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# Overall Evaluation of the Effects of the 24 January 2020 Sivrice Earthquake (East Anatolian Fault), Turkey

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## Abstract
Turkey is a country where earthquakes are frequent for it is at the junction of a number of tectonic plates. There have been more than 130 recorded destructive earthquakes during the 20th and 21st centuries and they have caused enormous damage. One of the most destructive was the one that hit the east of the country on 24 January 2020. The epicenter of this magnitude 6.8 earthquake was in the town of Sivrice in Elazığ. Sivrice earthquake did not produce primary surface rupture; however, triggered landslides and liquefaction over an area of ~55 km2. The 24 January 2020 earthquake, now known as the Sivrice earthquake, caused substantial human and material losses. Despite the fact that there is a considerable amount of papers available about the Sivrice earthquake, none presents a detailed account of the extensive impact of the Sivrice earthquake its significance. The present study will discuss in detail for the first time the overall impacts of the disaster. It will, therefore, begin with a description of the earthquake and tectonic setting of the area. It then will give an overall assessment of the impact of the earthquake: the direct and indirect losses. Direct effects include all human losses and total or partial destruction of material, as well as the estimated cost of the demolition and clean-up operation required in the region. indirect losses resulted from damage to social and economic infrastructure including accommodation for the homeless, difficulties in transportation and communication, and indirect economic effects. Turkey is highly susceptible to earthquakes and earthquakes related effects due largely to its geological location. Millions of people live in or close to a seismically active area in Turkey for many reasons. It; therefore, will review the policy for sustainable management of earthquakes in Turkey.

**Keywords:** Sivrice Earthquake, East Anatolian Fault, Effects of Earthquake, Recovery

## 1. INTRODUCTION

Turkey is highly susceptible to earthquakes and earthquakes related effects due largely to its geological location. Millions of people live in or close to a seismically active area in Turkey for many reasons. A long time ago, small communities settled near fault zones to easily reach freshwater or mineral sources, and these communities have grown into large settlements in time. The country is among the world's most seismically active zones as it is situated on several active

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fault lines, with the most potentially devastating being the Northern Anatolia Fault (NAF) and the East Anatolian Fault (EAF).

A devastating earthquake struck the town of Sivrice in Elazig province at 20:55 local time (17:55 GMT) on Friday, January 24 2020, with an estimated moment magnitude (Mw) of 6.8 and maximum Mercalli intensity of IX (violent). High-intensity shaking was felt from neighboring Syria, Lebanon and Iran. It was centered 8 km beneath the rural town of Sivrice on the central part of the East Anatolian Fault (EAF). The strong shaking of the main shock lasted about 20 seconds (AFAD, 2020a).

The county of Sivrice (Elazığ) with a population of nearly 10,000 is located in a coastal area of Lake Hazar. Seasonal tourists and second homes boost the population and local economies during summers in Sivrice. The 24 January 2020 Sivrice earthquake fortunately occurred in the winter season that causes a noticeably reduced death toll. Turkey's Disaster and Emergency Management Authority (AFAD) reports that 37 causalities were in Elazığ province and 4 deaths were reported in the neighboring province of Malatya.

Elazığ city lies 30 km northwest of the Sivrice and was home to a population of approximately 440,000 at the time of earthquake. There was catastrophic damage as a result of the earthquake, and according to the Government of Turkey, as of June 8, 2020, 45 citizens were rescued from the wreckage, 41 people were confirmed dead, over 1,600 injured and almost 20,000 (10% building stock) houses were heavily damaged (AFAD, 2020a).

It is from this viewpoint that the present study will seek to examine the overall impacts of the disaster. It will, therefore, begin with a description of the earthquake and tectonic setting of the area. It then will give an overall assessment of the impact of the earthquake: the direct and indirect losses. Afterward, responses will contain recommendations for a policy for sustainable management of earthquakes in Turkey. Finally, it will review the policy for sustainable management of earthquakes in Turkey.

## 2. GEOLOGICAL SETTING

### 2.1 Tectonic Setting

Turkey is among the world's most seismically active zones as it is situated on several active fault lines the meeting point of the African, Anatolian and Eurasian tectonic plates (McKenzie, 1972). Inconsequence of these collisions, primary deformation structures have developed in Turkey, such as the North and East Anatolian Faults, Aegean Grabens, Bitlis Zagros Suture Zone (BSZS), etc. (Figure 1a). The EAF, Turkey's second active fault, is a continental transform fault that forms part of the tectonic boundary between the Anatolian Plate and the African Plate. The strike-slip fault is characterized by mainly lateral motion in a sinistral sense, where the eastern (African) plate moves northward relative to the western (Anatolian) plate. EAF extends between Karlıova (Bingöl) in the northeast and Iskenderun Bay in the southwest, a distance of about 580 km. A recent study divides the EAF into three main sections with several subsegments: the southern (main) branch, the northern strand (Sürgü-Misis fault) and the Karasu trough (Duman and Emre, 2013). On 24 January 2020, a devastating Mw 6.8 earthquake occurred in the Pütürge segment of the southern (main) section of the EAF (Figure 1b).

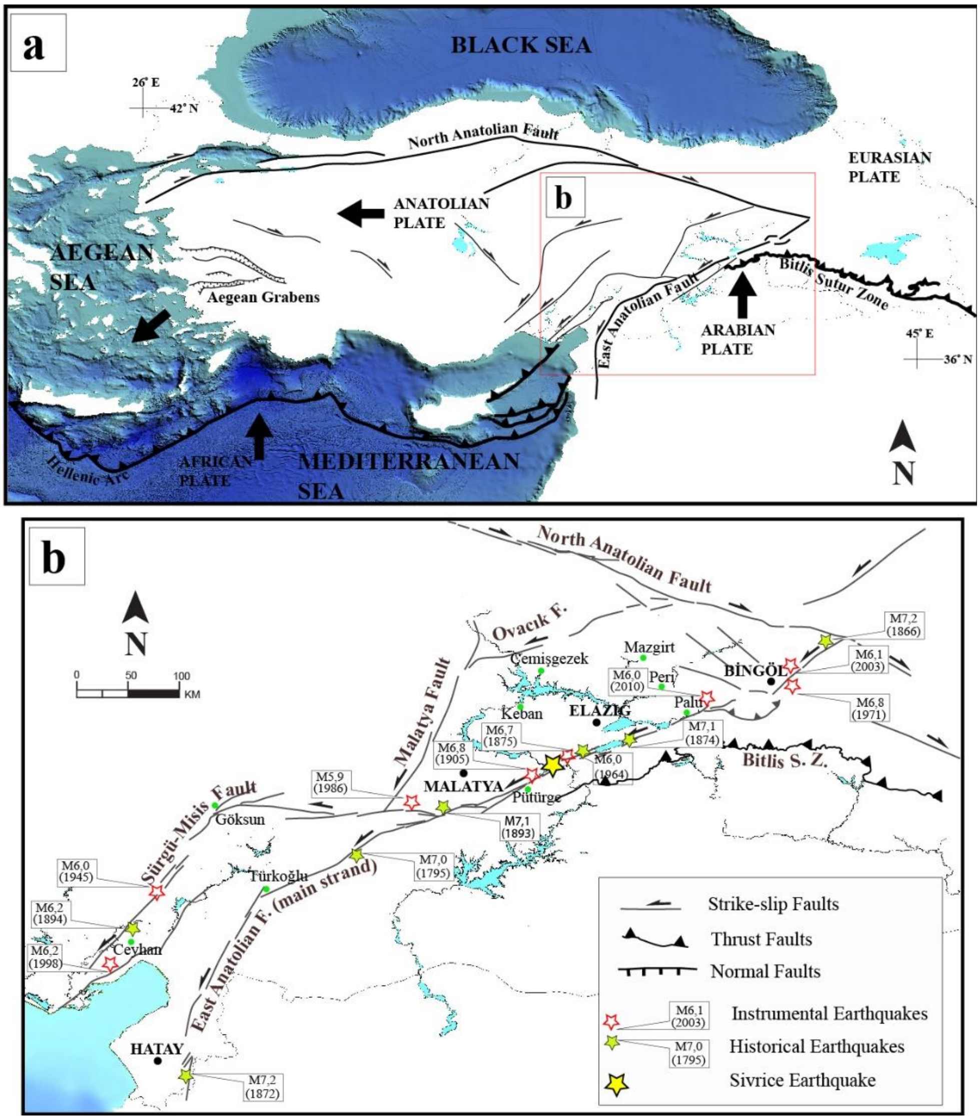


Figure 1. a) Simplified main tectonic features of Turkey and westward motion of Anatolian plate. Faults in Turkey (Emre et al., 2013) and faults located nearby of Turkey (Duman and Emre, 2013). Big black arrow indicates plate motion with respect to the Eurasian plate [38], b) Tectonic map of Eastern Anatolia, and historical and instrumental seismicity along the EAF. Historical earthquakes modified from (Duman and Emre, 2013; Ambraseys, 1989; Palutoğlu and Şaşmaz, 2017). Instrumental seismicity from (KOERI, 2020).

Geological and morphological features in different parts of the EAF reveal left-lateral offsets which cluster around 9 to 30 km. The Pütürge segment is home to around 22 km lateral offset on Middle Eocene volcanic rocks, and 13 km lateral offset on the Euphrates river valley suggest high tectonic activity on this fault segment (Arpat and Şaroğlu, 1975; Herece and Akay, 1992; Şaroğlu et. al, 1992; Westaway and Arger, 2001; Herece, 2008; Gökgöz et al., 2022).

The 96 km long Pütürge segment runs between the Lake Hazar releasing bend and Yarpuzlu restraining double bend. The Pütürge segment has several sub-sections with lengths that vary from 21 to 28 km. Several destructive earthquakes have occurred on the EAF in historical and instrumental periods (Figure 1b) (Köküm and Özçelik, 2020; Köküm, 2021; Doğan et al., 2019; Güvercin et al., 2020). The 1875 (Ms 6.7) and 1905 (Ms 6.8) earthquakes (Ambraseys, 1989) might have been ruptured on northern and southern sub-segments, hence the central part should have been unbroken (Duman and Emre, 2013) till 24 January 2020.

### 2.2. 24 January 2020 Sivrice Earthquake

A devastating earthquake that occurred at 20:55 local time (17:55 GMT) centered on 8 km beneath the Çevrimtaş town of Sivrice in Elazığ province caused 41 fatalities and 1600 injuries (AFAD). Based on several seismological observatories and institutes including AFAD, Kandilli Observatory Earthquake Research Institute of Bosporus University (KOERI), United States Geological Survey (USGS), the magnitude of an earthquake is estimated as Mw 6.6 or 6.8 with depth in the range from 5 to 10 km. The duration of the earthquake was reported as 20 seconds. Focal mechanism solutions of mainshock and aftershocks indicate a left-lateral strike-slip fault oriented approximately northeast-southwest. These solutions appear to be compatible with the left lateral strike-slip EAF. The main shock was followed by many aftershocks and some remotely triggered events. An aftershock is a smaller earthquake that follows a mainshock in the same area of the mainshock. Large earthquakes cause hundreds to thousands of aftershocks, whose number of sizes and frequency decrease with time. Great numbers of aftershocks were located along the trace of the 2020 rupture, tending to concentrate near the ends of the rupture. Aftershocks were strong and frequent including one on 25 January 2020 with a magnitude of 5.1, four others equal Mw 5 or greater, twenty larger than Mw 4, and about 3,000 smaller than Mw 3 in the first year of the main event (KOERI, 2020) (Figure 2). There are several remotely triggered events including the most remarkable one on 27 December 2020 (Mw 5.3) occurred on other structures, away from the EAF itself, such as the Uluova secondary fault zones, has not been mapped in detail in the area (Köküm, 2012, 2017, 2019; Köküm and Inceöz, 2017, 2018, 2020; Yazıcı, 2020).

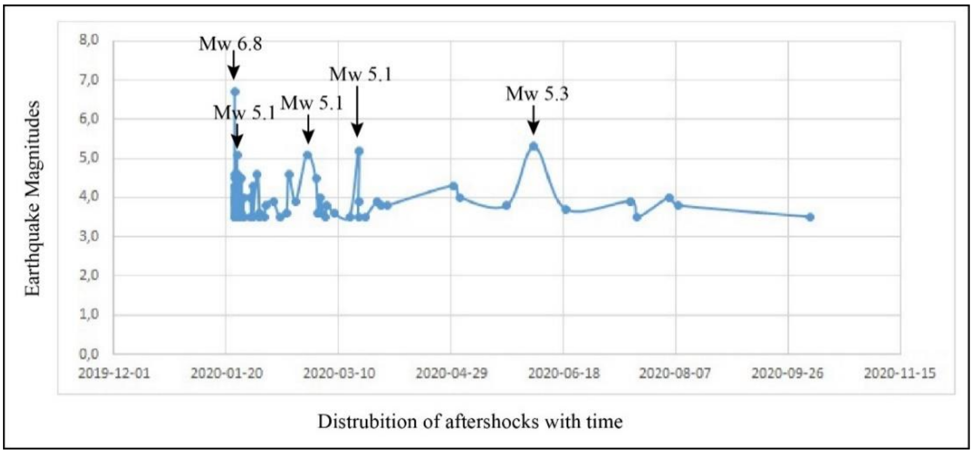


Figure 2. Sivrice earthquake and following aftershocks (equal or larger than Mw3.5) until 15 December, 2020 (KOERI, 2020).

## 3. OVERALL ASSESSMENT OF IMPACT OF THE EARTHQUAKE

The overall evolution of the damage caused by the earthquake in Elazığ and Malatya is not easy to make a few months after the earthquake. A reliable assessment will be possible when all the relief operations have been completed and all relevant information has been gathered. Nevertheless, a preliminary evolution based on the data gathered from relevant institutions and organizations and media, will give us a better perspective of the situation with regard to losses in social and economic terms.

The effects of the earthquake may be broadly classified into two categories: direct and indirect effects.

### 3.1. Direct Effects

Direct effects include all human losses and total or partial destruction of material, as well as the estimated cost of the demolition and clean-up operation required in the region. The earthquake caused substantial human and material losses.

According to the information provided by Turkey's Ministry of Interior, dated 30 January 2020, the death toll from the powerful earthquake in Turkey is 41, 1607 injured and more than 50,000 homeless. Additionally, three people died due to heart attacks during the earthquake; one in each of Adıyaman, Diyarbakır, and Kahramanmaraş provinces.

Table 1. A total human and material losses during Sivrice earthquake (AFAD, 2020b).

| | Human losses | Material losses | | | |
|---|---|---|---|---|---|
| | Dead | Collapsed buildings | Heavily damaged | Moderately damaged | Slightly damaged |
| **Elazığ** | 37 | 263 | 8256 | 1540 | 15671 |
| **Malatya** | 4 | 370 | 3056 | 621 | 7182 |

At the time of the disaster, Elazığ was home to a population of about 440,000. A maximum Mercalli intensity reached IX (violent) in the epicentral region and VII (very strong) in Elazığ where destruction was devastating. A major part of the Elazığ settlement located in alluvium sustained stronger shaking than nearby bedrock sites. The duration of the earthquake was reported as 20 seconds; however, it was felt at about 40 seconds in Elazığ province. A peak horizontal acceleration (PGA) for the Sivrice and Elazığ county is 0,30g at 24 km distant, and 0,14g at 35km distant respectively during the Sivrice event (AFAD, 2020a).

Based on the preliminary damage assessment in Elazığ by the government, 263 buildings were collapsed, 8,256 buildings were heavily damaged, 1,540 buildings were moderately damaged, 15,671 were slightly damaged. Malatya is the second most affected city from the earthquake with 370 were collapsed, 3,056 buildings were heavily damaged, 621 buildings were moderately damaged, 7182 were slightly damaged (AFAD) (Table 1). The cost of earthquake damage in the housing sector ranges from TL4 to 6 billion ($0.2 to 0.5 billion) (AFAD, 2020b).

Many notable landmarks and heritage buildings, residential housing, healthcare and schooling facilities were significantly damaged or destroyed by the Sivrice earthquake. A prison in Adıyaman was damaged during the earthquake and subsequently evacuated (AFAD, 2020a).

After the devastating 1999 Gölcük and Düzce earthquakes in Turkey, new regulations issued by the government that year mandated builders to use construction materials more resistant to tremors. Based on the preliminary damage assessment in Elazığ by the government, none of the buildings constructed after 1999 were neither damaged nor collapsed (AFAD, 2020a).
Environmental effects include landslides and liquefaction and hydrological changes. I conducted an on-ground field survey immediately after the Sivrice earthquake to document the general distribution and extend of landslides, lateral spreading, and to seek evidence of primary surface fault rupture (surface displacement) generated by this earthquake.

A total of 30 landslides were mapped by on-ground field studies (Figure 3). A peak horizontal acceleration (PGA) for the Sivrice and Pütürge county is 0,30g at 24 km distant, and 0,24g at 25km distant respectively during the Sivrice event (AFAD, 2020a). In addition, apart from the direct damage caused by the earthquake, a total of 30 landslides were triggered in an area of ~ 55 km2.

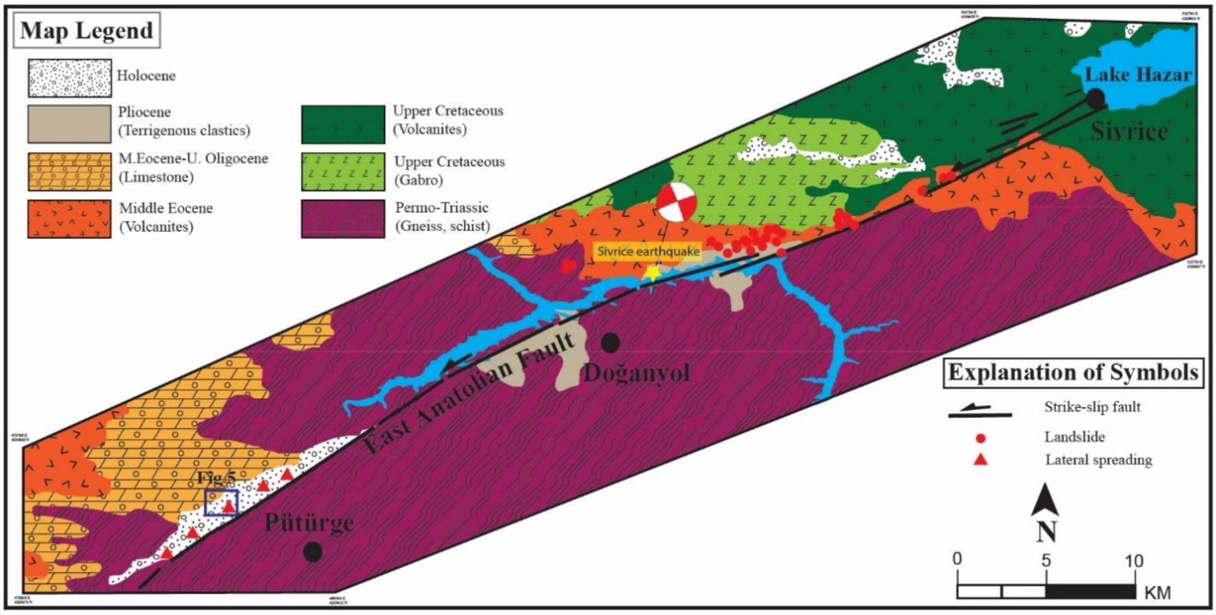


Figure 3. Geological and tectonic map for the study area (simplified from Akbaş et al. 2011 and Emre et al. 2013; Köküm and Inceöz 2018, 2020) shows the distribution of landslides, lateral spreading and other ground damaged effects triggered by the Sivrice earthquake have been highlighted.

In the study area, different types of rock units ranging in age from Paleozoic to Holocene are exposed (MTA, 2011; Kılınç and Ateş, 2015; Kılıç and Inceöz, 2015; Tekin et al., 2015; Ural et al., 2015, 2021; 2022; Ural and Cihan, 2021; Rizeli et al., 2016, 2021; Ertürk et. al, 2018, 2022; Sar, 2016; Sar et al., 2019; Sar and Kürüm, 2022; Beyarslan et al., 2022). The oldest geologic unit is Permo-Triassic gneiss and schist, which forms a basement under the Paleozoic, Mesozoic, and Cenozoic rocks and sediments. They are very extensive in the southern part of the map. The late Cretaceous units are mostly composed of gabbro and volcanic rocks. Middle Eocene unit contains basaltic, andesitic rocks intercalated and lateral-vertical transitive with sedimentary succession. The geological types of contacts of the Permo-Triassic rocks and Middle Eocene rocks are tectonically controlled by the EAF, hence about 10 km left-lateral offset accumulated along the EAF in the Middle Eocene rocks. Steep cliffs cut in Middle Eocene volcanic rocks are the sites of many landslides during the Sivrice earthquake (Figure 4). The middle Eocene-Oligocene unit is mostly composed of basal conglomerate and reef limestones. The Pliocene unit is a terrigenous clastics which is observed as narrow outcrops in the study area. The Holocene unit, mostly found in the strike-slip basin, consists of poorly sorted weakly cemented conglomerates and cross-bedded coarse-grained sandstones.

Many landslides were triggered from terrace edges cut into fluvial valley fill. Steep topography and thin soil cover make the region susceptible to shallow debris slides and falls. In addition to the high density of landslides near the epicentral region, there were many displaced boulders on terrace surfaces that also confirm to high levels of ground shaking in this area. It is also worth noting that, besides landslides failed completely, incipient landslide cracking, and cracking along ridge crests exist along the epicentral area. These ground deformations were mostly observed in gentle topography.

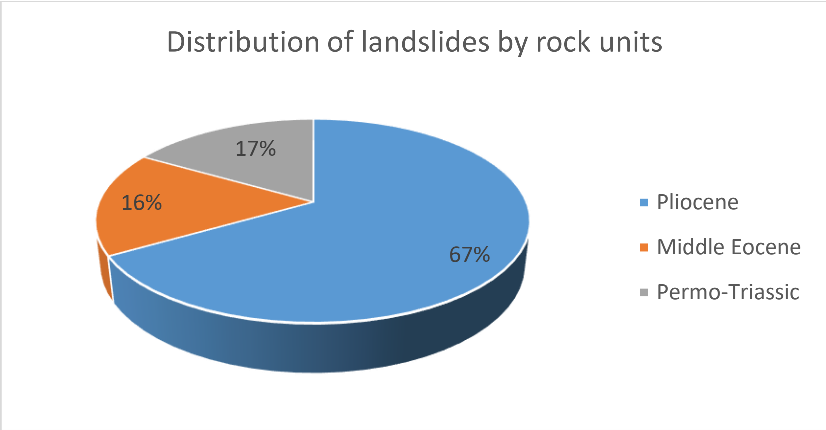


Figure 4. Distribution of landslides in regard to different rock units in the epicentral area.

The Holocene unit, mostly found in the strike-slip basin, consists of poorly sorted weakly cemented conglomerates and cross-bedded coarse-grained sandstones. The Sivrice earthquake generated extensive lateral spreading in Holocene age river banks, and result in the ground tears, opening surface cracks and fissure on flat ground (>5% ground slope). Pütürge is the most prominent area that shows extensive lateral spreading, however very few sand boils were tracked (Figure 5).

Surface cracks and fissures in Holocene age river banks can be seen between Ormaniçi and Yazıca (Pütürge). These cracks are a N400-650E trending and could be traced along 5 km in length and 50 m in width. On-ground field visits show that these cracks run parallel to the river indicating that they are associated with lateral movement of the ground towards the river, thus vertical displacements along these fractures are not surface faulting.

The main purpose of the on-ground field survey following the Sivrice earthquake was to seek evidence of surface fault rupture (surface displacement). After a detailed examination of the nearby roads and other structures, it was concluded that the Sivrice earthquake did not produce surface rupture.

It is well known that earthquakes cause hydrological changes (Waller et al., 1996; USGS, 2020). The groundwater level in wells could change up and down while seismic waves pass, and in some cases, the water level may remain higher or lower for a period of time after the seismic wave train has ended. It is verified by Elazığ Municipality, groundwater levels in wells rose after the earthquake in Elazığ.

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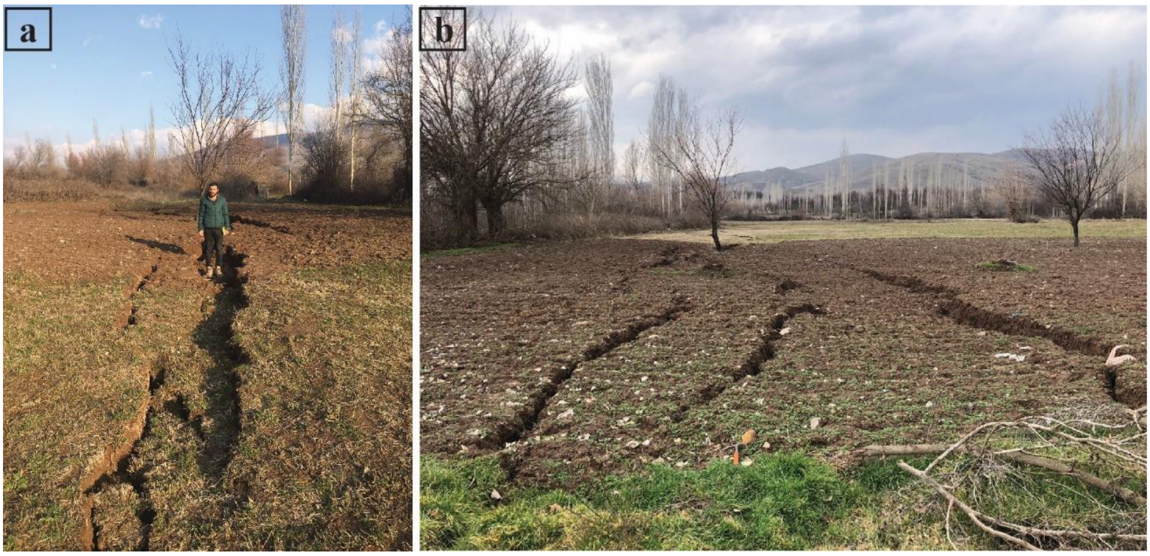


Figure 5. View of lateral spreading in Holocene age river banks near Pütürge. (Taken 6 February, 2020, location of the photos, 380 12' 41" N, 380 47' 50" E). a) Opening surface cracks on flat ground. b) General view of horst and graben structures.

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Another hydrological change was observed in Lake Hazar. The Lake Hazar is a 22 km-long, 7 km-wide strike-slip basin located on the central section of the EAF. The rise in Lake Hazar water level started on 25 January 2020 and continued for some time resulted in 8.00 meters. Locals confirmed that (December, 2020), water level in Lake Hazar is quite high comparing past years, although having a dry season.

It is observed in field studies some springs stopped flowing, however many increased in rate of flow, and new springs were formed. Moreover, new hot springs flowing were formed by the Şiro river.

Previous studies show that seismic wave oscillations commonly cause water-level fluctuations in wells, which may be either an increase or a decrease and may occur near or far from the epicenter (Cooper et al. 1965; Liu and Fearn, 1993; USGS, 2020). Besides, the fractures in wells may be widened, or narrowed because of the stress and strain effect of an earthquake. New water-bearing fractures could be formed. Groundwater levels may constantly increase or decrease as a result.

According to the statement made by Elazığ Municipality, the quality of groundwater was not affected, but pipes, wells and reservoirs were little damaged, and all of the supply was chlorinated to avoid contamination.

### 3.2. Indirect Social and Economic Effects

As indicated above, the Sivrice earthquake caused considerable direct human and material damage. Other indirect losses resulted from damage to social and economic infrastructure including accommodation for the homeless, difficulties in transportation and communication, and indirect economic effects.

After the earthquake, the Turkish government had to meet the needs of more than 50,000 people left homeless by the disaster. The Sivrice earthquake damaged nearly ten percent of the housing stock in the region caused a reduction in available buildings. After this situation, earthquake survivors started staying in temporarily established tents, schools, gyms, mosques and guesthouses in the city. Just after a month, families affected by a deadly earthquake were placed in more than 1,350 prefabricated houses, which have electricity and hot water, and were fully constructed. Based on the information from the AFAD web page (AFAD, 2020b), TL100 million ($14 million) in aid to some 50,000 homeless of recent earthquakes in eastern Turkey.

The earthquake struck at 20:55 and lasted less than a minute, but it urged thousands of people to flee buildings. Earthquakes lead to severe traffic jams in Elazığ and Malatya provinces which caused serious difficulty with travel not only for ordinary cars but also for emergency vehicles.
Landslides during the Sivrice earthquake were mostly located in epicentral areas and caused no damage to buildings. There were no casualties from landslides. Some roads were blocked by landslides, causing the closure of the secondary roads linking towns and mountain villages in the epicentral area. These landslides caused traffic interruption, and some delayed rescue vehicles from reaching the zones most damaged by earthquakes.

Network data from the NetBlocks internet observatory confirm telecommunication networks were influenced after the Sivrice earthquake, and AFAD urges residents to avoid non-essential telephone calls (URL-1). After two and a half hours, the telecommunication problem was solved. Soon after, telecom companies in the affected regions announced free access to internet and telephone services for residents.

The quake that struck Sivrice on 24 January 2020 damaged many schools and has forced the Elazığ and Malatya provinces to cancel classes for about 300,000 students and 22,500 teachers. Turkey's Education Ministry reported that all schools in the earthquake region were controlled and 39 of them should be demolished. In all, 73 schools were heavily or moderately damaged in Elazığ and Malatya province. Furthermore, 10,291 students and 2,000 teachers have been affected (AFAD, 2020a).

Turkey's Education Ministry decided to temporarily close the schools in the affected regions, continuation the semester break for three more weeks. After the additional holiday, over 1,000 schools had reopened for nearly 22,500 teachers and over 300,000 students.
The total budget necessary for the rebuilding of 39 schools has been estimated at about TL350 million ($50 million). Rebuilding the schools that were totally destroyed will take a year. That time frame poses a problem in regard to the education of 10,300 students and 1000 teachers (AFAD, 2020a).

Firat University, which is one of the largest in Turkey, is located in Elazığ. Since the establishment of Firat University in 1977, Elazığ has had the largest student population with about 45,000 including nearly 2,500 international students. About half of the Firat University students come from various cities to study. Sivrice earthquake leaves thousands homeless including several university students. Many students prefer to stay at the dormitories within or near the university campuses, less rent a house for a reasonable lease. Dormitories were not affected by the Sivrice earthquake; however, some students urge to leave their houses after damage assessments. These students had to return home and suspend their courses for one semester.

The first coronavirus in Turkey was recorded on 11 March 2020, and then, Turkish schools and universities were closed as of 16 March due to coronavirus. Turkey has been resuming its distance learning education system since March 2020.

Earthquakes may result in very substantial consequences for communities and individuals including a negative effect upon the mental health of the community. Earthquakes rarely occur, so such events may cause a negative effect on communities and individuals' mental health. Several studies have reported heightened anxiety, depression, and an increased incidence of post-traumatic stress disorder (Goenjian et al., 2005; Ishikawa et al., 2015) in earthquake survivors, and these effects could last for several years. Growing need for psychosocial support to earthquake victims in Elazığ and Malatya, Turkey's Ministry of Family and Social Policies over 800 personnel and Turkish Red Crescent (TRC) volunteers were immediately sent to the affected area. Personnel and volunteers provided that nearly 25,000 earthquake victims receive necessary psychosocial support and care to help them through this difficult time (URL-2).

Devastating earthquakes can result in a negative effect on the mental health of the community. Children would likely be a particularly vulnerable group but have been ignored in the past. TRC volunteer clinical psychologist said after earthquake children are more likely to wet their beds, which is a sign of traumatism. Hence, TRC volunteers are helping children cope after this traumatic event (URL-2).

A study by Fethi Sekin City Hospital's doctors to determine the psychiatric symptoms that arose on the Sivrice earthquake, and concluded that although the depression and anxiety levels of the post-earthquake survivors did not increase, trauma and dissociation scores increased [30]. According to these results, it is recommended that after disasters that cause loss of life and property the survivors must be well supported psychosocially to become used to their losses and not to become psychiatrically disturbed (Özsoy and Taşçı, 2020).

In addition to the social effects, the Sivrice earthquake has caused indirect economic losses. These losses have affected several sectors, including the insurance sectors and employment. Businesses in Elazığ and Malatya were highly damaged by the earthquake. Based on preliminary damage assessment in Elazığ and Malatya by the government, nearly 2,500 businesses were collapsed or heavily damaged, about 1,560 businesses were moderately damaged, some 12,000 were slightly damaged. Many others were forced to close temporarily. At least 5% of those businesses was closed permanently. It is estimated that nearly 5,000 people have lost their job resulting in the unemployment rate rising as earthquakes hit the economy (AFAD, 2020b). The damage and disruption caused many business stores to locate in other areas. Along with the reduction in the available buildings for business, the number of available rental workplaces decreased. As a consequence of the devastating earthquake, workplace purchase prices and rental prices are rather increased.

More than half of the people in the country are at risk of earthquake damage, according to Turkey's earthquake risk map prepared by AFAD. Compulsory Earthquake Insurance (DASK), which has been required by law forces since 1999 earthquakes in Turkey, provides coverage for your home, against earthquake risks. The insurance premium figure depends on factors, which are (1) the home's proximity to a fault line/seismic zone; (2) the home's construction; (3) the gross area of the residence. Over twenty years, although DASK is required, about half of the homeowners enroll in insurance. Elazığ and Malatya are among the cities with the most people at risk; however, the DASK enrollment rate of these cities is under average at about 45 percent (URL-2).

Since the day DASK was founded, it has paid more than TL1.263 billion for over 97,000 damages. For Elazığ and neighboring Malatya, DASK reported that about TL440 million were paid for the about 25,000 homeowners, whose 65 percent of appeal from Elazığ and rest in Malatya (URL-2).

## 4. RESPONSES

Crucial aid, which mainly involve search and rescue and helping the injured, was quick in Elazığ and Malatya. Shortly after the earthquake, response and rehabilitation phases of disaster management continue effort under the coordination of AFAD along with the public authorities such as UMKE (National Medical Rescue Team), 112 Emergency, Fire Brigade and Gendarmerie, in order to rescue those who are trapped under the debris and normalize life. All these operations were carried out within the scope of TAMP (Turkey National Disaster Response Plan) under the coordination of AFAD.

Search and rescue activities continued in the debris of 3 buildings at the city center of Elazığ. A total of 3.733 personnel from 21 public offices and institutions, total of 554 vehicles, three of them being Mobile Coordination Service, 17 dogs, 3 UAVs, 1 helicopter and a plane worked under the coordination of AFAD (AFAD, 2020b).

The number of survivors later reached 45, according to AFAD. A 35-year-old woman named Ayşe Yildiz was trapped for 28 hours under her apartment building in Elazig with her 2-year-old daughter, Yusra. According to Turkish media, rescue workers pulled the young girl from the wreckage at around 8:30 p.m. local time on Saturday, but it took nearly five more hours to rescue Yildiz, whose arm was trapped under a pile of rubble.

In circumstances of extreme conditions such as devastating earthquakes, hurricanes, flooding, people are more likely to cooperate and help others. Sivrice earthquake has led to an increase in supportive Facebook messages and tweets to victims of the earthquake. One such example of that Turkish TV launched a campaign to raise funds for victims of the Sivrice earthquake. Acun Ilicali, who is the owner of the TV8 channel, ask the people of Turkey in a live campaign to donate money for Sivrice earthquake victims and raised TL51 million ($8.6 million) within only four hours.
As a result of the ongoing donation campaign, a total of TL 111,796,221 of it collected AFAD; TL 49.456.740 of it collected in Red Crescent was collected for earthquake victims in Elazığ and Malatya (AFAD, 2020b).

Turkey's Ministry of Interior said TL460 million in aid to some 150,000 victims of recent earthquakes in eastern Turkey. 311 trucks carrying humanitarian aid materials were delivered to the earthquake area under the coordination of AFAD (AFAD, 2020b).
Hospitals are a key first response infrastructure to be fully operative in the event of an emergency. Elazığ Fethi Sekin City Hospital was safe in an earthquake thanks to having an earthquake isolation system.

After an immediate response, mainly involving search and rescue and helping the injured, has been completed, long-term response studies have already started. Just after a month, families affected by a deadly earthquake were placed in more than 1,350 prefabricated houses, which have electricity and hot water, and were fully constructed (AFAD, 2020b).

Preliminary damage assessment activities with 530 technical personnel to detect buildings must be demolished urgently were completed only one month after the earthquake.
On 24 February 2020, Turkey's Environment and Urbanization Minister said the government would begin building a total of 23,734 houses in two provinces, 19,190 in Elazig, and 4,544 in Malatya (AFAD, 2020b).

A total of 38 schools in Elazig, 14 of which are severely damaged and 24 of them are moderately damaged, a total of 36 schools in Malatya, 13 of which are severely damaged and 23 are moderately damaged by the Sivrice earthquake (AFAD, 2020b).
Some benevolent citizens in Elazığ and Malatya have promised to build 25 new schools instead of those schools that were severely damaged by the Sivrice earthquake. Those schools will be completed by the new school year of 2021.

On the anniversary of the Sivrice earthquake, Turkey's Environment and Urbanization Minister said 7 billion TL was allocated for the reconstruction of 23,734 houses in two provinces. 8,000 of those houses were already delivered to the families. Rest will be delivered to the families by the end of June 2021 (AFAD, 2020b).

## 5. POLICY FOR SUSTANIABLE MANAGEMENT OF EARTHQUAKES IN TURKEY

Earthquakes are common in Turkey, and more than 80,000 people died and destroyed over 300 thousand dwellings by more than 100 earthquakes in the past 100 years (AFAD, 2020c). It has been calculated that an earthquake with Mw 6 or larger occurs once every year that causes loss of life and property. Repeated significant loss of life and property due to earthquakes in Turkey is an important national issue.

As part of a national risk management program, the Turkish Government has produced several regulations for risk assessment, safe buildings, and response since 1940. Since then, The Governments have passed over ten revisions of the code with the latest update in 2018. Besides, a very substantial update in structural standards after the 1999 earthquakes when collapsing buildings caused massive loss of life.

A preliminary damage assessment results show that none of the buildings were constructed after 1999 were neither damaged nor collapsed from the Sivrice earthquake. The main problem, however, is that buildings constructed earlier than 1999. Turkey is furthermore encountered with the problem of rapid population growth and rural-to-urban migration, which has influenced the form of urbanization, in turn, urban settlements and industries spreading into vulnerable regions enhanced the risk of loss of life and property (AFAD, 2020b).

The Government has been implementing urban transformation projects nationwide to improve the building and safety standards as a preventive measure against disaster. Over the past nine years, the government has allocated more than TL15 billion ($2 billion) for the urban transformation project that covered more than 1,3 million housing units. It is, however, there are more than 6,7 million housing units that need to be transformed (URL-3).

Turkey is among the world's most seismically active areas as it is situated. Active faults in Turkey cover a large space from east to west. Some of Turkey's settlements have always been in danger of destruction from earthquakes due to faults underlying these settlements. Thousands of existing buildings located on fault lines have to move to safer places. It is, however, there is no law to ban buildings on and near the fault lines in Turkey. As part of the efforts, the Government is planning to pass a law banning new buildings on and near fault lines as well as to bring comprehensive zoning changes for location.

Earthquake is the most frequent natural disaster in Turkey, and public awareness and public education is an important issue to decrease the level of loss and damage. Several factors contributed increasing the risk of situation including weak economic conditions, poor quality of construction, ignoring regulations (ISDR, 2002).

The weak economic condition is one of the main obstacles that Government should overcome to help homeowners build safer structures. Another main problem is that the regulations are not fully applied. The government and local authorities should share the responsibility for the implementation of regulations.

The public awareness and education continue effort under the coordination of AFAD. AFAD teaches how to take action to protect themselves during and after the earthquake. After the devastating Sivrice and İzmir earthquakes, the government has just announced that 2021 will be the Disaster Training year in Turkey. The purpose of this training is classified into two categories: risk management and public awareness and education.

The Building Code of Turkey has been revised in 2018. The new Turkish Building Earthquake Code is a comprehensive revision of the previous one dated 2007. Earthquake building code was published in Official Gazette on 18th of March, 2018 and became legally effective on 1st of January, 2019. The main improvements are on the definition of site specific design ground motions, and on the seismic design of tall buildings, base isolated buildings and pile foundations.

The Turkey National Disaster Response Plan (TAMP in Turkish) outlines the roles and responsibilities for every involving party in disaster and emergency response situations to determine the basic principles of response plan in all three phases: before, during and after the disaster and emergency situations.

## 6. CONCLUSION

This study provides an extensive impact of the Sivrice earthquake that caused 41 causalities until the time that this article was written. The overall impacts of the Sivrice earthquake are classified into two categories: direct and indirect effects. It, then, reviewed the response and policy for sustainable management of earthquakes in Turkey. Human and material losses in the Sivrice earthquake show that Turkey has taken considerable steps on regulations for risk assessment, it is, however, the country remains delicate to destructive earthquakes.

This vulnerability is attributable to a number of factors, including:

- Existing of low strength buildings, which mostly were constructed earlier than 1999, in Turkey,
- Rapid population growth and rural-to-urban migration, which has influenced the form of urbanization, in turn, urban settlements and industries spreading into vulnerable regions enhanced the risk of loss of life and property,
- Thousands of existing buildings located on fault lines. However, there is no law to ban buildings on and near the fault lines in Turkey.

Sivrice earthquake caused substantial human and material losses. In addition to the human and material losses, the Sivrice earthquake has caused indirect economic losses. These losses have affected several sectors, including the insurance sectors and employment. Consequently, if the Turkish Government aims to reduce the impact of future natural disasters, it should work to improve the legislative and technical aspects of disaster for management. The objectives of the aspects should be,

- Strengthen disaster risk management organizational policies, practices and decision-making,
- Establishing a micro-zone map to potential disaster hazards for a region to provide planned and healthy land use,
- Educate and inform populations to manage risks and strengthen their resilience to disasters. 2021 was declared as the Disaster Training Year in Turkey in order to develop

disaster awareness in the society, decrease the risk of disasters and make a change in habits regarding disaster handling. The aim is to reach 51 million people in 2021 as a part of Turkey Disaster Training Year. These are positive developments, but they must be sustained.

- Provide that effective and people-focused early warning systems are established.

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