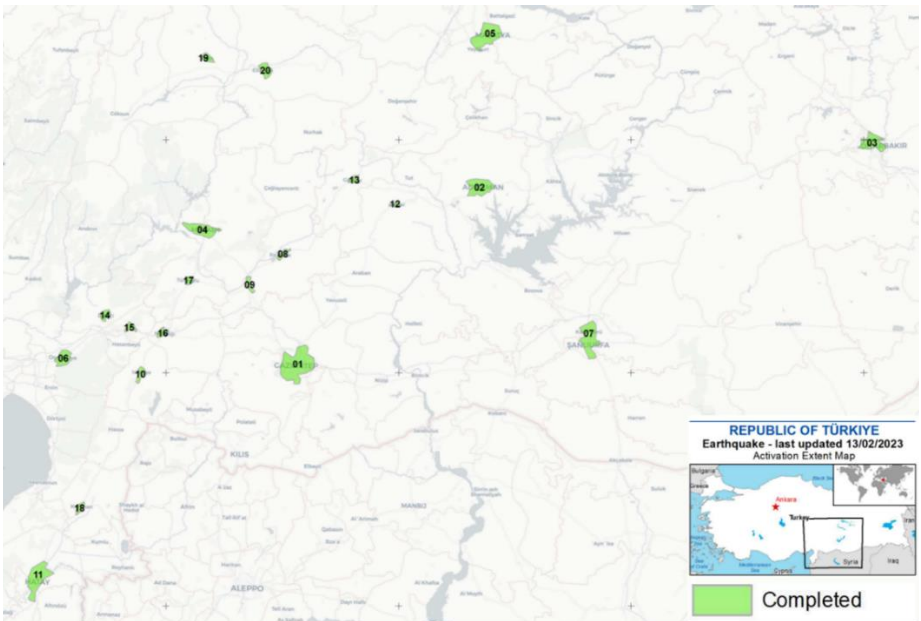


Figure 30. Activation Extent Map: overview of the areas of interest and map production for EMSR648. Latest update here.



All the results of the damage assessments, which include the location of the buildings and roads identified as affected and of the temporarily camps, are available for download on the activation webpage and can be visualized on the Activation Viewer.

No other assessment is planned to be conducted over these areas. However, the activation remains open in case analysis over new areas or consolidations of previous assessments are requested.

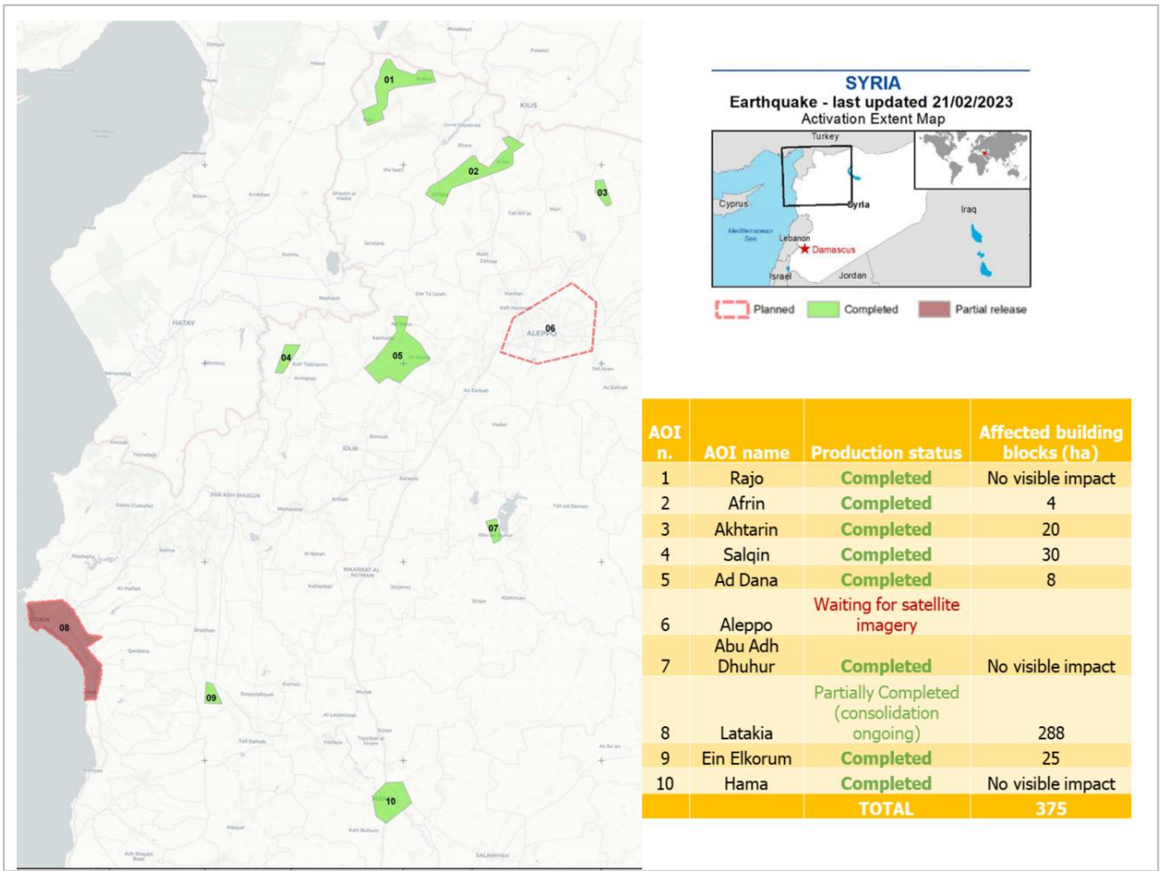
5.2 Copernicus EMS Rapid Mapping activation in Syria

On 15 February, the ERCC activated the European Commission's Copernicus emergency satellite mapping system, following a request from the United Nations Development Programme. The aim is to carry out damage assessments based on archive and new imagery, as new aftershocks are reported in affected areas, furthering the destruction of buildings and critical infrastructure (especially water and electricity infrastructure). The analysis is being carried out on 10 areas covering almost 1 000km^2.

Just like for the activation EMSR648, the JRC Copernicus Mapping Team is providing support to the activity. This activation is sensitive and the products are therefore not publicly available.

Archive images acquired on 08 and 09 February (2 and 3 days after the M7.8 earthquake in Türkiye) were first analyzed, while new acquisitions of very high resolution (less than 1 meter) optical images are being acquired since 15 February. The figures below shows the location of the AOIs, the production status and the damages detected on the satellite imagery. While the analysis was completed for 8 AOIs, it is partially completed or still planned for 2 AOIs.

Figure 31. Activation Extent Map: overview of the areas of interest and map production for EMSR651.



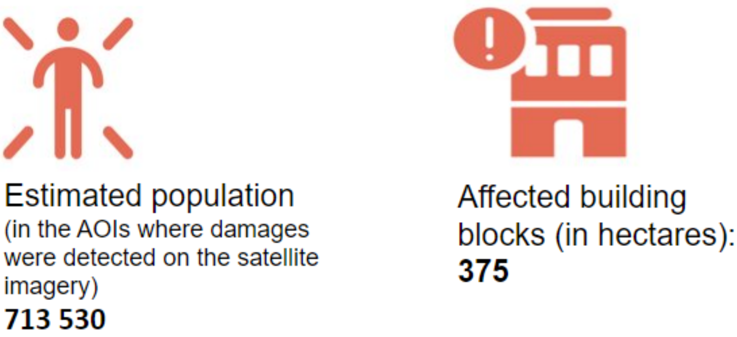
AOI n.	AOI name	Production status	Affected building blocks (ha)
1	Rajo	Completed	No visible impact
2	Afrin	Completed	4
3	Akhtarin	Completed	20
4	Salqin	Completed	30
5	Ad Dana	Completed	8
6	Aleppo	Waiting for satellite imagery	
7	Abu Adh Dhuhur	Completed	No visible impact
8	Latakia	Partially Completed (consolidation ongoing)	288
9	Ein Elkorum	Completed	25
10	Hama	Completed	No visible impact
		TOTAL	375

Most of the damage identified on the satellite images was observed in the area around the town of Latakia (288 hectares out of the 375 hectares identified as affected in the 9 areas analysed). The first analysis over AOI08 (Latakia) was based on an image acquired on 09 February and, if weather conditions allows, a new image will be analysed on 22 February to provide more accurate figures for the damage assessment.

In the towns of Rajo, Abu Adh Dhuhur and Hama, no damage was visible on the satellite images acquired on 17 and 21 February.

UNOSAT also carries out damage assessments over some of the areas showed in Figure 18, based on satellite imagery acquired after 20 February, date of the M6.3. earthquake.

Figure 32. Preliminary results of the damage assessments as performed by the Copernicus EMS Rapid Mapping team in the context of the EMSR651 activation.
Situation as of 23 February at 18:00 CET.



5.3 Copernicus Risk and Recovery Service

Due the devasting consequences of these seismic movements the ECHO-ERCC, on behalf of United Nations Development Programme/UNDP, requested an activation to facilitate the response/early recovery phase of the affected areas in Syria, specifically in 14 urban areas, where UNDP plans to facilitate aid. More specifically to verify and highlight detailed damage assessment using various sources, IDP camps and informal settlement's location, volume of debris from destroyed/partially destroyed buildings and direct and indirect economic loss assessments. This activation is about to start and the results will be available within 10 calendar days.

5.4 International Charter for Space and Major Disasters, and UNOSAT activations in Türkiye and Syria

On 06 February (date of the M7.8 earthquake), the International Charter for Space and Major Disasters was activated in Türkiye (activation 797), as well as in Syria (activation 798). Since then, several assessments have been conducted. UNOSAT provides access to their products through: https://experience.arcgis.com/experience/af8529245dbb4041ba532fab46ee02d2/page/UNOSAT/?views=Home.

UNOSAT also integrates products developed by:

1) The Wuhan University in collaboration with the United Nations Satellite Centre (UNOSAT) related to light loss assessment: (https://unosat.org/products/3495)
2) The GIS centre of Médecins Sans Frontières (MSF) damage analysis in Al Atarib (Aleppo Governorate) available at: https://disasterscharter.org/image/journal/article.jpg?img_id=18768677&t=1676556763408.

6 Health-related issues

The JRC continues to monitor the situation in the area impacted by the earthquakes with a specific filter defined in the Epidemic Intelligence from Open Sources (EIOS) system. Other public health institutions using the platform such as WHO and ECDC are also doing the same.

6.1 Health system capacity

According to a WHO statement on 22 February[55], in Türkiye, at least 15 hospitals have been damaged with many health facilities affected, while 7 hospitals and 145 health facilities have been damaged across the Syrian Arab Republic, with many of these affected services being in the north-west.

According to media reports[56], following the major aftershocks on 20th February, two hospitals in the southernmost city of Hatay (Türkiye) were evacuated out of precaution, with patients in intensive care unit being transferred to Dörtyol State Hospital, and emergency services subsequently provided in a field hospital. Another source[57] reports some hospitals in the region, including Iskenderun State Hospital, a private hospital in Hatay, two private hospitals in Malatya, and another private hospital in Adıyaman, are non-functional or only partly functional due to earthquake damage. However, 9 seismically isolated (base-isolated) hospitals in the region are functional, including the world's second-largest base-isolated 2000-bed Adana City Hospital.

As reported by media sources[58], according to health authorities in North-West Syria, more than 59 health centres have been totally or partially destroyed and more than 50 healthcare providers have been killed by the earthquake, thus severely damaging the primary health care system in the area.

6.2 Epidemiological situation

Public health authorities such as WHO[55] and ECDC[59] have expressed concerns about a high risk of new or exacerbated outbreaks of food and waterborne disease, respiratory and vaccine-preventable infections in both Türkiye and Syria, due to damaged utility infrastructure (causing limited access to clean water, inadequate sanitation and hygiene facilities, improper refrigeration, and cooking systems), crowded settings (i.e. temporary settlements or campsites for survivors), and cold weather.

According to ECDC[59], in the coming weeks a surge of cholera cases has to be likely expected in the affected areas, and in particular in North-West Syria. The public health agency issued the following recommendations:

- Resume and accelerate the planned cholera vaccination campaign disrupted by the earthquakes in North-West Syria.
- Ensure continuity of routine vaccinations and address prior vaccination gaps in the affected regions from Türkiye and Syria.
- Ensure availability of clean water and control of food handling are to avoid the spread of other food and or waterborne diseases (viral infections such as hepatitis A, norovirus and rotavirus, infections caused by parasites or bacterial infections) in camps.
- Setup of health surveillance systems by public health staff to facilitate the early warning and detection of outbreaks, with the support of mobile laboratories and expert assistance to be provided by international organizations in both affected countries.
- Offer tetanus prophylaxis to rescuers (as per existing national guideline)s to mitigate the risk of infection from injuries and open wounds caused by contact with debris.

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[55] https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing---22-february-2023

[56] https://www.dailysabah.com/turkiye/2-hospitals-evacuated-as-precaution-after-new-quakes-jolt-turkiyes-hatay/news

[57] https://temblor.net/temblor/preliminary-report-2023-turkey-earthquakes-15027/

[58] https://www.scidev.net/mena/news/epidemic-fears-after-health-teams-die-in-syria-quake/

[59] https://www.ecdc.europa.eu/en/news-events/earthquakes-turkiye-and-syria-infectious-diseases-expected-be-concern-two-four-weeks

- Ensure access to healthcare for trauma and other urgent care, shelter, potable water, and adequate sanitation and hygiene facilities
- Dedicated risk communication and community engagement interventions

As reported by media[60], according to the Assistance Coordination Unit (ACU) NGO and the Early Warning and Epidemic Response Network (EWARN)[61] the number of suspected cholera infections in northwestern Syria raised to 50 734 on 26 February[62], due to population displacement and difficulty of access to clean water.

The White Helmets also reportedly warned of a cholera case surge in the same area to the great destruction of infrastructure, water and sewage networks. Health authorities operating in northwestern Syria also reported to media that 1.7 million doses of cholera vaccine (provided by the World Health Organization) arrived in the region at the end of last month, but the earthquake affected their distribution[63].

Figure 33. Latest infographic available on the number of cholera cases in Northwest Syria from Assistance Coordination Unit (ACU) and the Early Warning and Epidemic Response Network (EWARN).

According to the Minister of Health of Türkiye, a case of chickenpox was detected in the country and there is an increase in acute intestinal infections, with a small number of patients being hospitalized, while the situation is currently not likely to cause other major epidemics[64]. However, the same Minister also warned against drinking mains water in the Kahramanmaraş province, according to media[65].

Local media news had previously been reporting about scabies according among adults in Adiyaman (Türkiye) according to a source[66]. Also, NGOs had reported report children in Antakya (Türkiye),

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60 https://www.enabbaladi.net/archives/630205#ixzz7uEO7kXe

61 https://acu-sy.org/ewarn/

62 https://t.me/covid19_arabic/2658

63 https://www.aljazeera.net/news/2023/2/27/%D8%A8%D8%B9%D8%AF-3-%D8%A3%D8%B3%D8%A7%D8%A8%D9%8A%D8%B9-%D9%85%D9%86-%D8%A7%D9%84%D8%B2%D9%84%D8%B2%D8%A7%D9%84-%D8%AA%D8%AD%D8%B0%D9%8A%D8%B1%D8%A7%D8%AA-%D9%85%D9%86-%D8%AA%D9%81%D8%B4%D9%8A

64 https://twitter.com/drfahrettinkoca/status/1627376859167047680?ref_src=twsrc%5Etfw%7Ctwcamp%5Etweetembed%7Ctwterm%5E1627376859167047680%7Ctwgr%5E838b7d1648badca0c8ee0de8225661dd29727bc6%7Ctwcon%5Es1_

65 https://t24.com.tr/haber/kahramanmaras-ta-konusan-bakan-koca-dan-sebeke-suyunu-icmeyelim-uyarisi,1094348

66 https://www.downtoearth.org.in/news/world/lack-of-clean-water-sanitation-facilities-put-quake-survivors-in-turkey-at-risk-87692

experiencing symptoms such as vomiting and diarrhea, possibly associated with the spread of a communicable diseases[67].

[67] https://reliefweb.int/report/turkiye/lack-clean-water-toilets-puts-earthquake-survivors-particularly-children-turkiye-risk-disease

7 Expected Updates

The report will be updated upon need to monitor the event and the response activities.

Annexes

Annex 1 – Available data and information by key sector

A list of sector specific reports, datasets, maps and infographics is presented below. The list should not be considered exhaustive and is subject to regular updating.

1. Restoration of critical infrastructure and services

1.1. Building damage and debris
1.2. Water
1.3. Community infrastructure & services
1.4. Energy
1.5. Health
1.6. Cultural heritage

2. Supporting livelihoods and socio-economic recovery

2.1. Employment and food security
2.2. Agriculture
2.3. Manufacturing & Industries
2.4. SMEs

3. Gender equality and support to vulnerable groups

3.1. Social protection
3.2. Refugees and internally displaced people (IDPs)
3.3. Psychosocial Support
3.4. Other vulnerable groups

4. Governance and Institutions

4.1. Recovery and Reconstruction Governance
4.2. Participatory governance for recovery & reconstruction
4.3. Legal Framework and Regulatory Systems
4.4. Legal aid
4.5. Data governance

5. Other Dimensions

5.1. Population
5.2. Macro-Economic and Human Development Impact
5.3. Demining
5.4. Disaster risk reduction (DRR)

1. Restoration of critical infrastructure and services

1.1. Building damage and debris

Title: Copernicus Rapid Mapping Activation – Earthquake in East Anatolian Fault Zone
Description: Damage assessment in 20 areas of interest (AoIs) in Türkiye and 10 in Syria.
Source: European Union – Copernicus programme
Last update: 15/02/2023
Geographical coverage: Türkiye, Syria (restricted)
Format: Map/ pdf, jpeg, vector package
Link: https://emergency.copernicus.eu/mapping/list-of-components/EMSR648

Title: International Charter Activations in Syria and Türkiye
Description: Multiple AoIs in Syria and Türkiye, including cultural sites and different remote sensing analysis (eg. Light loss assessment, flood impact analysis). The maps are produced by UNOSAT and MSF
Source: International Charter
Last update: 20/02/2023
Geographical coverage: Syria, Türkiye
Format: Maps (png) and reports (pdf)
Link: https://disasterscharter.org/web/guest/activations/-/article/earthquake-in-syrian-arab-republic-activation-798-
https://disasterscharter.org/web/guest/activations/-/article/earthquake-in-turkey-activation-797-
https://experience.arcgis.com/experience/af8529245dbb4041ba532fab46ee02d2/page/UNOSAT/?views=Layers
https://unosat.org/products/3495

Title: Syria Earthquake Impact
Description: Number of fatalities, injuries, damaged and destroyed buildings, temporary accommodation, IDPs, population needs, accessibility.
Source: Assistance Coordination Unit - ACU Syria
Last update: 22/02/2023
Geographical coverage: Syria: Idleb, Aleppo (admin 4)
Format: Table/xls
Link: https://data.humdata.org/dataset/syria-earthquake-impact?

Title: Damage to buildings and Key Infrastructure
Description: Composite score of key informants (KI) damage estimates for buildings and key types of infrastructure. Online dashboard also available
Source: REACH
Last update: 14/02/2023
Geographical coverage: Syria: Aleppo, Idleb
Format: Map/png
Link: https://reliefweb.int/map/syrian-arab-republic/damage-buildings-and-key-infrastructure-composite-score-ki-damage-estimates-buildings-and-key-types-infrastructure-production-date-14-february-2023
https://reach-info.org/syr/earthquake2023/

Title: Damaged buildings in NW Syria
Description: Number of damaged buildings per district
Source: Syria direct

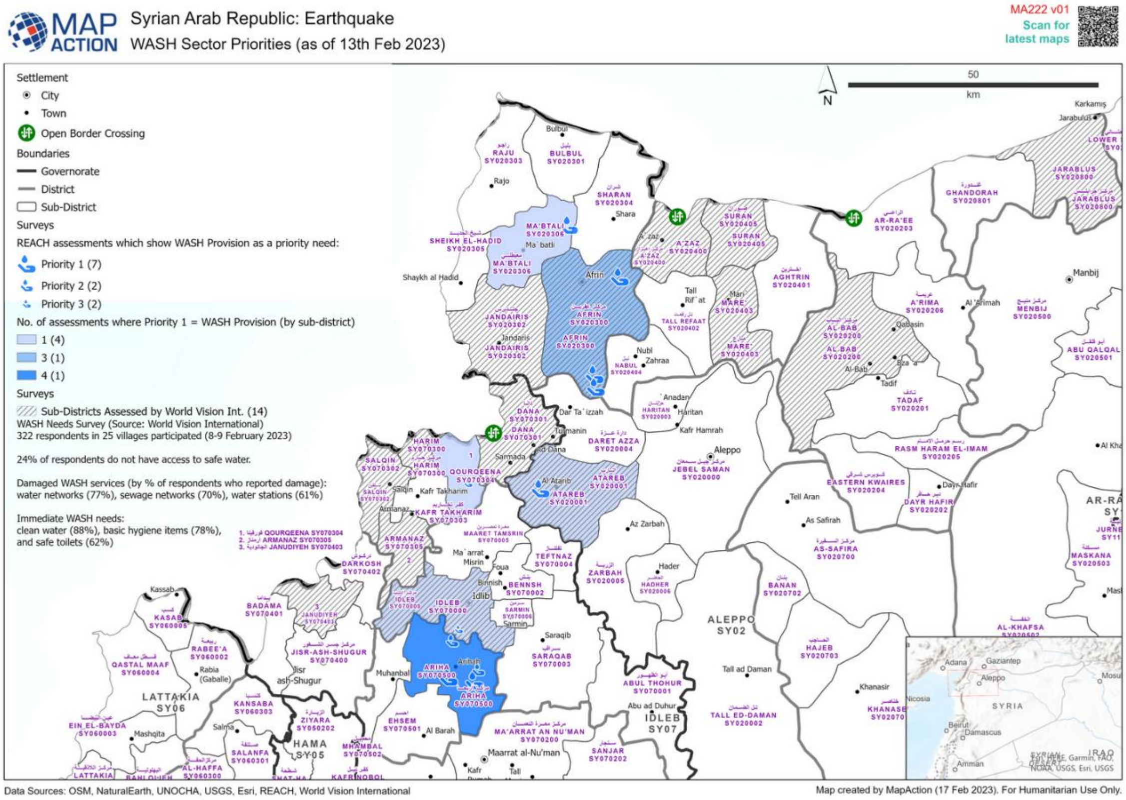
Last update: 16/02/2023
Geographical coverage: Syria: north-west
Format: Map/online
Link: https://syriadirect.org/earthquake-years-of-war-make-northwestern-syrias-buildings-graves-above-ground/

Title: IFRC Damage Assessment
Description: Damage assessment
Source: IFRC
Last update: 16/02/2023
Geographical coverage: Türkiye
Format: Maps
Link: https://go.ifrc.org/emergencies/6345#reports

Title: Human and material damage statistics
Description: Number of fatalities, injuries, damaged and destroyed buildings
Source: Emergency Response Committee
Last update: 23/02/2023
Geographical coverage: Syria, north-west
Format: Online dashboard/free data download
Link:
https://app.powerbi.com/view?r=eyJrIjoiNmY4NDYzYzEtYzJkYi00MzIyLWJlMTktNGRkYzAzMmQ3NDQwIiwidCI6ImZhZjlhYjEwLTM5MzEtNDMzNy1hNmZiLWQ2NDI2MzA5ZTc4NiIsImMiOjl9

Title: Damaged buildings and needs assessment
Description: Damage and needs assessment (shelter and NFI, food, fuel, cash)
Source: Map Action
Last update: 12/02/2023
Geographical coverage: Syria, north-west
Format: Map
Link: https://reliefweb.int/map/syrian-arab-republic/syrian-arab-republic-earthquake-damaged-buildings-and-needs-assessment-sub-district-nahya-survey-surveys-12th-feb-2023

1.2. Water

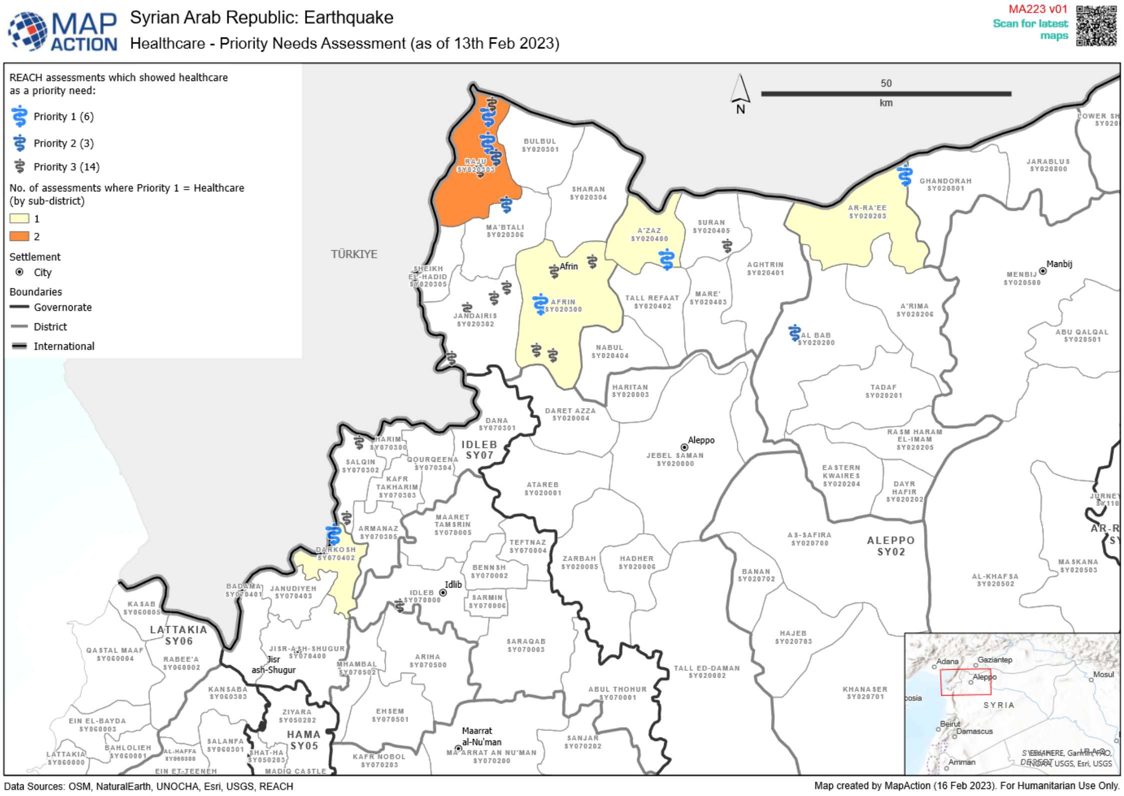


Title: Water and sanitation (WASH) - Priority Needs Assessment
Description: Map on WASH Sector Priorities
Source: Map Action
Last update: 17/02/2023
Geographical coverage: Syria
Format: Map/png
Link: https://maps.mapaction.org/dataset/2023-syr-001-ma222-v1

1.3. Community infrastructure & services

1.4. Energy

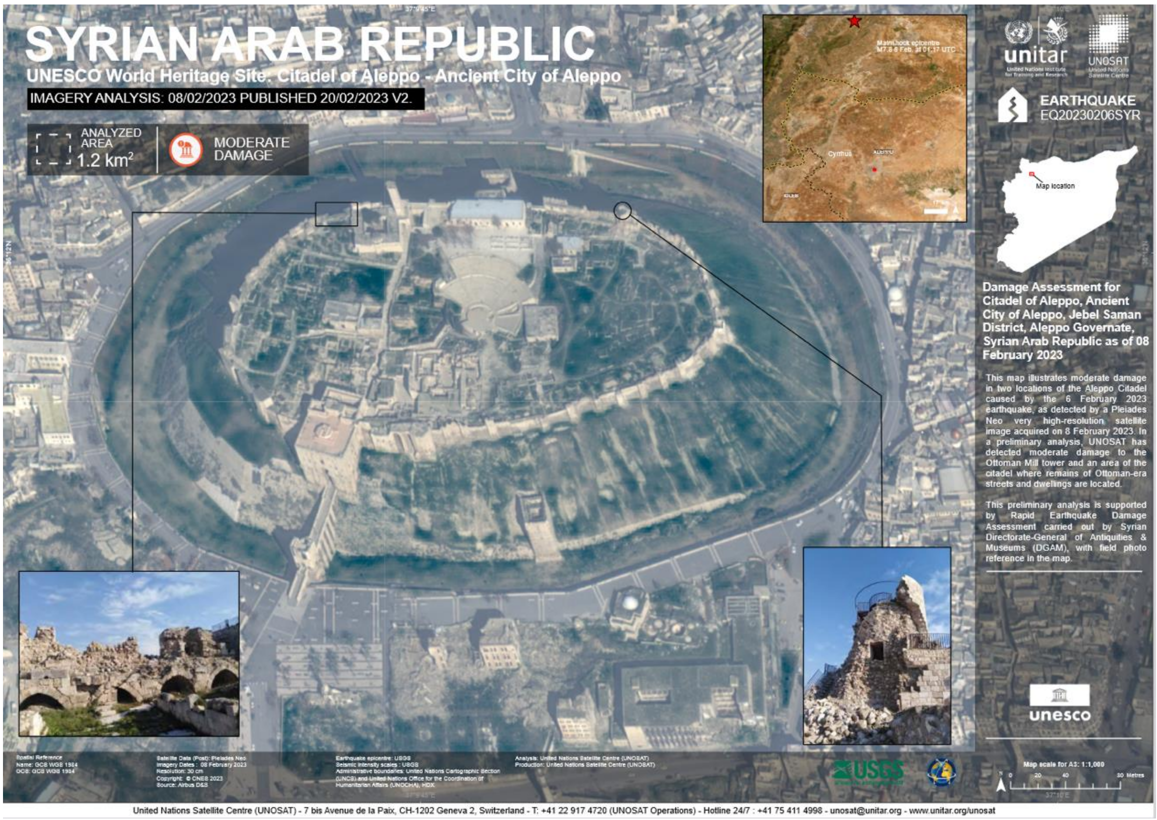
1.5. Health



Title: Healthcare - Priority Needs Assessment
Description: Map on priority of healthcare
Source: Map Action
Last update: 16/02/2023
Geographical coverage: Syria
Format: Map/png
Link: https://maps.mapaction.org/dataset/2023-syr-001-ma223-v1

Title: Post-Quake Rapid Needs Assessment
Description: M Rapid Needs Assessment Report for Türkiye
Source: MDM-T DDD
Last update: 22/02/2023
Geographical coverage: Türkiye
Format: Report/pdf
Link: Post-Quake Rapid Needs Assessment Report for Türkiye (February 20, 2023) - Türkiye | ReliefWeb

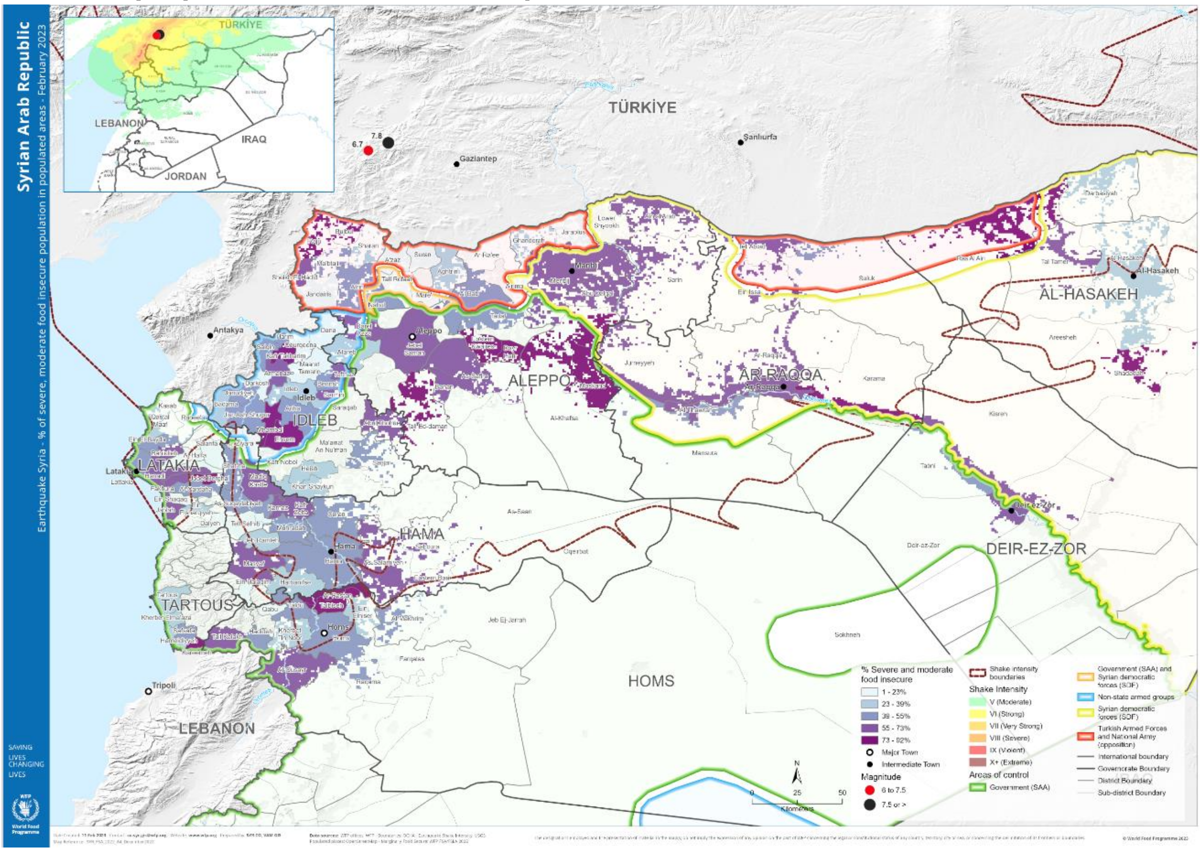
1.6. Cultural heritage



Title: International Charter Activations in Syria and Türkiye
Description: Multiple AoIs in Syria and Türkiye, including cultural sites.
Source: International Charter
Last update: 20/02/2023
Geographical coverage: Syria, Türkiye
Format: Maps (png) and reports (pdf)
Link: https://disasterscharter.org/web/guest/activations/-/article/earthquake-in-syrian-arab-republic-activation-798-
https://disasterscharter.org/web/guest/activations/-/article/earthquake-in-turkey-activation-797-
https://experience.arcgis.com/experience/af8529245dbb4041ba532fab46ee02d2/page/UNOSAT/?views=Layers
https://unosat.org/products/3495

2. Supporting livelihoods and socio-economic recovery

2.1. Employment and food security



Title: % of severe, moderate food insecure population in Syria
Description: Map on food insecurity at the sub-national level
Source: World Food Programme (WFP)
Last update: 20/02/2023
Geographical coverage: Syria
Format: Map/png
Link: https://reliefweb.int/map/syrian-arab-republic/syrian-arab-republic-earthquake-syria-severe-moderate-food-insecure-population-populated-areas-february-2023

Title: North-West Syria - Earthquake Rapid Needs Assessment
Description: The dataset contains community-level information from key informants in 607 assessed communities covering 1) Population & Displacement, 2) CCCM, 3) Shelter damage & SNFI emergency needs, 4) Nutrition & Protection 5) Key Infrastructure Impacts & Service Access, 6) Priority Needs and 7) Humanitarian Assistance. Online dashboard also available
Source: REACH
Last update: 14/02/2023
Geographical coverage: Syria: Aleppo, Idleb
Format: Table/xls
Link: https://data.humdata.org/dataset/nws-earthquake-rapid-needs-assessment
https://reach-info.org/syr/earthquake2023/

Title: Food Security - Priority Needs Assessment
Description: Map on priority of food support
Source: Map Action

Last update: 13/02/2023
Geographical coverage: Syria
Format: Map/png
Link: https://maps.mapaction.org/dataset/2023-syr-001-ma221-v2

Title: ILO Response to the Earthquake in Syria
Description: Presenting the response in Syria with major focus on preparing an emergency employment scheme in Aleppo.
Source: International Labour Organization (ILO)
Last update: 17/02/2023
Geographical coverage: Syria: Aleppo
Format: Report/pdf
Link: https://www.ilo.org/wcmsp5/groups/public/---arabstates/---ro-beirut/documents/briefingnote/wcms_867949.pdf

Title: Access of Households to Key Services
Description: Composite score of key informants (KI) access estimates for key types of services. Online dashboard also available.
Source: REACH
Last update: 14/02/2023
Geographical coverage: Syria: Aleppo, Idleb
Format: Map/png
Link: https://reliefweb.int/map/syrian-arab-republic/access-households-key-services-composite-score-ki-access-estimates-key-types-services-production-date-14-february-2023
https://reach-info.org/syr/earthquake2023/

Title: Joint Rapid Assessment of Markets in northwest Syria
Description: Accessibility of Markets to Populations Residing in Assessed Communities. Online dashboard also available.
Source: REACH
Last update: 23/02/2023
Geographical coverage: Syria: Aleppo, Idleb
Format: Table/xls, Report and brief/pdf
Link: https://www.impact-initiatives.org/what-we-do/news/turkiye-and-syria-emergency-response-activated-following-two-powerful-earthquakes/#23022023_-_Key_findings_from_the_Joint_Rapid_Assessment_of_Markets_in_northwest_Syria
https://www.impact-repository.org/document/reach/dda9f5f2/SYR2302_JRAM_NWS_SO_Feb2023-3.pdf
https://www.impact-repository.org/document/repository/6d076f4e/JRAM-Key-findings_Final.pdf

2.2. Agriculture

2.3. Manufacturing & Industries

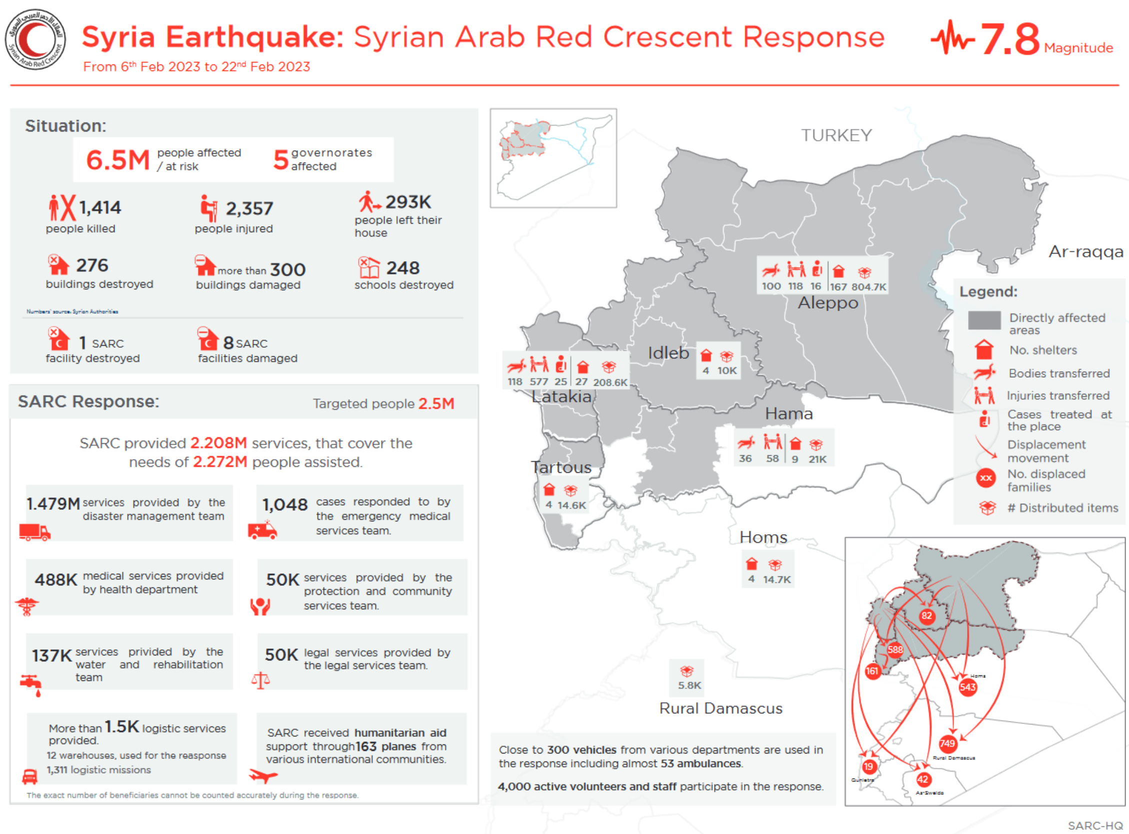
2.4. SMEs

3. Gender equality and support to vulnerable groups

3.1. Social protection

Title: Cash-based Interventions in Gender-based Violence Risk Mitigation, Prevention, and Response
Description: Established by the dedicated Task Team (TT) for the use of cash-based interventions (CBI in GBV risk mitigation, prevention, and response (referred as CBI in GBV from here on) by 3RP partners in Türkiye to harmonize and increase CBI support to survivors and those at risk of GBV.
Source: UNHCR
Last update: 21/02/2023
Geographical coverage: Türkiye
Format: Report/pdf
Link: https://data.unhcr.org/en/documents/details/99022

3.2. Refugees and internally displaced people (IDPs)



Title: IFRC Infographics
Description: Casualties, affected, IDPs, shelters per district
Source: IFRC
Last update: 21/02/2023 - daily update
Geographical coverage: Syria
Format: Infographic
Link: https://go.ifrc.org/emergencies/6346#reports

Title: North-West Syria - Earthquake Rapid Needs Assessment
Description: The dataset contains community-level information from key informants in 607 assessed communities covering 1) Population & Displacement, 2) CCCM, 3) Shelter damage & SNFI

emergency needs, 4) Nutrition & Protection 5) Key Infrastructure Impacts & Service Access, 6) Priority Needs and 7) Humanitarian Assistance
Source: REACH
Last update: 14/02/2023
Geographical coverage: Syria: Aleppo, Idleb
Format: Table/xls
Link: https://data.humdata.org/dataset/nws-earthquake-rapid-needs-assessment

Title: Shelter Database
Description: Geographical information on shelters, type of shelters, needs of IDPs and available response to the needs.
Source: Assistance Coordination Unit - ACU Syria
Last update: 22/02/2023
Geographical coverage: Syria: Idleb, Aleppo (admin 4)
Format: Table/xls
Link: https://data.humdata.org/dataset/syria-earthquake-impact?

Title: Shelters in north-west Syria
Description: Information on geographical distribution and household needs in Syria
Source: Emergency Response Committee
Last update: 23/02/2023
Geographical coverage: Syria, north-west
Format: Online dashboard/free data download
Link:
https://app.powerbi.com/view?r=eyJrIjoiNmY4NDYzYzEtYzJkYi00MzIyLWJlMTktNGRkYzAzMmQ3NDQwIiwidCI6ImZhZjlhYjEwLTM5MzEtNDMzNy1hNmZiLWQ2NDI2MzA5ZTc4NiIsImMiOjl9

Title: UNHCR geoservices
Description: Refugee data including population of concern, camps, border crossings, and other.
Source: UNHCR
Last update: N/A
Geographical coverage: Türkiye, Syria
Format: GIS
Link: geoservices (unhcr.org)

3.3. Psychosocial Support

Title: Mental health and psychosocial support, child protection
Description: Multi sectoral initial rapid needs assessment: Mental health and psychosocial support, child protection
Source: Nirengi Association
Last update: 23/02/2022
Geographical coverage: Türkiye, Syria
Format: Report/pdf
Link: PUBLICATIONS – Nirengi Association (nirengidernegi.org)

3.4. Other vulnerable groups

4. Governance and Institutions

4.1. Recovery and Reconstruction Governance

4.2. Participatory governance for recovery & reconstruction

4.3. Legal Framework and Regulatory Systems

Title: IDRL Emergency Fact Sheet, Türkiye
Description: This International Disaster Response Law (IDRL) Emergency Fact Sheet is intended to provide key information to international humanitarian actors, including the Red Cross and Red Crescent Movement operations and network, relating to the regulatory and policy environment applying to the entry of incoming disaster relief in Türkiye.
Source: IFRC
Last update: 23/02/2022
Geographical coverage: Türkiye
Format: Report/pdf
Link: IDRL Emergency Fact Sheet, Türkiye - Update No.2 | IFRC

4.4. Legal aid

4.5. Data governance

5. Other Dimensions

5.2. Population

Title: Türkiye Population and Housing Census, 2021
Description: Türkiye Population and Housing Census, 2021
Source: Turkish Statistical Institute (TurkStat)
Last update: 2021
Geographical coverage: Türkiye
Format: Table/xls
Link: TURKSTAT Corporate (tuik.gov.tr)

Title: Türkiye/Syria Earthquakes - Estimates of People Living in Affected Areas
Description: estimates on the number of people living in the affected areas, divided by exposure class
Source: WFP, Advanced Disaster Analysis & Mapping (ADAM)
Last update: 15/02/2023
Geographical coverage: Syria, Türkiye, and neighbouring countries
Format: Table/xls
Link: https://data.humdata.org/dataset/affected-population-estimation-turkiye-syria-earthquake-february-2023

Title: Syrian Arab Republic: Baseline Population
Description: Information on the total population in the Syrian Arab Republic, disaggregated by sex and age, as well as administrate levels 1 through 4. The dataset is available upon request
Source: OCHA
Last update: 10/02/2023
Geographical coverage: Syria

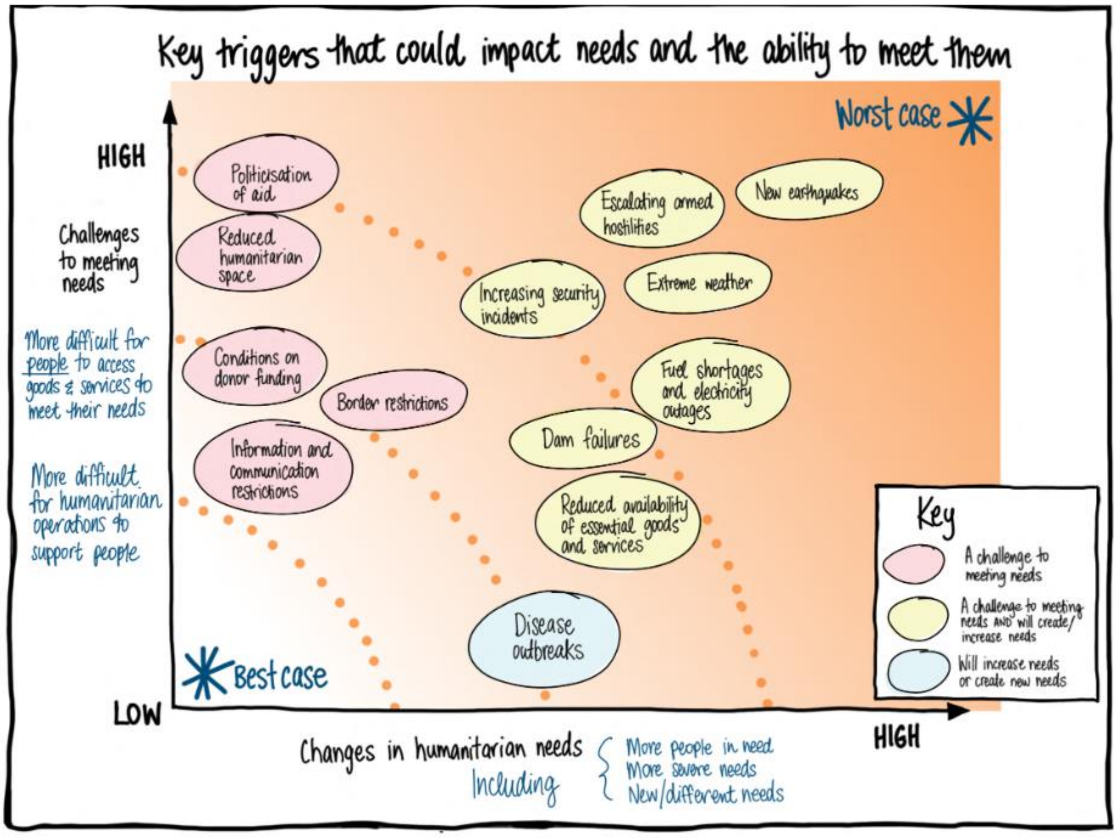
Format: Table/xls
Link: https://data.humdata.org/dataset/syrian-arab-republic-baseline-population

5.3. Macro-Economic and Human Development Impact

5.4. Demining

5.5. Disaster risk reduction (DRR)

6. Cross-sector



Source: ACAPS

Title: Overview of what to watch over the next month
Description: An overview exposition of what to watch for over the next month, highlighting key variables to monitor that could play a role in the development of the crisis, can contribute to informing the strategic planning, programming, and preparedness of humanitarian responders
Source: ACAPS
Last update: 17/02/2023
Geographical coverage: Syria, Türkiye
Format: Report/pdf
Link:
https://www.acaps.org/sites/acaps/files/products/files/20230217_acaps_anticipatory_analysis_turkiye_and_syria_earthquake_what_to_watch_over_the_next_month.pdf

Title: Early Recovery and Livelihoods Sector HCT - EQ Response Update
Description: Key figures, daily highlights, ongoing and planned activities
Source: UNDP

Last update: 20/02/2023 - regularly updated
Geographical coverage: Syria, HCT
Format: Report/pdf
Link: https://reliefweb.int/report/syrian-arab-republic/early-recovery-and-livelihoods-sector-hct-eq-response-update-february-20th-2023

Title: Data Portal for Statistics
Description: National and sub-national statistical data per theme
Source: Turkish Statistical Institute (TurkStat)
Last update: N/A
Geographical coverage: Türkiye
Format: Table/xls, databases, reports
Link: TÜİK - Veri Portalı (tuik.gov.tr)

Title: IFRC Earthquake impact
Description: Projections of the impact of the earthquake in different sectors
Source: IFRC
Last update: N/A
Geographical coverage: Türkiye
Format: Report/pdf
Link: https://go.ifrc.org/emergencies/6345#reports
https://prddsgofilestorage.blob.core.windows.net/api/sitreps/6345/ShakentotheCore_1.pdf

Title: North-west Syria: Flash Update
Description: Key figures and situation
Source: UN-OCHA
Last update: 23/02/2023 - regularly updated
Geographical coverage: Syria, north-west
Format: Report/pdf
Link: https://reliefweb.int/report/syrian-arab-republic/earthquakes-north-west-syria-flash-update-no-13-22-february-2023

Title: Humanitarian Country Team (HCT) Coordinated Response Flash Update
Description: Key figures and situation
Source: UN-OCHA
Last update: 18/02/2023 - regularly updated
Geographical coverage: Syria, HCT
Format: Report/pdf
Link: Syrian Arab Republic - Humanitarian Country Team (HCT) Coordinated Response Flash Update #13 - Earthquake (As of 18 February 2023) - Syrian Arab Republic | ReliefWeb

Title: DFS Bi-Weekly Highlights
Description: Bi-weekly highlights for Türkiye, Syria government-controlled areas and North-west Syria
Source: Data Friendly Space (DFS)
Last update: 24/02/2023 – Bi-weekly updated
Geographical coverage: Syria, Türkiye
Format: Report/pdf
Link: https://reliefweb.int/report/turkiye/turkiye-earthquake-february-2023-bi-weekly-highlights-24022023

https://reliefweb.int/report/syrian-arab-republic/syria-earthquake-february-2023-government-controlled-areas-bi-weekly-highlights-24022023
https://reliefweb.int/report/syrian-arab-republic/northwest-syria-earthquake-february-2023-bi-weekly-highlights-24022023

Annex 2 – Damage estimation based on Mean Damage Ratio

To perform this analysis, the following data are used:

- Copernicus Global Human Settlement Layer (GHSL)
- USGS Shakemap, which provides the shaking intensity due to the earthquake, subdivided in Modified Mercalli scale (MMI).

This damage estimation methodology is based on the relation between the damage, expressed as a percentual Mean Damage Ratio (MDR%), and the shaking intensity published by G.R. Birss ('Methodology for the Assessment of the damage cost from a large earthquake in the vicinity of Wellington'). The figure below shows that for intensity VIII and IX the Mean Damage Ratio (MDR%) strongly depends on the type of construction.

As a conservative hypothesis, with the aim of assessing the worst-case scenario, the curve with the highest MDR values has been used, meaning that unreinforced masonry structures are assumed to be the representative type of structure in the area:

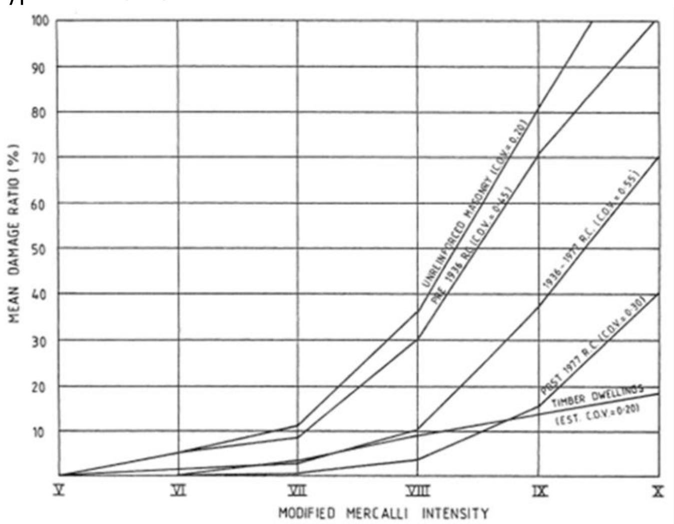


Fig. 1. Mean Damage Ratio vs Modified Mercalli Intensity Scale

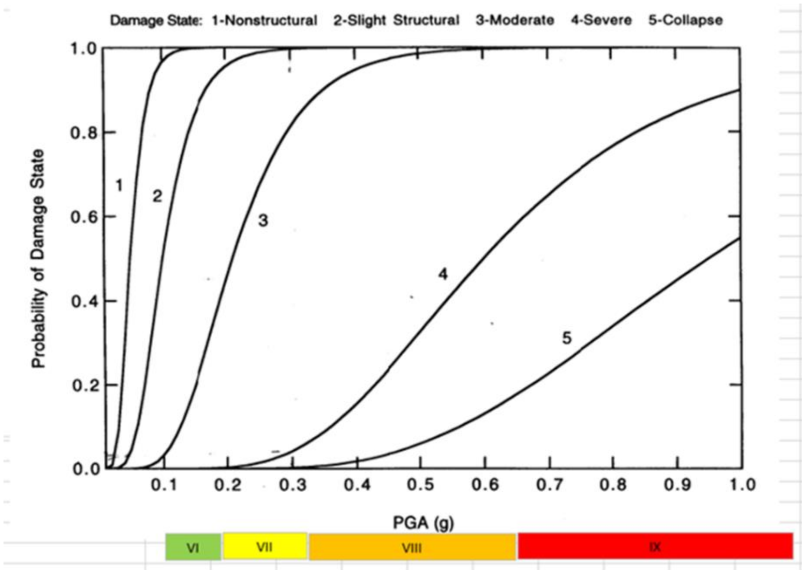


Fig. 2. Fragility Curve for a Concrete Structure with Moderate Seismic Vulnerability in Memphis, TN (1-5 stores) (Hwang et al. 1994)

According to the literature, the following Mean Damage Ratio % have been selected:

MMI	MDR %	Damage category
IX	82	Widespread Destruction
VIII	37	Widespread Moderate damage
VII	12	Widespread Slight damage
VI	5	Widespread Slight damage

The following equations are then applied:

Built-up damage estimation = ƒ (Built-up volume, MMI, Damage Ratio)

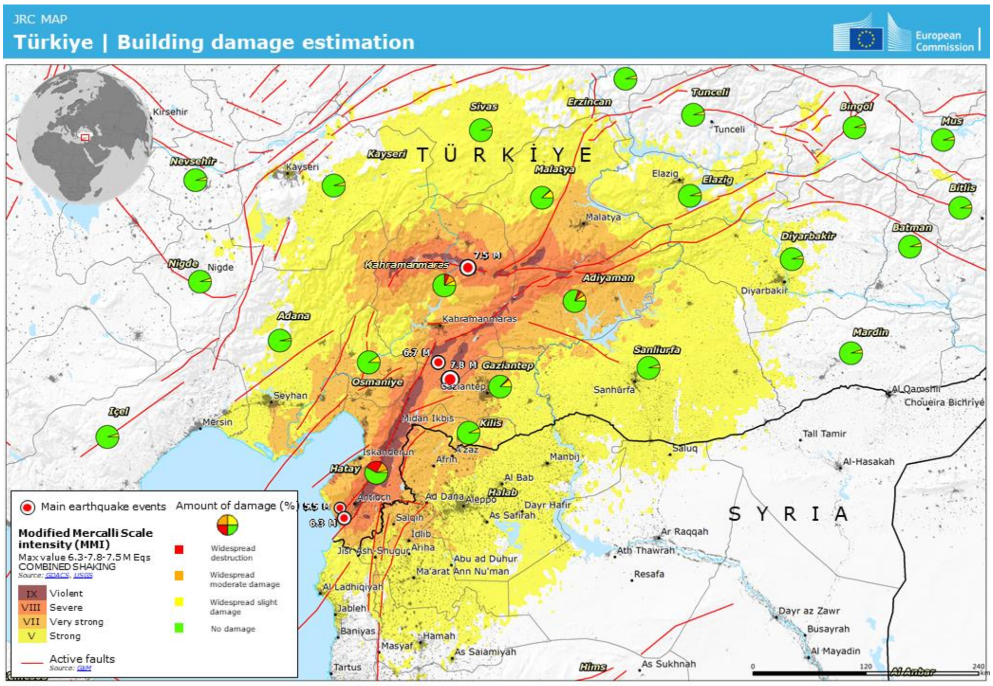
*Built-up damage estimation = Built-up Volume (m3) * Damage Ratio (MDR%)*

The results applied at province level are the following, with the **Hatay region resulting as the most affected with figures of 24% of its built environment expected to have suffered widespread destruction, 13% of widespread moderate damage and 4% of widespread slight damage.**

The damage distribution is represented also in the map, to show the severity of the damage localised in Hatay, Kahramanmaras and Adiyaman.

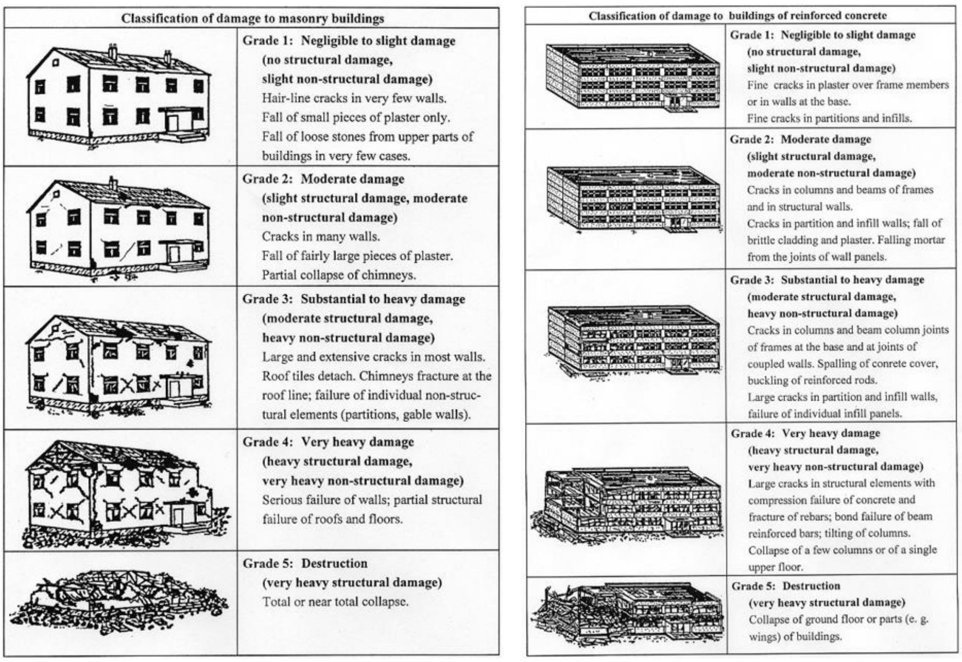
	Widespread Slight damage	Widespread Moderate damage	Widespread Destruction	Not damaged	Total Build up volume
Adana	19,397,624	42,519	0	557,419,940	576,860,083
Adiyaman	12,493,747	9,408,692	6,170,066	112,027,988	140,100,492
Amasya	6,254	0	0	118,819	125,072
Batman	47,327	0	0	899,215	946,542
Bingöl	261,495	0	0	4,968,412	5,229,907
Bitlis	6,112	0	0	116,131	122,243
Diyarbakir	10,899,663	0	0	206,060,222	216,959,885
Elazig	6,466,224	0	0	119,347,516	125,813,741
Erzincan	56,041	0	0	1,064,779	1,120,820
Gaziantep	55,332,485	3,342,205	12,800,515	456,230,986	527,706,191
Hatay	19,188,356	58,927,208	109,766,110	265,399,334	453,281,008
Içel	5,023,945	0	0	95,454,948	100,478,893
Kahramanmaras	18,090,510	27,136,071	18,210,450	186,240,264	249,677,295
Kayseri	11,081,890	0	0	209,686,909	220,768,799
Kilis	3,239,123	86,173	0	45,182,667	48,507,963
Malatya	19,097,263	768,518	2,086,818	152,174,039	174,126,639
Mardin	104,736	0	0	1,989,982	2,094,718
Mus	29,999	0	0	569,978	599,976
Nevsehir	4,675	0	0	88,832	93,507
Nigde	462,430	0	0	8,786,166	9,248,596
Osmaniye	11,854,438	1,172,843	0	108,119,062	121,146,343
Sanliurfa	22,487,727	0	0	406,408,499	428,896,226
Sivas	3,649,498	0	0	64,922,886	68,572,384
Tokat	280	0	0	5,328	5,608
Tunceli	88,217	0	0	1,676,123	1,764,340

	Widespread Slight damage	Widespread Moderate damage	Widespread Destruction	Not damaged
Adana	3	0	0	97
Adiyaman	9	7	4	80
Amasya	5	0	0	95
Batman	5	0	0	95
Bingöl	5	0	0	95
Bitlis	5	0	0	95
Diyarbakir	5	0	0	95
Elazig	5	0	0	95
Erzincan	5	0	0	95
Gaziantep	10	1	2	86
Hatay	4	13	24	59
Içel	5	0	0	95
Kahramanmaras	7	11	7	75
Kayseri	5	0	0	95
Kilis	7	0	0	93
Malatya	11	0	1	87
Mardin	5	0	0	95
Mus	5	0	0	95
Nevsehir	5	0	0	95
Nigde	5	0	0	95
Osmaniye	10	1	0	89
Sanliurfa	5	0	0	95
Sivas	5	0	0	95
Tokat	5	0	0	95
Tunceli	5	0	0	95



Annex 3 – Building Damage Estimation based on the Lagomarsino & Giovinazzi (2006) method

The macroseismic method developed by Lagomarsino & Giovinazzi (2006)[68] within the framework of the RISK-UE project allows to estimate the proportion of a population of buildings that are expected to reach different damage states when exposed to a given macroseismic intensity. The approach is based on the European Macroseismic Scale (EMS98), which in accompanying documentation proposes a damage scale comprising 5 damage states, both for houses and multistorey buildings (see figure below).



There are several versions of the methodology, but in the present study the simplest one is applied, which assumes a binomial distribution of damage states for a given building typology. The expected value of this distribution, or expected damage μ_D $(0 < \mu_D < 5)$ is calculated as follows:

$$\mu_D = 2.5\left[1 + \tanh\left(\frac{I + 6.25V - 13.1}{Q}\right)\right],$$

Where the hazard is characterised by the macroseismic intensity *I*, and the response of a given building typology is characterised by the vulnerability index *V* and the ductility index *Q.* Of note is that the macroseismic intensity refers to the EMS98 scale, however, it is generally accepted that the scale is equivalent to the MMI scale (see for example Musson *et al.* 2009[69]).

The above-mentioned expected damage distribution can be expressed as follows for a given damage grade *k*:

$$\mu_D = \sum_{k=0}^{5} p_k\, k$$

[68] S. Lagomarsino & S. Giovinazzi (2006). Macroseismic and mechanical models for the vulnerability and damage assessment of current buildings. Bull Earthquake Eng (2006) 4:415–443 DOI 10.1007/s10518-006-9024-z

[69] Roger M. W. Musson, Gottfried Grünthal, Max Stucchi. The comparison of macroseismic intensity scales. Journal of Seismology, 2009, 14 (2), pp.413-428. ff10.1007/s10950-009-9172-0ff. ffhal-00535499

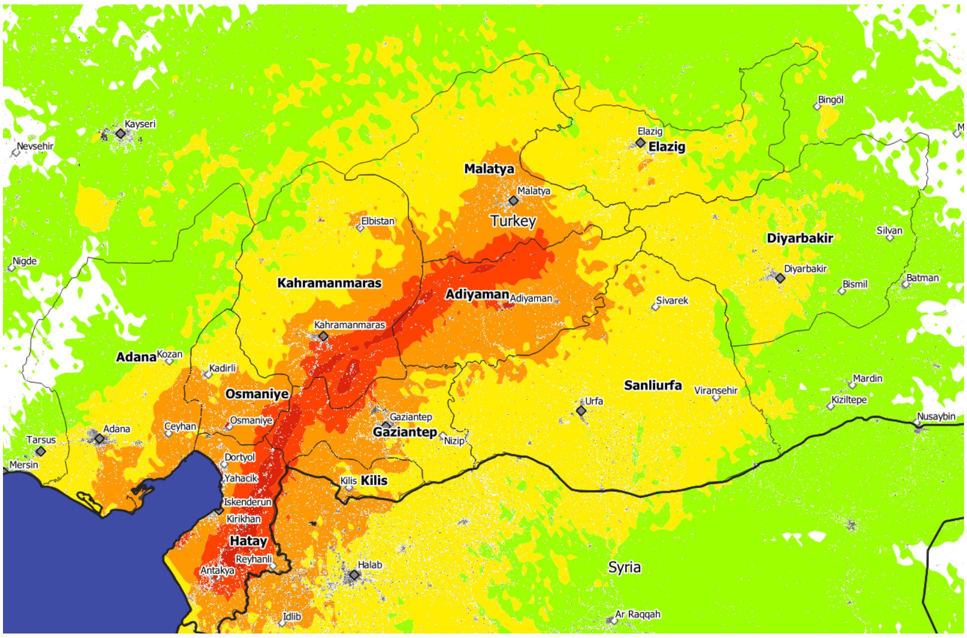
Assuming a binomial distribution, it is the possible to obtain the probability p_k that a building has reached a given damage state by evaluating the following probability mass function:

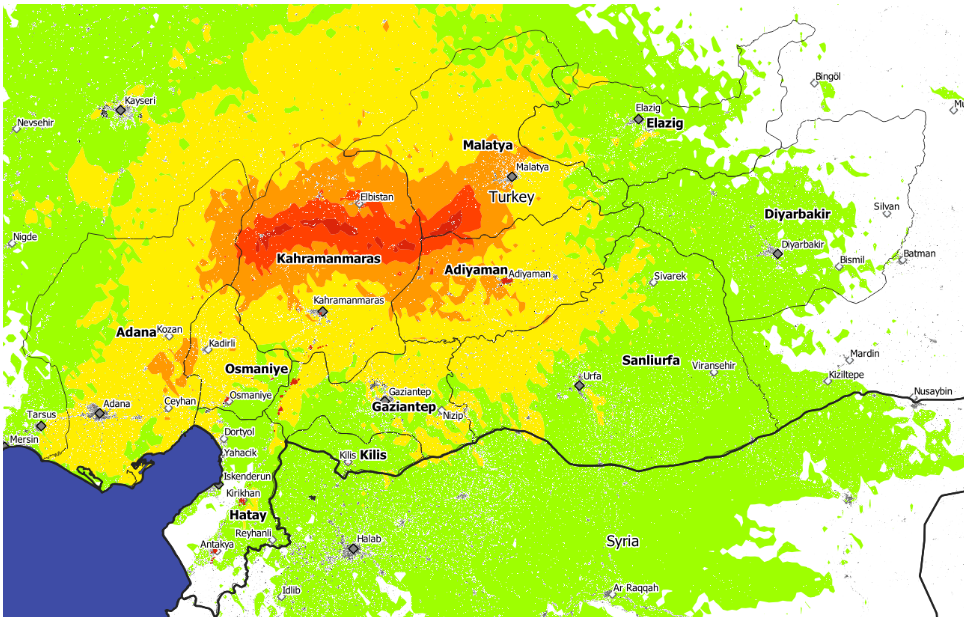
$$p_k = \frac{5!}{k!\,(5-k)!}\left(\frac{\mu_D}{5}\right)^k \left(1 - \frac{\mu_D}{5}\right)^{5-k}$$

Thus, in order to estimate the damage in the area by applying the formulae above, the following information is required:

1. The EMS98 macroseismic intensity in every point of the area of study
2. An exposure layer, allowing to estimate how much of the built environment was exposed to each level of shaking intensity.
3. A characterization of the vulnerability of the built environment in terms of vulnerability index *V* and the ductility index *Q* for every building typology.

The macroseismic intensity was obtained by taking the most up-to-date version of the USGS Shakemap (v9 for the M7.8 event and v5 for the M7.5 event) and calculating the maximum MMI intensity (MMI and EMS98 are assumed to be equivalent) at every point of the 11 provinces listed in the Turkish building survey, which comprise the area of study. When buildings are exposed to a strong shaking intensity, even if they resist with no or minor damage they are often fragilised, and less capable to face future earthquakes, resulting in higher damage states than expected when a second event strikes. This cumulative effect is not accounted for by the proposed approach, which is therefore likely to underestimate the actual damage in areas that were subjected to strong shaking from both events. Two provinces are noted in particular: in Kahramanmaras, the underestimation is assumed to be small, since the overlap is not very significant and affected mostly uninhabited areas. On the contrary, in the province of Malatya the underestimation is expected to be significant, since there was considerable overlap of strong (VII+) shaking intensities in urban areas (see figure below). However, to the authors' knowledge, there is no available macroseismic damage methodology that properly accounts for cumulative events.





The 2022 edition of the Global Human Settlement Layer (GHSL) built-up area grid (product identifier: GHS_BUILT_S_E2020_GLOBE_R2022A_54009_100_V1_0_R5_C22) was used as an exposure layer. While the GHSL layer does not allow to identify individual buildings, it does allow to identify how much of the built environment in each province was affected by each level of shaking. In order to quantify the number of buildings exposed to shaking, it was assumed that the built-up area is proportional to the number of buildings. This proxy is expected to underestimate the number of buildings located in rural areas, where more buildings take up less area. Obtaining a total number of buildings per province proved challenging, since this information was not included in the 2021 Turkish building census (which uses dwellings as its main unit). The total number of buildings per province was instead obtained from the exposure model of the EFEHR project[70] [71] [72] associated to the 2020 edition of the European Seismic Risk Model (ESRM20). The EFEHR exposure model for Turkey was downloaded from the online repository[73]. The model for Turkey uses data from the 2001 census and a study of building permits for the period of 2001 to 2017 to estimate a total number of buildings. The estimated total number of buildings is 1198213.

The EFEHR exposure model does not however geolocalize the buildings beyond the regional level. Thus, the EFEHR exposure model and the GHSL are complementary. The authors note that GHSL also offers a product that distinguishes urban and rural environments, which could be used together with EFEHR to further refine the way the geographic building distributions can be assigned. A version of this study produced under less time pressure could ideally utilize all this available information.

The EFEHR dataset also contains a classification of buildings at provincial level in terms of construction materials, a classification of their vulnerability in terms of the GEM methodology, and standard floor sizes for dwellings and standard reconstruction costs. However, due to time constraints, this information could not be fully capitalized in the present study to establish building typologies

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[70] Crowley H., Dabbeek J., Despotaki V., Rodrigues D., Martins L., Silva V., Romão, X., Pereira N., Weatherill G. and Danciu L. (2021) European Seismic Risk Model (ESRM20), EFEHR Technical Report 002, V1.0.1, 84 pp, https://doi.org/10.7414/EUC-EFEHR-TR002-ESRM20

[71] SERA Deliverable D26.3 (Methods for developing European commercial and industrial exposure models, and residential model update), Available from URL: http://eu-risk.eucentre.it/wp-content/uploads/2019/08/SERA_D26.3_Exposure_Models_Non-res_Res.pdf

[72] Crowley H, Despotaki V, Rodrigues D, Silva V, Toma-Danila D, Riga E, Karatzetsou A, Sousa L, Ozcebe S, Zugic Z, Gamba P (2020) “Exposure model for European Seismic Risk Assessment,” Earthquake Spectra, doi: https://doi.org/10.1177/8755293020919429

[73] H. Crowley, V. Despotaki, D. Rodrigues, V. Silva, C. Costa, D. Toma-Danila, E. Riga, A. Karatzetzou, S. Fotopoulou, L. Sousa, S. Ozcebe, P. Gamba, J. Dabbeek, X. Romão, N. Pereira, J. M. Castro, J. Daniell, E. Veliu, H. Bilgin, C. Adam, M. Deyanova, N. Ademović, J. Atalic, B. Bessason, V. Shendova, A. Tiganescu, Z. Zugic, S. Akkar, U. Hancilar and Exposure Contributors (2020). European Exposure Model Data Repository (Version 1.0) [Data set]. Zenodo. HYPERLINK "http://doi.org/10.5281/zenodo.4062044"http://doi.org/10.5281/zenodo.4062044

and vulnerabilities. Instead, a single combination of the vulnerability index *V=0.74* and the ductility index *Q=2.3* was applied to the entire built environment. These values correspond to a midrise building with a mid-to-low quality reinforced concrete frame with masonry infills, which the EFEHR dataset confirms to be one of the dominant structural types in the area. These structures are typical of the Mediterranean, due to the ease and speed of construction, however, they have been known to be very dangerous during earthquakes: the presence of masonry infills is often not accounted for in the engineering of the buildings, leading it to react differently than what the engineers expected, and even worse, these infills are usually left out of the ground floor, leading to soft storey collapses. Anecdotally, several of these buildings have been observed as having collapsed in the present crisis.

With these assumptions, the methodology produced the following figures for damaged buildings:

EMS98	
IX	3.06
VIII	1.99
VII	1.09
VI	0.52
V	0.23

p_k	**IX**	**VIII**	**VII**	**VI**	**V**
p_0	0.009	0.079	0.294	0.577	0.788
p_1	0.069	0.261	0.408	0.335	0.192
p_2	0.219	0.346	0.226	0.078	0.019
p_3	0.345	0.229	0.063	0.009	0.001
p_4	0.272	0.076	0.009	0.001	2.22E-05
p_5	0.086	0.010	0.4E-04	1.22E-05	2.16E-07

In order to compare these values with those of the published damage survey, it is necessary to convert the damage states into the classification used by the survey (see the comments outlined in the previous paragraph). The definitions of the five damage grades (six, counting "no damage"[2]) used by the EMS-98 are presented in Figure above. The survey instead uses only three damage grades (four, counting "no damage"): "slight damage", "moderate damage" and "heavy damaged/destroyed".

Assuming that the language used to describe the damage states is similar, the following conversion was applied:

D0 = No damage
D1 = Slight damage
D2 = Moderate damage
D3 + D4 + D5 = Heavy damage/destroyed

As a caveat, buildings in EMS98 D3 damage status can often be repaired, so it is not clear whether they would be systematically demolished as the Turkish authorities have declared, but as indicated before, there are questions about the classification of the midrange of damage.

The conversion results in the following damage estimates for the entire area of study, which compares favourably in particular with the published totals for heavy damage:

It is notable that these numbers imply that nearly 10% of the buildings in the area are classified as "heavy damage". Mismatches in the prediction of damage by the methodology become more apparent at provincial level, where the results are as follows:

Total	
no damage	482774.9
slight	397537.1
moderate	196231.1
heavy	121669.6

Hatay	
no damage	31807.49
slight	54441.63
moderate	51029.19
heavy	61403.05

Adana	
no damage	133968.7
slight	99310.88
moderate	36325.86
heavy	8996.758

Kahramanmaras	
no damage	22705.77
slight	39301.25
moderate	34275.8
heavy	28170.83

Adiyaman	
no damage	15455.56
slight	20898.3
moderate	12542.84
heavy	6521.106

Kilis	
no damage	7230.555
slight	5971.862
moderate	2381.205
heavy	638.3001

Elazig	
no damage	33395.63
slight	18668.76
moderate	4441.078
heavy	611.6283

Malatya	
no damage	30582.16
slight	34721.6
moderate	18297.79
heavy	7377.985

Diyarbakir	
no damage	77045.51
slight	34713.32
moderate	7089.176
heavy	821.1868

Osmaniye	
no damage	25649.85
slight	29343.72
moderate	15159.48
heavy	5014.888

Gaziantep	
no damage	73522.99
slight	84679.14
moderate	46530.97
heavy	22345.69

Sanliurfa	
no damage	104933.6
slight	60165.75
moderate	14688.62
heavy	2113.838

However, as indicated, the estimation was produced under time pressure and did not fully apply all the information that was available. The methodology is presented primarily as an example of how damage modelling can contribute to the assessment of reconstruction needs, especially if the results are then converted into monetary reconstruction costs. A new study, ideally with the participation of Turkish experts, would produce much better results.

Annex 4 – Comparison between building damage estimation and field assessment

	Heavy damage/Destroyed %	Moderate damage %	Slight damage %	No damage %	TOT %
Adana					
Lagomarsino	3	13	36	48	100
MDR			3	97	100
Reported	1	4	20	72	95
Adiyaman					
Lagomarsino	12	23	38	28	101
MDR	4	7	9	80	100
Reported	22	7	31	29	88
Diyarbakir					
Lagomarsino	1	6	29	64	100
MDR			5	95	100
Reported	3	2	24	61	90
Elazig					
Lagomarsino	1	8	32	58	100
MDR			5	95	100
Reported	22	4	45	26	97
Gaziantep					
Lagomarsino	11	21	37	31	100
MDR	3	1	10	86	100
Reported	7	3	10	60	79
Hatay					
Lagomarsino	31	26	27	16	100
MDR	24	13	4	59	100
Reported	19	5	23	49	95
Kahramanmaras					
Lagomarsino	23	28	31	18	100
MDR	24	13	4	59	100
Reported	19	2	29	39	88
Kilis					
Lagomarsino	4	14	37	44	100
MDR			7	93	100
Reported	8	2	31	52	93
Malatya					

Lagomarsino	8	20	38	34	100
MDR	2		11	87	100
Reported	26	3	27	27	83
Osmaniye					
Lagomarsino	7	20	39	34	100
MDR		1	10	89	100
Reported	7	1	21	65	94
Sanliurfa					
Lagomarsino	1	8	33	58	100
MDR			5	95	100
Reported	1	1	36	49	87

Annex 5 – Preliminary seismic site effects evaluation

The phenomena known as site effects are regionalized or localized modulations of the level of shaking, most often due to certain types of surface geology or topographic features causing impedance contrasts in the seismic wave propagation. As a result, some areas can experience stronger shaking due to localized amplification.

A seismic microzonation evaluates the geological and geomorphological aspects that might cause the seismic site amplifications (e.g. different soils/rocks formations respond differently to an earthquake and areas with morphological elements causing amplification and site effects, e.g. crests, slopes >15°).

The analysis of seismic amplification zones is a crucial element for both the construction and reconstruction in seismic zones.

In this paragraph, a preliminary analysis of possible site effects linked to geology/geomorphology is carried out. For this aim the following data are considered:

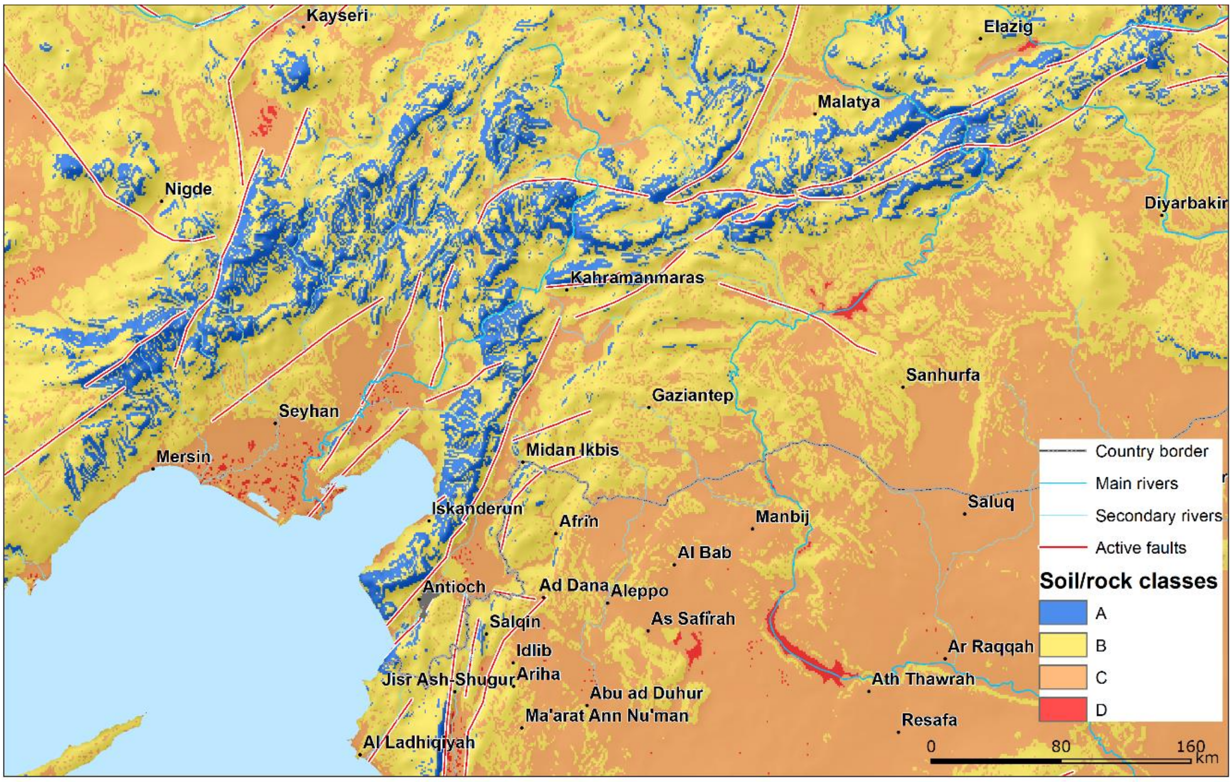
- Soil (ground) types based on v_s30 (m/s). The v_s30 (m/s) data are extracted from the U.S. of Geological Survey[1] catalogue.
- Active faults (data source: GEM[2] , Global SEISMIC HAZARD MAP).
- Topographic data (source U.S. Geological Survey). Almost the entire area is prone to topographic amplification as the slope is > of 15°.

To achieve a complete a detailed analysis, a further in-depth study should be carried out to consider other factors: liquefaction, landslides and geomorphological. Furthermore, before rebuilding, a detailed geotechnical and geophysical field survey (e.g. the horizontal to vertical spectral ration (HVSR), Multichannel analysis of surface waves (MASW)) to obtain the fundamental subsoil resonance frequencies and the depth of soil/bedrock contact, should be implemented.

Figure 1 shows the main result of this preliminary analysis. The area is classified in terms of v_s30 (m/s), which denotes the propagation speed of seismic shear waves (S * waves) averaged over the first 30m of depth.

The soil/rock classification is based on the on the Eurocode 8[1]**.** The Eurocode 8 classification is similar to the International Building Code (IBC)[2]. The Eurocode is slightly conservative than the IBC, although both codes are mainly based on NEHRP National Earthquake Hazard Reduction Program (1994)[3].

Figure 1. A preliminary map of seismic amplification zones (lithological amplification and seismic active faults)



[1] U.S. ***Geological Survey*** https://usgs.github.io/shakemap/manual4_0/sg_installation.html#downloading-and-configuring-vs30-and-topography

[2] GEM Global SEISMIC HAZARD MAP v 2019.1 globalquakemodel.org

A description of the Classes can be found in **Tab.1**. The figure also shows the active faults, and the main riverbeds.

It is widely accepted that the concomitance of the Soil class D with active faults is the worst scenario of seismic amplification, and this condition is verified for, e.g., East South of Elazig, East of Adana, Iskendurun, Aleppo).

The area of study can be divided in two main categories:

Stable zones: areas which present the speed of the S* waves: Vs30>800 m/s (**Tab. 1**): *class A* (in deep blue in the figure).

Zones with lithological amplification: lithology which present the speed Vs30<800 m/s, further divided in other 3 *classes B, C, D* (the worst soil condition, for the seismic effects, is the class D, **Tab.1**).

An in-depth study should be implemented to further characterize the class D (for this reason the other classes of the Eurocode 8 are not included in the **Tab.1**).

Tab. 1: Prospect of Ground types (extracted from the Eurocode 8)

Ground type	Description of stratigraphic profile	Vs_{30} (m/s)
A	Rock or other rock-like geological formation, including at most 5 m of weaker material at the surface.	>800
B	Deposits of very dense sand, gravel, or very stiff clay, at least several tens of meters in thickness, characterized by a gradual increase of mechanical properties with depth.	360-800
C	Deep deposits of dense or medium-dense sand, gravel or stiff clay with thickness from several tens to many hundreds of meters.	180-360
D	Deposits of loose-to-medium cohesionless soil (with or without some soft cohesive layers), or of predominantly soft-to-firm cohesive soil.	<180

Analysis of the Shake map, damaged cities and site amplification data

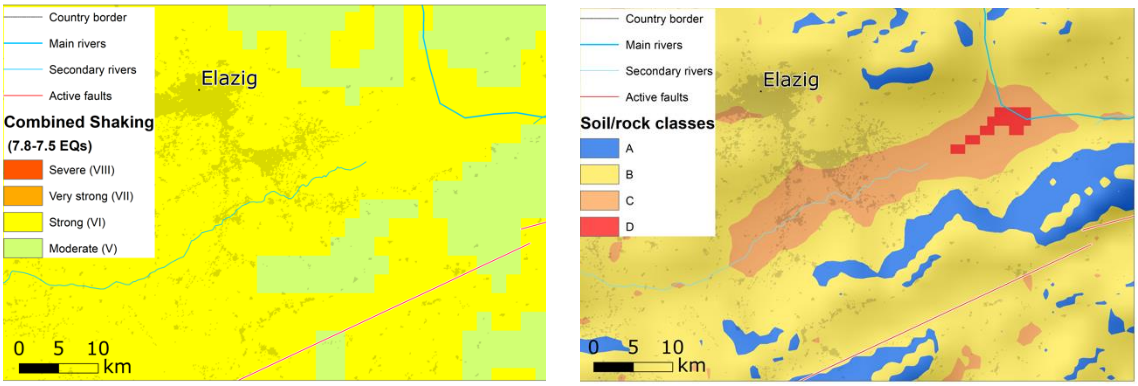
In this paragraph some zones strongly affected by the earthquake are analysed by comparing against the shake map classes and the location of zones characterised by seismic amplification.

CASE A - Elazig (Türkiye)

In this area the shake map classes are moderate, though strong damages to the building are registered. The analysis of the corresponding seismic amplification zones shows that this area is characterised mainly by unconsolidated sediments/rocks (classes C and D), **FIG.3**

Besides the building structures/densities and the lithologies underneath them, other reasons for the observed damages could be due to topographic effects (e.g. slope crests and the incised river valley at North). Furthermore, the presence of the river, the possible suspended phreatic zones and the alluvial sediments could cause liquefaction.

Figure 3. Comparison of the shake map, seismic amplification effects map and morphology



[1] Euro code https://help.geostru.eu/spw/ro/eurocodice_8.htm

[2] IBC https://codes.iccsafe.org/content/IBC2021P1/chapter-18-soils-and-foundations

[3] NEHRP, National Earthquake Hazard Reduction Program, (1994). Recommended provisions for seismic regulations of new buildings: Part I, Provisions, FEMA 222A, Federal Emergency Management Agency, Washington, D.C.

CASE B – Gaziantep (Türkiye)

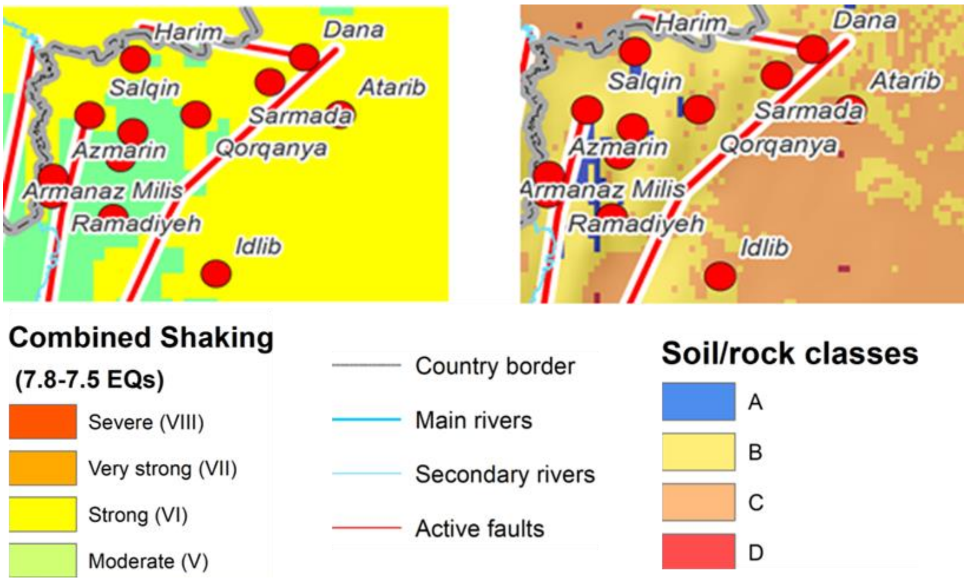
FIG.4 shows the overlay of the damages assessment of Copernicus[1] and the seismic amplification zones of **FIG.3**. Most of the damaged buildings (red squares) falls in the areas characterised by scarce quality of sediments/rocks (unconsolidated sediments/rocks, classes C and D) and probably by the presence of alluvial sediments, which correspond to a zone probably prone to liquefaction.

Figure 4. Damaged building – red squares (Copernicus) and the seismic amplification map.

CASE C Northern Syria reportedly affected locations

FIG.5 shows some of the affected places in North of Syria (red points) censed by UN-Ocha. Those locations fall mainly in areas where the shake map classes are moderate (to the west, in green), rather than where they are strong (to the east, in yellow). Therefore, the observed damages could be partially due to the geological setting of the zone. Indeed, evidenced-based analysis of the seismic amplification zones show that this area is characterised mainly by unconsolidated sediments/rocks (classes C and D) and by a widespread zone of seismic active faults.

Figure 5. Comparison of the shake map (at the left) and the seismic amplification map (at the right). The red points are the affected places in Syria.



[1] Copernicus Damages Assessment
https://emergency.copernicus.eu/mapping/download/200898/EMSR648_AOI01_GRA_MONIT01_r1_RTP03_v1_vector.zip

To support rebuilding cities/villages in this area, an in-depth study with major resolution should be carried out to refine this preliminary analysis.

A geological and geomorphological remote and/or site analysis should be carried out to consider other factors: liquefaction analysis, landslides and a detailed geomorphological analysis.

A geophysical study should be accomplished through the horizontal to vertical spectral ration (HVSR), Multichannel analysis of surface waves (MASW) analysis and other geotechnical test, to provide the Vs30 detailed data, the depth of the bedrock/sediments contact, the soil resonance frequencies and the amplitudes. This last parameter is a crucial factor for the reconstruction planning (e.g. to prevent double resonances between the building and the soil).

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