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Sinkholes and Agricultural Sustainability

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Abstract

Natural disasters are known as natural events that suddenly occur in a certain region on earth, create social stress, create significant losses on people and human settlements, and disrupt life in society. Sinkholes are considered a natural disaster that can cause serious damage to society and the environment. Such unpredictable geological disasters have the potential to cause irreversible damage, especially to settlements and agricultural areas. There are thousands of sinkholes in regions containing salt, gypsum and carbonate rocks in different parts of the world and the main factor that accelerates them is human activities. Disaster prevention and damage reduction policies can be developed with sinkhole risk assessment studies, and disaster-oriented planning can be made to reduce the damage caused by sinkholes. These natural events that occur beyond human control cause loss of life and property. Within the scope of this study, sinkholes, that are considered as an important component of natural disasters and whose numbers are increasing over the world, and agricultural sustainability are discussed.

Key Words: *Climate Change, Disaster management, Groundwater, Sinkhole susceptibility, Unconscious Agriculture*

Introduction

In general, a sinkhole can be defined as the collapse of underground cavities formed as a result of groundwater interacting with the soil, unable to carry the surface weight. Disasters are events that can occur due to natural or anthropogenic causes, affect people physically, socially or economically, stop or interrupt daily life, and cannot be dealt with by local means (AFAD, 2014). Sinkholes, which are karst landforms, are formed when rocks that can dissolve underground such as limestone (limestone, marl, gypsum, etc.) create cavities over time and the ceilings of these cavities collapse (Tapur and Bozyiğit, 2013). Karstification, unlike the external factors that form the surface (streams, glaciers, volcanoes, wind, coastal geomorphologies), develops similar to a large structure connected to each other both on the surface and underground (Anonymous, 2021). Sinkholes are expressed as "karst collapse areas" in another source (MTA, 2018). The main criteria in the formation of sinkholes are; While natural events such as geological, hydrogeological, tectonic and climatological occur, the main accelerating factor is human activities (Günay et al., 2010; Caló et al., 2017).

There are thousands of sinkholes with similar characteristics in regions containing salt, gypsum and carbonate rocks in different parts of the world. Carbonate rocks cover approximately 13.2% of the world's surface except for Antarctica and Greenland. When evaporitic rocks are included, more than 15% of the world's surface is covered with soluble rocks (Anonymous, 2018). In regions where carbonate rocks such as limestone, clayey limestone, marl, dolomitic limestone, dolomite, and evaporites such as gypsum and anhydrite are widespread in the event of interaction with water, the formation of karstic forms such as caves, dolines, lapias and sinkholes is a common geological and geomorphological event (Erol, 1990; Karadoğan, 2001). Since sinkholes are depressions caused by the dissolution of rocks generally composed from calcium carbonates likewise dolomite and also limestone on the surface, karstic rock areas are even more vulnerable than in other regions (Taheri et al., 2021). The widest mechanisms of crack formation are the unconsolidated alluvial basins, as the groundwater level drops, thinner shaped alluvium that is close to edge of basin experiences less compression and subsidence than the thicker shaped alluvium close to deeper, basin central part, besides stress resulting from discriminatory compression causes cracks to form in the overlying cover (Anderson, 1988).

That is a well known fact that formation of the sinkholes accelerates with the rapid decrease in groundwater as a result of excessive water withdrawal from wells (Subramani et al., 1983; Galloway et al., 1999; Yılmaz, 2010). In order to prevent unsustainable water use, it is important to modernize irrigation systems and correctly assess water system requirements. Minimizing problems such as over-irrigation and water insufficiency by ensuring that water is delivered to plants in the right amount and time by modernizing irrigation systems, and adopting conscious and sustainable practices in soil protection and management are important steps to reduce the formation of sinkholes (Ewaid et al., 2019; FAO, 2019). In this study, literature information on sinkholes was reviewed, cause-effect relationships were examined and recommendations were made.

Sinkholes and Agricultural Sustainability

Sinkholes are shaped owing to effects by natural hydrogeological, geological, structural geological in addition to geomorphologic situations. Sinkholes are defined as natural wells represented in karst lands (Bui et al., 2018). Karst formations refer to a land formed by dissolution of main rock besides the improvement of underground shaped drainage. For this reason, although they are primarily associated with limestone, they can also form on the other soluble rocks and carbonates (Waltham et al., 2005). In his technical study on sinkholes (Gutierrez, 2016), he generally justifies the implementation of preventive or compensatory risk reduction measures against these formations in economic and/or social contexts. By natural types geologic factors which give rise to formation for the sinkholes, lithological characteristics and geologic structure, climatic changes, drought factors, hydro-geologic characteristics cannot be controlled by humans, but one of the most important factors that can be controlled is water use (Göçmez et al., 2022). Sinkholes are quite common in all countries in Europe except Iceland, in the Mediterranean and oceanic countries of Africa, in Turkey, Lebanon, Palestine, Israel, Syria, Iraq and Iran in the Middle East, and in Afghanistan, Pakistan, India and China in Asia (Anonymous, 2024a; b). When the literature on sinkholes is examined, it is seen that the subject is more important at the geological and engineering levels, but the sociological importance of the situation is not evaluated in the context of climate crisis, drought and unconscious agricultural practices (Saa, 2022).

It is important to implement preventive planning and corrective measures in high priority risk areas. Anthropogenic factors such as land use, excessive groundwater use, well density, intensive agricultural activities, etc. increase the frequency of sinkhole formation in many places in the world (Galve et al., 2009; Ke, 2017; Wu, 2018). In this study, the researcher stated three main issues that need to be changed by the laws. The mentioned laws are; re-definition for sinkholes, definition for structure based damages and improvement of quality for the underground research (Zisman, 2013). Sinkhole formations can destroy buildings, roads or railways, causing these structures to collapse and high material losses (Xua et al., 2017). As another result that is revealed by the study (Ciantia, 2023), the disintegration in the ground could trigger collapse over time. It was also stated that following the displacement over time in rocks with this type of disintegration is a method that should be used to calculate the safety life of the structure.

It is expected that sinkholes might be occurred in future welded by same or similar conditions as they occurred in the past, and sinkhole inventory maps are used as a basis in defining the hazard areas and creating hazard maps according to this principle (Orhan et al., 2020). In their research (Sahu et al., 2015), they investigated the collapses that occur in the ground and their causes. They stated that collapses are usually caused by underground mines or sinkholes. They stated the factors affecting the collapse as the working techniques performed in underground mining, adjacent working areas, depth of the work, presence of geological deformations, stresses in the ground, surface topography, decreases in groundwater, precipitation and earthquakes. Since the sinkholes formed in the regions where soluble rocks are located have a continuously collapsing structure, the collapses might be monitored based on the surface. Due to suddenly collapses are not expected by those sinkholes, it is possible to develop monitoring and early warning systems for the people living on them and take precautions against the dangers. The inability to fully detect underground structures such as artificial and natural cavities, groundwater or natural caves causes sudden formation of sinkholes of different sizes and shapes and thus increases the extent of environmental damage (Gutiérrez et al., 2014; 2016). Researchers (Nam and Kim, 2017) stated that they are generally studied from a geological perspective, but engineering solutions for sinkholes are still insufficient, and large collapse sinkholes that may occur in metropolises and cities will pose a very serious threat. Considering the difficulties and dangers related to sinkholes, researchers stated that there is still a lack of geotechnical understanding and methods related to sinkholes and that they are insufficient to measure cost-effective repair methods and technologies for sinkholes.

In the literature, studies on the creation of susceptibility maps for many disasters such as landslides, floods, avalanches, fires have been successfully applied (Malczewski, 2006; Abedi et al., 2021; Iban and A. Sekertekin, 2022; Varol, 2022). Subsurface-based soil erosion throughout a crack trace acts the role for opening, widening besides subsequently development of crack channels (Carpenter and Bradley, 1986). Researchers (Gutiérrez et al., 2009) emphasized that conducting trench-opening examinations in settlements against sinkhole risks is cheaper, more reliable and important in reaching detailed information. In their study (Caudron et al., 2006), they analyzed how the soil and structure interactions will be during of the sinkhole event by quite small-scaled model using a 2-dimensionals ground with the building model. In their study, the researchers stated that considering the ground-structure interactions during the presence of a sinkhole or similar hazard can be very cost-effective. In particular, the effect of human activities on the formation of sinkholes is considerable. The dissolution of calcareous rocks by underground water leads to the formation of sinkholes (Shalev et al., 2006). In their study (Zisman et al., 2009), they investigated the damages in structures caused by sinkholes. They stated that in order to determine the source of the cracks that occur, it is necessary to examine the displacement along the cracks, the geometry and movement of the building.

Financial based costs for deal with conclusions for sinkholes are quite often (Kuniansky et al., 2015). One of the most important points for risk evaluation and management of disasters such as sinkholes is the creation from susceptible maps which predicts besides presenting the spatial probability for the future based disaster (Pradhan et al., 2011; Elmahdy et al., 2020). As reported in a study (Fritz, 1961), disasters provide an opportunity for the restoration of social order, and this reconstruction process can increase community solidarity and mutual assistance. Accurate estimation of crop water requirements is important in agricultural irrigation management to prevent water wastage and to increase agricultural productivity. Accurate estimation of water volumes to be supplied to irrigated areas has the potential to decreasing of risk on water scarcity as well as to guarantee the sustainable usage of the water resources (Todorovic, 2005).

Conclusions

Sinkholes, which are considered as one of the important disaster types, cause seriously security-related affairs in the sites where they appeared. Today, the problems about question are seen on the areas where the basic components likewise a gradual reduce in underground water resource, intensively agriculture based activities carried out devoid of considering climate based features, and the existing geological structures in the regions at risk are risky for the formation of sinkholes. Sinkholes are structures that are considered aspect of nature based disasters and their numbers have been increasing in recent years around the world.

Sinkholes are considered a natural disaster that can cause serious damage to society and the environment. People not using the right methods when using nature and not giving enough importance to sustainability issues can cause natural disasters and have negative social consequences. In addition to human activities, climate and geological events are other factors that affect karst formation. It is of critical importance to educate and raise awareness of people living in places with sinkhole risk and those engaged in agricultural activities, to conduct studies through cooperation, to monitor underground water resources and manage them consciously, and to ensure that natural resources are used in accordance with sustainability principles.

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