# ОПАСНЫЕ ПРОЦЕССЫ В ГИДРОСФЕРЕ: ФУНДАМЕНТАЛЬНЫЕ И ИНЖЕНЕРНЫЕ АСПЕКТЫ
# HAZARDOUS PROCESSES IN THE HYDROSPHERE: FUNDAMENTAL AND ENGINEERING ASPECTS

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## AVALANCHE DISASTER REVIEW IN TURKEY

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**Abstract.** One of the natural disasters encountered mostly on barren slopes and in the spring season, in the mountainous parts and high plateaus of Turkey, in Central and Eastern Anatolia, is avalanche. Especially in heavy snow areas of the Eastern Anatolia, people living in villages and hamlets far from the city centers, lose their lives and homes, roads are closed. Energy pilons and energy transmission lines are destroyed due to heavy snow accumulation and avalanches. During snow storms, excessive snow accumulation on flat and earthen roofs, and icing on eaves adversly affect the living conditions of people. Every year, about 25 people lives are lost in avalanche accidents in urban areas, very few at winter tourism locations, and the loss of property is not clearly known. In this study, the present situation of the areal distribution of avalanche events, their distribution in time, and in this context, the recent avalanche mapping, modelling and simulation studies that have been done so far are exemplified. Based on the data available, avalanche-hazardous zones in Turkey are identified, the analysis of avalanche data for the period 1950–2019 is given. The structural and non-structural measures necessary to control the avalanche problem are defined. Opinions are shared on the necessity of coordination among the state institutions working on avalanche disaster prevention.

## ОБЗОР ЛАВИННЫХ КАТАСТРОФ В ТУРЦИИ

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**Аннотация.** Одним из стихийных бедствий, встречающихся в основном на склонах и в весенний период, в горных районах и высокогорных плоскогорьях Турции, в Центральной и Восточной Анатолии, являются лавины. Особенно в сильноснежных районах Восточной Анатолии люди, живущие в деревнях, удаленных от городских центров, лишаются жизни и домов, дороги перекрываются. Энергетические опоры и линии электропередач разрушаются из-за сильного снежного покрова и схода лавин. Во время метелей чрезмерное скопление снега на плоских и земляных крышах, обледенение карнизов отрицательно сказываются на условиях жизни людей. Ежегодно около 25 человек погибает в результате схода лавин в городских районах, очень мало в местах зимнего туризма, а потери имущества точно не известны. В этом исследовании иллюстрируется нынешняя ситуация с территориальным распространением лавин, их распределение во времени и, в этом контексте, недавние исследования по картированию лавин, моделированию, которые были выполнены до сих пор. На основании имеющихся данных выделены лавиноопасные зоны в Турции, дан анализ лавинных данных за период с 1950 по 2019 год. Определены структурные и неструктурные меры, необходимые для борьбы с лавинной проблемой. Обсуждаются мнения о необходимости координации деятельности государственных структур по предотвращению схода лавин.


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**Keywords:** avalanche disaster in Turkey; release and motion of avalanches; winter climatic conditions; stability of snow layer on slopes; dynamic avalanche modelling; avalanche mapping study.

**Ключевые слова:** лавинные катастрофы в Турции; возникновение и движение лавин; зимние климатические условия; устойчивость снежного покрова на склонах; динамическое моделирование лавин; лавинное картографирование.

## Introduction

The 78% of Turkey's surface area consists of mountains and approximately 47% of the population lives in mountainous areas [EEA, 2010]. The average elevation in Turkey is 1 132 m a.s.l. and the average land slope is 17%. Therefore, mountainous areas are very important in Turkey's living conditions. The common natural disasters in winter, especially in Eastern Anatolia, are heavy snow fall, roof collapse and the snow avalanche. Although the avalanche is a natural event, due to unplanned settlements, inadequacy of early warning systems, the lack of education on avalanche prevention methods, and on proper avalanche disaster awareness etc., it turns out to be a natural disaster.

### *Spatial Distribution of Avalanches in Turkey*

When the spatial distribution of avalanches is examined in Turkey, 87% of the deaths in avalanches occurred in rural settlements (where people live constantly) [Gurer, 2002; AFAD, 2009]. If abroad: for example, in the United States, 88% of the deaths in avalanche events between 1950 and 2000 were in winter vacationers, while similarly about 90% of the deaths in avalanches in Switzerland occurred in winter activities [Schweizer, Lütschg, 2001].

When the province-based distribution of avalanche events that have occurred since 1950 (figure 1) is examined, Bingöl city ranks first with 274 events. This is followed by Bitlis with 265 avalanches, Tunceli with 170 avalanches and Malatya with 81 avalanches. Avalanches that occurred in these four provinces accounted for a significant 49 percent of the total avalanches. In other words, it can be said that about half of the avalanche events since 1950 have occurred in Bingöl, Bitlis, Tunceli and Malatya [AFAD, 2020].

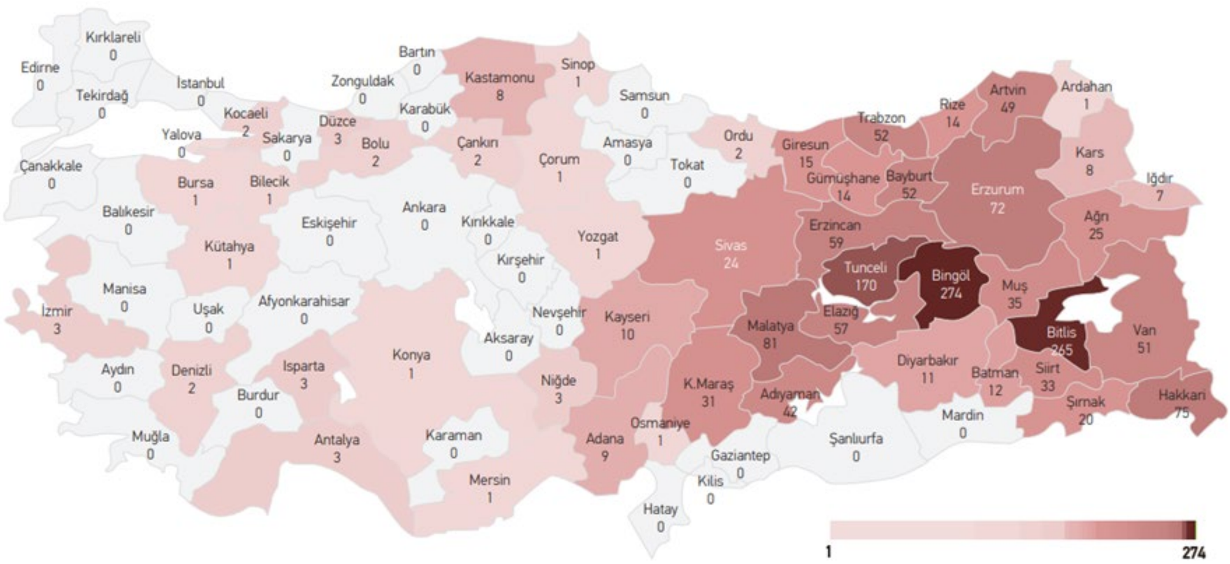


**Figure 1.** Province-based numbers of avalanche events in Turkey in the period 1950–2019 [AFAD, 2020].
**Рисунок 1.** Количество лавин в Турции в период с 1950 по 2019 год по провинциям [AFAD, 2020].

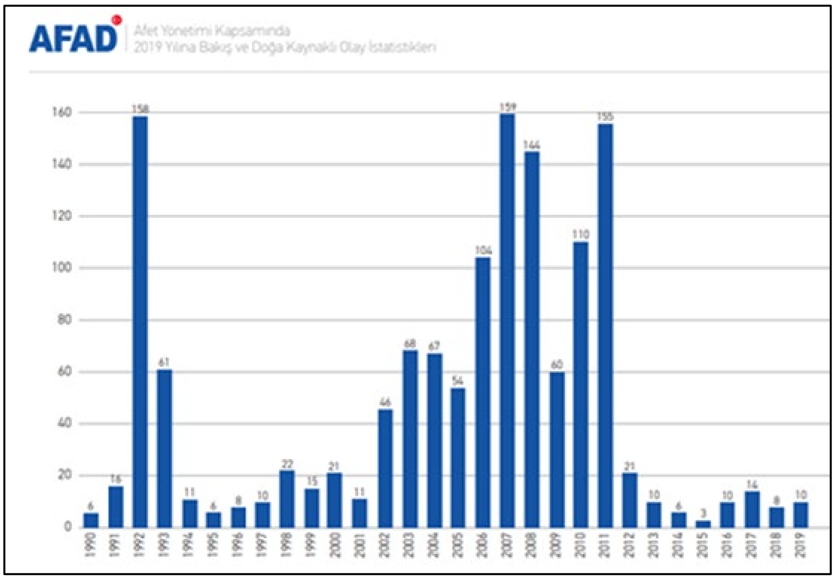


**Figure 2.** Variation of the number of avalanches according to years [AFAD, 2020].
**Рисунок 2.** Изменение количества лавин по годам [AFAD, 2020].

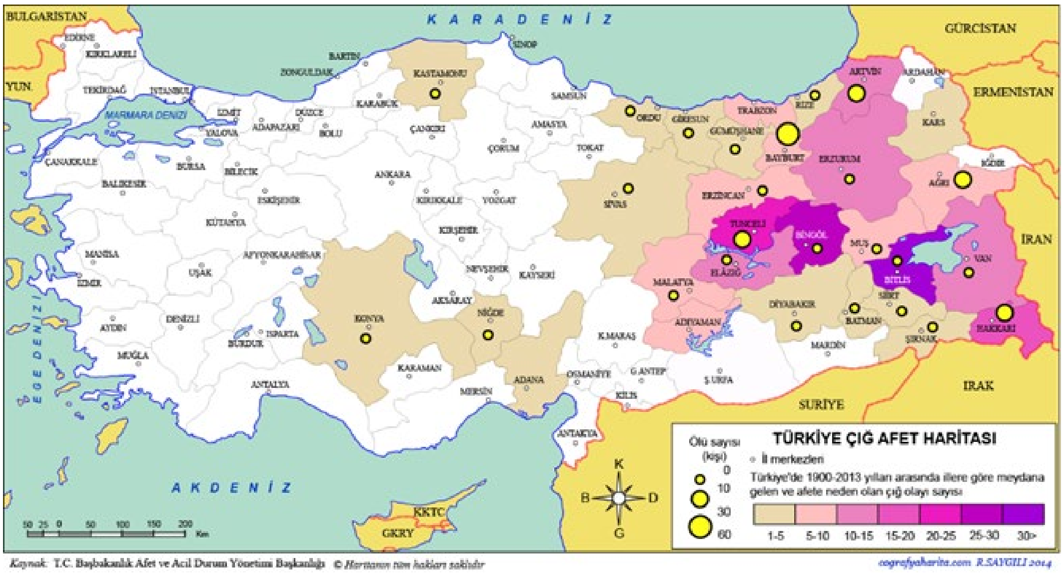


**Figure 3.** Spatial distribution of the number of deaths in avalanches [AFAD, 2020].
**Рисунок 3.** Пространственное распределение числа погибших в лавинах [AFAD, 2020].

***Temporal Distribution of Avalanches in Turkey***

When the avalanche statistics for the period 1950–2019 are examined in terms of the number of avalanche events and the number of deaths in avalanches (figures 2, 3), although a fairly horizontal course was observed in the number of events until the 1990s, fluctuations started from 1992. There were 158 events in 1992, 104 events in 2006, 157 events in 2007, 144 events in 2008, 110 events in 2010 and 155 events in 2011 are the years that stand out. The years after 2012 showed a decreasing trend [AFAD, 2020].

According to data of AFAD in 1227 avalanches that occurred in Turkey from 1990 to the end of 2019: 1 417 people lost their lives and 412 people were injured [AFAD, 2020]. Only on January 18, 1993, in the avalanche that occurred in Bayburt Üzengili, 75 houses were affected and 59 lives were lost [Gürer, Naaim, 1994]. In the winter of 1991/1992, there were a total of 328 casualties.

At the mountainous area of Kastamonu and Sinop provinces in the western part of the Black Sea Region of Turkey, during 25–30 December 1992, blizzard with heavy snowfall caused roof collapse and major avalanche events whereby 13 people were killed and 2 injured. It was the first time, in the villages closely located in a narrow high band about 10 km inward direction from the coastal strip of Black Sea of Northwest Anatolia, where there has never been an avalanche before. The Black sea region has a mild climate, where dominant precipitation types are rain on the coastal zones and snow over the mountains. Comparing with the period of 1966–1991 during which the maximum measured snow depth was 40 cm, and minimum of 6 cm, and an average value of 15 cm, but in 1991/1992 winter, the total snow depth was eight times higher than the previous average value [Gürer, Tunçel, Yavaş, 1995].

On the 4–5 February 2020, at Van-Bahçesaray, 41 of people lost their lives and 84 people were injured in two consequitive avalanches at the same locations. The first avalanche occurred during the opening of the highway at the 33rd km of the road. Five people lost their lives in the first avalanche, and 33 people in the second avalanche, and it was stated that the search efforts for the three people who were under the avalanche were continuing. However, it was confirmed by the Van Governorship that a firefighter was still under an avalanche and his body could not be reached due to bad weather conditions. The last body was found after 39 days[1].

On January 27, 2022, two people lost their lives in the avalanche that occurred in Erzurum, Horasan district, Kadicelal Mahallesi Çayanyurdu hamlet due to two days of continous snow fall and billzard.

According to the avalanche risk map of Turkey (figure 4), it is clearly seen that the elevation of the land from the sea and seasonal climatic conditions are decisive factors in the occurrence of avalanche events in Anatolia. As a matter of fact, avalanche events are frequently encountered in the Eastern Anatolia Region and the Eastern Black Sea Region, while less avalanche events occur in other regions. New settlements to be opened in mountainous areas, establishment of winter sports facilities, new roads may increase the number of avalanches, loss of life and property. Because the design and implementation of new precautionary structures to be developed against the risks to be identified are important in Turkey. The most important parameters to be considered in the evaluation of avalanche effects are the temporal and spatial distributions of the avalanches. For this reason, dynamic modeling studies should be carried out using the analysis of meteorological conditions of each event, land surveys and past avalanche records in order to decide the possible dimensions of the avalanche disaster [Uçar, 2014].

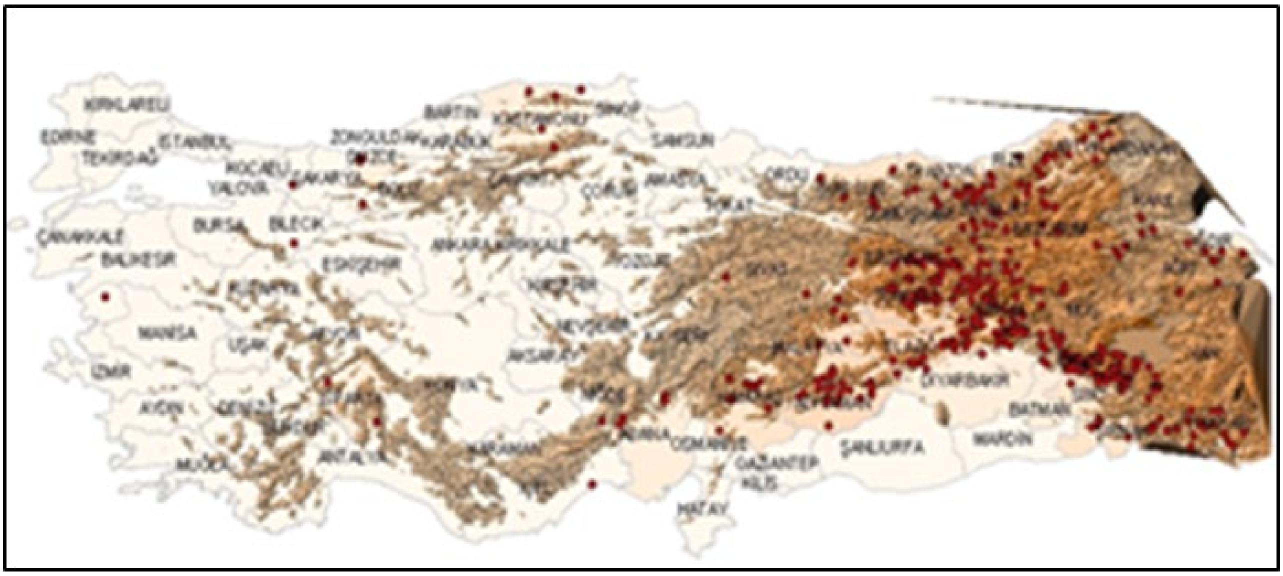

**Figure 4.** Avalanche risk map of Turkey [AFAD, 2020].
**Рисунок 4.** Карта лавинной опасности Турции [AFAD, 2020].

[1]Van'da iki yıl önce 42 kişinin öldüğü çığ felaketinin acısı tazeliğini koruyor [The pain of the avalanche disaster in Van, which killed 42 people two years ago, remains fresh]. Available at: https://goo.su/FeGzYZt.

**Snow observations**

The occurrence of an avalanche is closely related to amount of snowfall. Daily fresh snow and ground snow data are continuously collected at the meteorological stations of the General Directorate of Meteorology of Turkey (further – MGM), at all the stations of network covering the whole country. The maps of "Annual Average Number of Snow Covered Days", "Annual Snowy Days" and "Observed Maximum Snow Thickness" prepared by MGM regarding the areal distribution of Turkey's snow cover are renewed approximately every 5 years.

Physical parameters characterizing the snow layer, especially at the starting zone, such as: total snow depth (m), daily fresh snow depth (m), density (kg/m$^3$), air and snow temperatures (°C), snow water equivalent (mm), dry or moist (humidity), albedo (%), snow stratification and determination of strength – are important parameters [USDA, 1961; Krasser, 1966; La Chapelle, 1969]. This can be realized by the Automatic Weather Observation Stations (further – AWOS), located at the avalanche starting zones and operated by MGM.

In terms of avalanche formation, snowpack is a deformable material. Snow cover is motionless on the slope without any external influence. Every day, a few millimeters of movement towards the base occurs due to gravity and internal stresses within itself. Vegetation has a reducing effect on this phenomenon (figure 5). Snow being a viscoelastic material, exhibits the properties of both a slow flowing viscous liquid and an elastic solid. These features vary according to the density of snow, grain type and air temperature depending on the local climate.

In recent years, the snow-water equivalents can also be determined indirectly with the help of satellite images or using radioactive methods to estimate avalanche risk in Turkey. Also a Ramsonde Rod and a 1 kg cylindrical special ring moving on it are used to create the structural profile of snow pack to determine the stratification and strength of the snow in Turkey (figure 6) [Gürer, 2012].

**Figure 5.** Release and motion zones of avalanche over a local farm.
The farm, barn and other units in the avalanche flow region, located at the left bank of Zap river (Van-Hakkari state road 173rd km, during February, 1993).

**Рисунок 5.** Зоны сброса и движения лавины над местной фермой.
Ферма, амбар и другие объекты в зоне лавинного схода, расположенные на левом берегу реки Зап (173-й км государственной дороги Ван-Хаккари, февраль 1993 года).

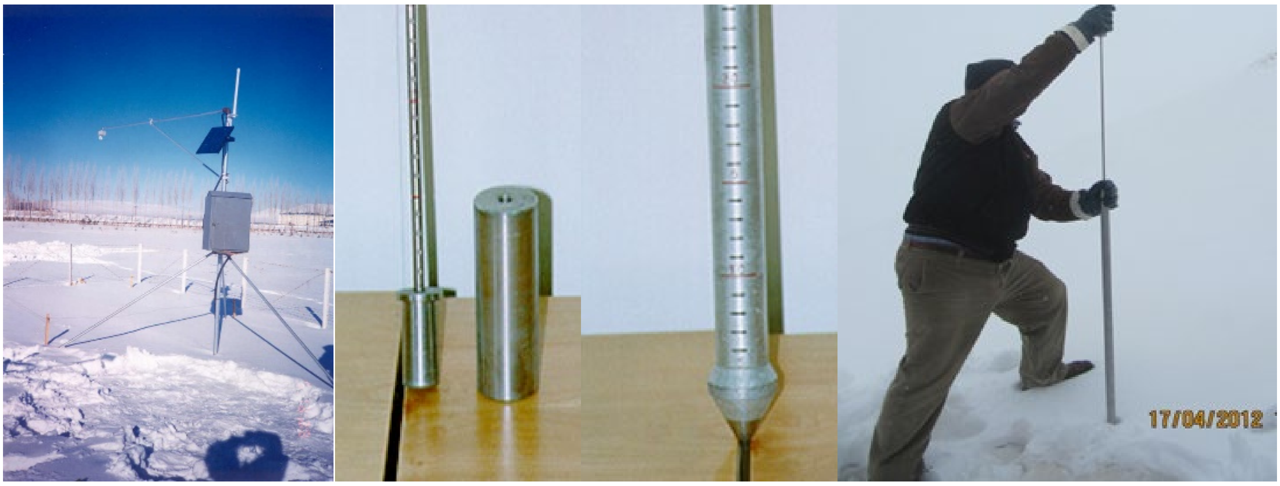


**Figure 6.** AWOS at Erzurum reserch station at 2005, Ramsonde instrumentation [Gürer, 1988] and Determination of snow pack layers with Ramsonde at Trabzon Karester Plateau [Gürer, 2012].
**Рисунок 6.** Автоматическая метеорологическая станция на исследовательской станции Эрзурум в 2005 год, зонд Хефели [Gürer, 1988] и определение слоев снежного покрова с помощью зонда Хефели на плато Трабзон Карестер [Gürer, 2012].

***Pre-Avalanche Snow Layering***

*Avalanche occurs when* the snow mass hanging on the slopes moves down on a slippery surface. The biggest danger in the avalanche event is the formation of a thick new layer with the accumulation of fresh snow on the old snow cover. The old snow is stuck on the ground, and a slippery ground is formed between the old and new snow layers by the mostly hot air flow coming after the blizzard and this triggers the avalanche.

Due to geographical location of Turkey, a significant amount of precipitation in winter is in the form of snow. Especially mountains at Central and Eastern parts of the country are very windy. On slopes between 28° and 55°, especially bare slopes are natural avalanche routes. The direction and speed of the wind in avalanche regions depend on the altitude and distance from of the sea, topography and local air currents (valley wind), slope angle, aspect/orientation (the most common avalanche and destructive effect occurs in the section between northwest and southeast), air and snow temperatures, the presence of weak snow layers in the snow mass, slope cover and slope roughness (forest cover, slopes with bare and/or stunted plants where the snow thickness exceeds their height, affect downhill speeds). Likewise, the roughness of the slopes is effective in "full" avalanches sliding over wet ground under the snow layer.

Snow fringes (cornices) on the ridges near the summit are formed in the direction of the prevailing wind at a speed of 5–25 m/s (18–90 km/h) of snow crystals with a grain size of around 0.1 mm (figure 7). The cornice breaks over time, causing a sudden and heavy load on the downwind snow layer, causing avalanches to fall.

Avalanches are also triggered by artificial effects: skiers entering the avalanche start zone, hunters, people interested in winter sports, soldiers going on winter exercises, etc. Snow vehicles, earthquakes and artificial avalanche release systems using explosives can be considered effective in avalanche control. Avalanches can occur depending on whether the snow cover is loose or compacted as Block avalanche (slap avalanche) as layers or Powder avalanche (loose snow avalanche) which is a type of avalanche that occurs as a cloud formed from dry snow when the snow cover is loose, almost like dust.

**Figure 7.** Cornice formation on the near-ceak slope in the dominant wind direction [ANENA, 1994; Sivardiere, 1996].

**Рисунок 7.** Формирование карниза на привершинном склоне по господствующему направлению ветра [ANENA, 1994; Sivardiere, 1996].

### Avalanche prevention / control methods used in Turkey

The main methods in avalanche control are: Active and Passive methods for long-term and short-term use [Hotckiss, 1972]. For example:

a. The closing of avalanche-hazardous areas (Passive Method). This method is used commonly in roads of small traffic activity in winter.

b. Closing the roads and parts of the regions with avalanche danger and/or putting them into service in a controlled manner in certain periods. It is also possible to evacuate the risky area. Drivers should be constantly warned with signaling / traffic signs and media broadcasts, especially during the passive method application on highways. This method is used on winter recreational areas, especially on deep gorges and cut-sections parts of roads during snow blizards.

c. The avalanche protective dams (figure 8) control the snow mass formed by naturally falling avalanches. A similar approach has been employed at just before the stopping zone of Bayburt Uzengili avalanche (59 people died in this avalanche at February 1992) where the flowing snow mass was diverted to a deeper valley located next to the Üzengili village.

It is possible to deviate the avalanche from the usage area or keep it on the route, especially with artificial and long-term structural methods such as Çiğkiran/Spur (figure 9) to protect energy transmission pylons and highland houses [ANENA, 1994]. In 2019, when the special zone electric transmission line pole (PCH 30) of the Line between Oymapinar Dam and Seydişehir Aluminum Facilities Complex was destroyed by an avalanche, to solve the problem, an avalanche prevention structure (spur dike type) project was made for this pole by TEİAŞ. Then, the responsible regional directorate was contacted and important information support was received [Oğurlu, 2021].

**Figure 8.** Avalanche protective dams in France and Switzerland to dissipate the flowing avalanche, to stop the avalanche and use summer water [SFISAR, 1992; ANENA, 1994].

**Рисунок 8.** Противолавинные защитные дамбы во Франции и Швейцарии для рассеивания стекающей лавины, остановки лавины и использования летней воды [SFISAR, 1992; ANENA, 1994].

**Figure 9.** Avalanche Splitters made with different construction materials to deflect the course of the flowing avalanche [ANENA, 1994].

**Рисунок 9.** Лавинные разделители, изготовленные из различных строительных материалов, чтобы отклонить направление стекающей лавины [ANENA, 1994].

***Active Prevention Methods used in Turkey***

In history, the oldest avalanche control method is to keep the avalanche in the starting area or to use diverting walls and embankments to change its direction. For centuries, heavy masonry walls and sword-like barriers have been used to protect small, independent buildings against avalanche danger in the Alps [La Chapelle, 1969].

Today, terracing, staggered piles, tripods, horizontal or vertical lathed barriers, avalanche containment nets, snow trenches and fences, and reforestation between structures can be given as examples of the permanent methods preferred to reduce and prevent avalanche rupture and flow in the avalanche starting region (figure 10). At Bolu Ayikaya avalanche route avalanche nets were used.

The most used but more expensive avalanche routing artifact is avalanche tunnels (figure 11). It protects highways and railways in mountainous areas against avalanches in areas with avalanche danger.

***Passive Prevention Methods***

Restricting or blocking the use of avalanche-hazardous areas mainly protects skiers and vehicles on the road. This method is successful if it is applied for a certain period of time when the danger is greatest. Persistent restriction or obstruction will create discontent in this part of the society and cause illegal use (figure 12).

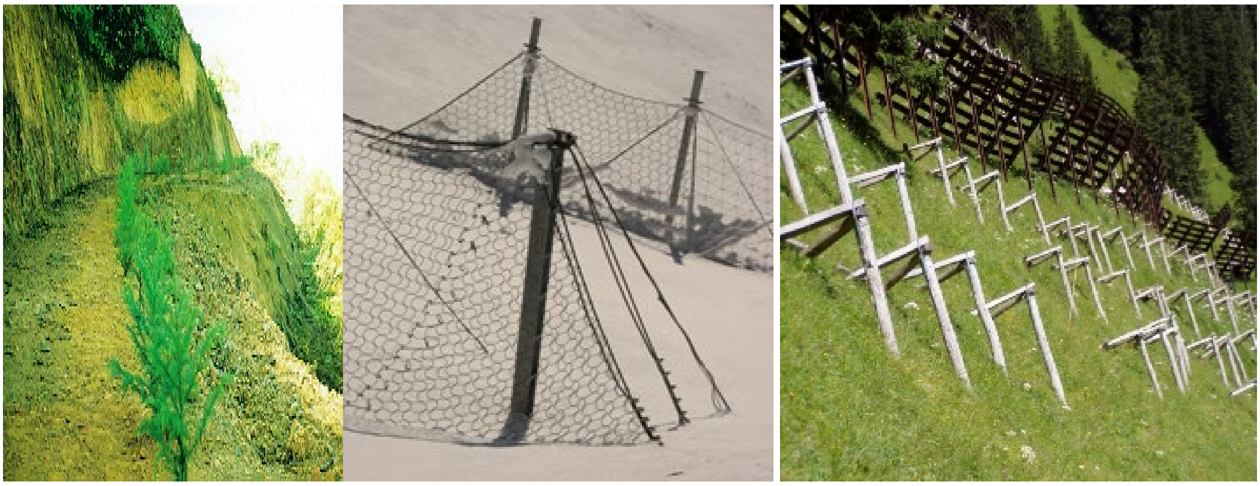

**Figure 10.** In the avalanche starting zone: Terracing, Tripods, Barriers, Avalanche Nets [Snow avalanches…, 1961; SFISAR, 1992; Gürer, 2015].

**Рисунок 10.** В зоне схода лавин: Террасирование, треноги, снегоудерживающие барьеры, противолавинные сетки [Snow avalanches…, 1961; SFISAR, 1992; Gürer, 2015].

**Figure 11.** Avalanche tunnel at Van-Hakkar Highway [Gürer, 1993] and operational problems met (some of the tunnels on the Tunceli-Erzincan highway are being extended longitudinally)[2].

**Рисунок 11.** Лавинный туннель на шоссе Ван-Хаккар [Gürer, 1993] и возникшие эксплуатационные проблемы (некоторые из туннелей на шоссе Тунджели-Эрзинджан расширяются в продольном направлении)[2].


**Figure 12.** Warning signs, temporary road closures and warnings for skiers and road drivers in USA and France [ANENA, 1994].

**Рисунок 12.** Предупреждающие знаки, временное закрытие дорог и предупреждения для лыжников и водителей в США и Франции [ANENA, 1994].

[2]Çığ Tünelleri Uzatılıyor [Avalanche Tunnels Extended]. Available at: https://www.sondakika.com/haber/haber-cig-tunelleri-uzatiliyor-5311388/.

*Using Detonators*

Road warning and closure systems are generally used in the operation of Highways during the avalanche period. Various detonation methods (avalanche balls, single or multi-barrel avalanche reducers) and explosive material types (CATEX, GAZ-EX, AVALHEX) can be used to modify the nightly accumulated snow cover on the terrain. Creating artificial avalanches using these methods are the most commonly used temporary methods. Previously, artificial avalanches were created in the United States and in countries such as Switzerland, Austria, France and Russia using only sound-producing howitzer and mortar shells. Mechanical destroyers can be skis, bulldozers and dynamite.

An artificial avalanche is created by means of remote control method by using dynamite and similar explosives when it comes to the avalanche routes with the cable car lines placed in previously determined places and known as CATEX in France, and the avalanche danger is eliminated. This solution is not used in Turkey because all kinds of explosives' use is strictly under the state control.

In the 1990s, the most used method in avalanche control was GAZ-EX. In this method, an artificial avalanche is created on predetermined avalanche routes by mixing oxygen and propane gases and detonating them in a controlled manner. Although the maintenance and operating costs are quite low, the initial investment cost seems to be higher than other methods. Erzurum, Palandöken ski center, the GAZ-EX system, which was established as three units, was finalized by the Erzurum Special Administration and trial explosions were carried out in the winter season of 2001/2002.

The latest method for creating artificial avalanches by blasting is AVALHEX technology. The mixture of air and hydrogen gas is detonated by remote control by sparking and an avalanche is reduced artificially by the sound and pressure wave that occurs. It is stated by the manufacturer that assembly and operation are easier and reliability is higher (figure 13).

*Establishment of Avalanche Forecast and Early Warning System*

Priority as in avalanche endangered countries; Continuous measurement of snow layer structure; manually or at automatic measurement stations, establishment of nivological measurement network, implementation of snow profile studies throughout the country, other available meteorological and topographical datas, surface roughness of avalanche paths, vegetation, etc, and then set up an "Avalanche Forecast and Early Warning System.

**Figure 13.** Artificial avalanche release methods with avalanche cannon, CATEX, GAZ-EX, and AVALHEX blasting methods [ANENA, 1994].

**Рисунок 13.** Методы искусственного схода лавин с помощью лавинной пушки, взрывных работ CATEX, GAZ-EX и AVALHEX [ANENA, 1994].

*Determination of the weak layers of Snow pack*

i. The snow profile is set up by manually determining the hardness of the snow layers. Detection of transitions in snow layers is easier and more precise than other methods.

ii. In the measurement made with the Ramsonde (figure 6) the device is placed perpendicular to the snow cover, the number of drops of the ram weight (1 kg) and the change in the amount of advance of the tube in the snow cover along the snow thickness are monitored. At each stage, the Ram Profile is obtained from the pile resistances of the snow layer in kg/cm$^2$. From this graph, it is determined which layer and/or layers in the snow cover are suitable for slipping.

iii. Rutschblock (Swiss army ski) test, drop-stuffblock test can be used to reveal the slip surface in layers with low strength in the snow mass suspended on the slope.

## Available modeling methods

In order to understand the extent and possible effects of natural disasters, modeling (simulation) studies should be done before they occur. In addition to structural prevention methods, it is of great importance to model avalanches before they occur and to provide risk management before crisis management in terms of applying non-structural techniques such as early warning. In addition, animations prepared with avalanche modeling methods are of great importance for decision makers to implement protective measures.

Avalanche modeling methods are applied for the determination of avalanche hazard and risk maps, the determination of maximum avalanche accumulation distances and amounts, as well as for sizing and site selection of structural solutions.

Avalanche models can be mainly divided into two. These are empirical and dynamic methods. Empirical methods are studies similar to the "Alpha-Beta Flow Model", in which the effects of possible new avalanches can be predicted based on observations, using the distances reached by previously experienced avalanches and topographical parameters [Gürer et al., 1995].

Instead of empirical methods, dynamic models in which the effects of possible avalanches (such as avalanche velocity and dynamic impact pressure) can be determined in flow and accumulation regions. Dynamic models: AVAL-1D [Christen, Bartelt, Gruber, 2002], VARA 1D [Natale, Nettuno, Savi, 1994], NIS [Norem, Irgens, Schieldrop, 1986], etc. can be listed as the first examples of 1D dynamic analysis software, which is generally based on the velocity at the center of mass. With these models, speed and distance effects can be determined in one direction. With the development of technology, 2D and even 3D softwares have emerged that can determine the settlements that may remain within the avalanche propagation areas and that the avalanche can progress in both x and y directions.

Used in 2D dynamic avalanche models Software such as AVAL-2D [Gruber, 2001], RAMMS [Christen, Bartelt, Gruber, 2002], ELBA+ [Kleemayr et al., 2000], MN2L [Naaim et al., 2004] can be given as examples. SAMOS [Sampl, Zwinger, 2004] can be shown as an example of 3D software. In general, “RAMMS” and “ELBA+ 2D” are used more in 2D avalanche modeling in Turkey (figure 14).

These softwares are generally provide solutions using 3D Digital Elevation Models prepared with high precision (high resolution) maps, using the finite volume method, which is generally based on the Voellmy model. However, avalanche modeling should be used carefully, because each software is a tool. When using these modeling softwares, it is necessary to introduce the following parameters to the system very precisely in order to achieve a healthy result.

- avalanche rapture / starting zone boundaries;
- avalanche depth at starting, flowing and stopping zones;
- snow density;
- Coulomb roughness (Friction) ($\mu$) and Turbulent drag ($\xi$) (m/s$^2$) coefficients.

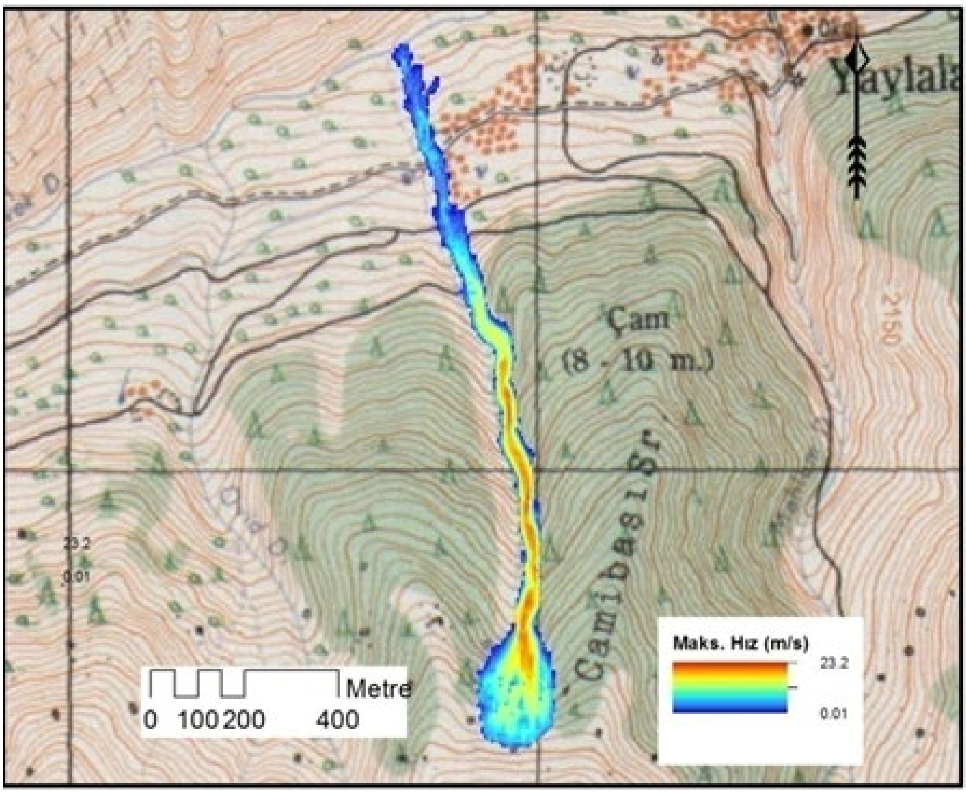


**Figure 14.** Yaylalar village (Yusufeli/Erzurum) ELBA+ 2D avalanche modeling (maximum velocity) [Uçar, 2014].

**Рисунок 14.** Деревня Яйлалар (Юсуфели/Эрзурум) ELBA+ 2D моделирование лавин (максимальная скорость) [Uçar, 2014].

Continous field observations and measurements should be made for the first three of these parameters. Calibration and verification of the roughness and drag coefficients are only possible by back-analyzing the observed avalanches. Modeling is completed by making use of the results of observations and modeling obtained by some researchers in the literature in regions where there are no observations and measurements in some projects in Turkey and the world. However, a 15% change in the μ coefficient causes a 10% change in the length of the avalanche flow path, while it causes a 50% change in the dynamic impact pressures [Barbolini et al., 2000].

## Avalanche maps

In order to determine the spatial distribution of the avalanche events in Turkey, since the beginning of the 1990s, "Avalanche Hazard Maps", which first show the limits of avalanches with various frequencies, then "Avalanche Risk Maps" and zoning, including the number of the people who may be affected and finally the economic analysis of each disaster, have been started.

***Avalanche Hazard Maps***

By using aerial photographs and 1/25 000 scale topographic maps, archive data, slope topographic features (slope, aspect, etc.), avalanche probability, vegetation and geomorphological data, all the areas with avalanche potential are marked. The avalanche routes are classified as possible avalanche path, definite avalanche path, flow line, probable flow line. This classification, used in Avalanche Hazard Maps, indicates the hazardous area with the magnitude of the hazard (figure 15).

***Avalanche Risk Maps***

More detailed numerical data and sensitive work are needed in the production of "Avalanche Risk Maps", to answer the questions such as: "What size the avalanche might be", "What areas it can affect to what extent", "How many people it can affect", "What pressure it will hit", etc. Avalanche risk maps are usually prepared in 1/5 000 or 1/1 000 scales in Turkey.

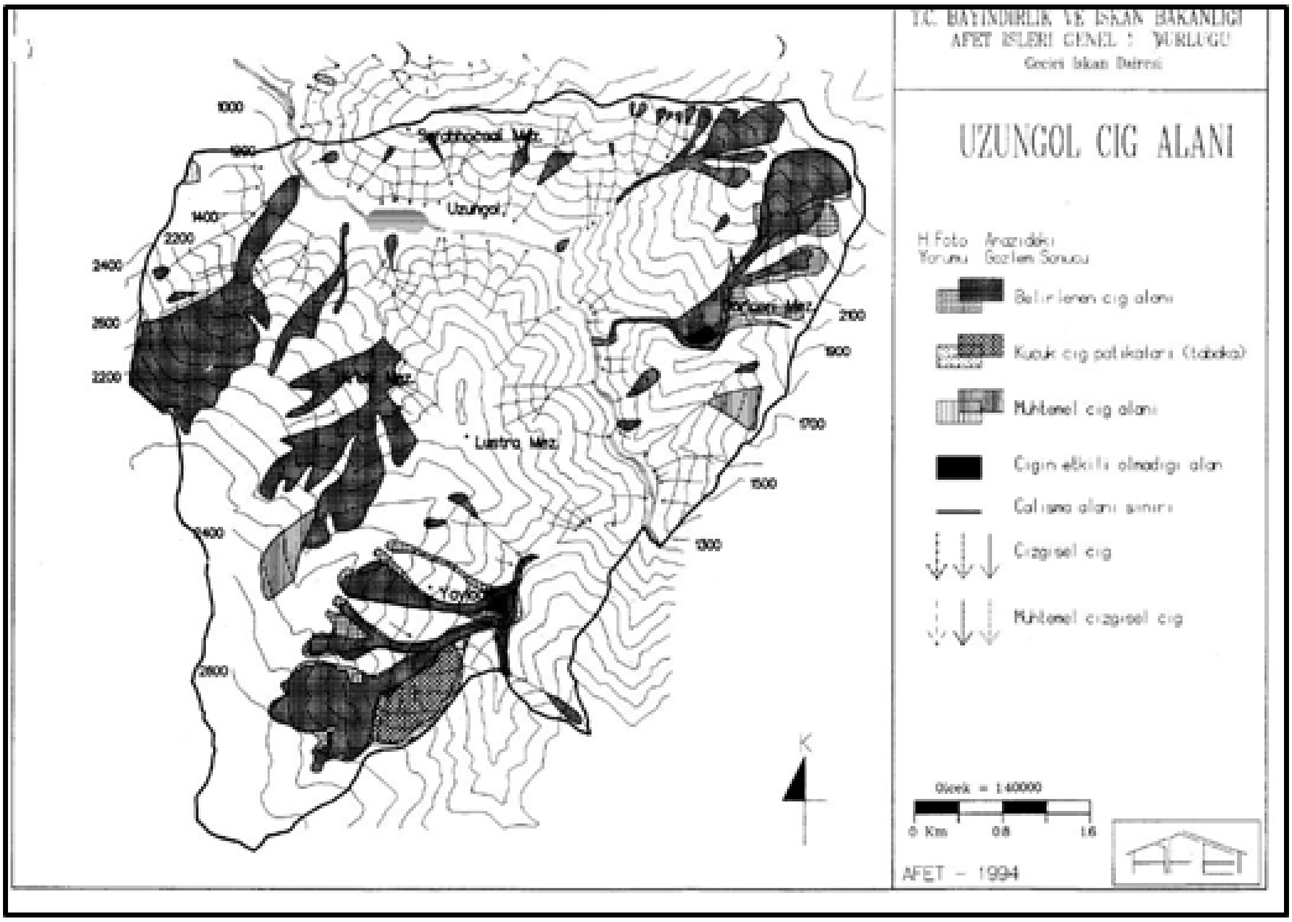


**Figure 15.** Avalanche Hazard Map [AFET, 1994].
**Рисунок 15.** Карта лавинной опасности [AFET, 1994].

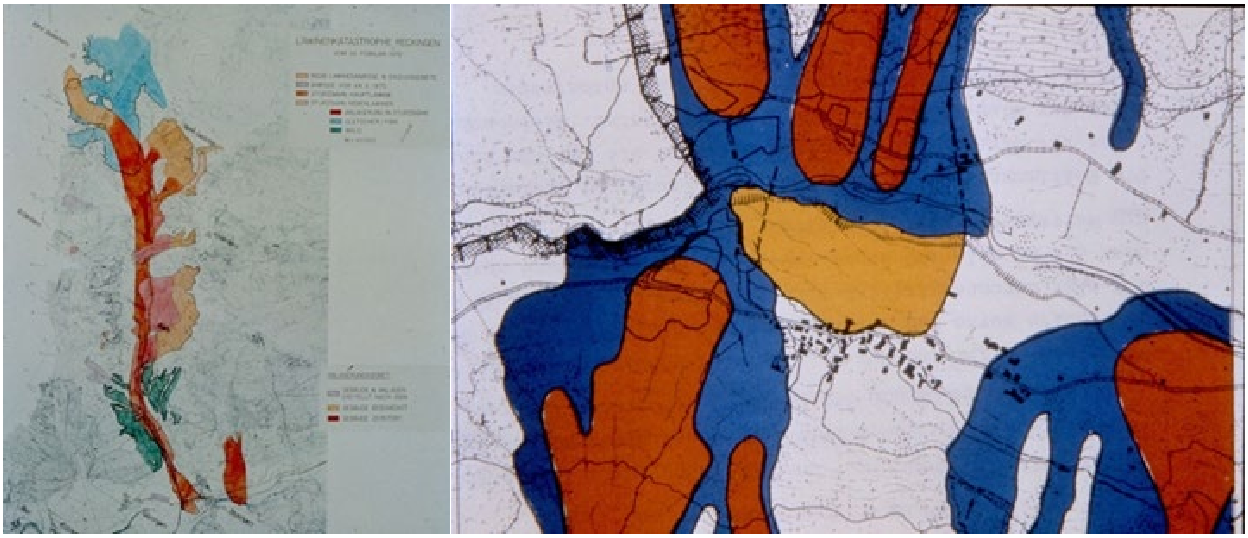

**Figure 16.** Avalanche Risk Map [SFISAR, 1992].
**Рисунок 16.** Карта лавинного риска [SFISAR, 1992].

Avalanche risk is defined in 3 different colors in the avalanche risk maps prepared by AFAD (formerly AFET) using the avalanche zoning method used in France (figure 16). The red zone is the areas where construction and residence are not allowed with very high avalanche risk; blue zone is the areas with moderate avalanche risk, where construction and residence are allowed, provided that precautions are taken; the white zone indicates areas where there is no avalanche risk and is used in regional planning studies [Yavaş, Şahin, 2007].

## Conclusion

Dealing with disasters is a job that requires sacrifice. One has to believe that he will survive in the fight and be successful in the struggle. Also, continuous state and public support is essential in dealing with natural disasters. To overcome the avalanche disaster all the related organizations; Ministry of Interior, Ministry of Environment, Urbanization and Climate Change, Ministry of Agriculture and Forestry and related general directorates; General Directorate of Meteorology (MGM), General Directorate of Forestry (OGM), Disaster and Emergency Management Presidency (AFAD), Research Units of Universities, TUBITAK, Local Administrations, Security Forces, Police Units and Non-Governmental Organizations working voluntarily on the subject (for example Search and Rescue Association-AKUT) – have to cooperate and work in harmony. Since each institution has its own founding laws and regulations, it may be necessary to come together and make certain decisions regarding compliance and cooperation in the event of major disasters. If a new structuring is decided, it may be difficult to gather all units under the same umbrella. If TUBITAK would be the umbrella institution, it may be easier to carry out research and application studies.

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