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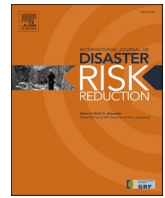
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Detection of disaster-prone vernacular heritage sites at district scale: The case of Fındıklı in Rize, Turkey

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ABSTRACT

The district of Fındıklı in the Northeast city of Rize in Turkey is environmentally and culturally rich with its rural, built, and natural heritage. The city of Rize has been experiencing more frequent and severe rainfall, flooding, and landslides in the last decade. River flooding along the coast and in the center of the city is destroying infrastructure and residential areas, while landslides are becoming more destructive and repetitive in the hinterland of the district. Vernacular heritage is particularly exposed to the catastrophic consequences of floods and landslides, e.g., through the deterioration of historic building façades. This paper aims to identify the vernacular settlements under the threat of natural disasters in the selected case area. ArcGIS software was used to reveal the changes in spatial planning since 1969 in combination with geo referenced built and natural heritage sites at risk in the district. The comparison between the maps of 1969 and 2019 aerial pictures on ArcGIS illustrates the river transformation, coastal change, urban sprawl, and deforestation as threats to vernacular heritage in the area. Furthermore, this paper will highlight landslide-prone sites in the hinterland and river floods on the coastal area on the current map to show heritage sites at risk. The findings of this study intend to present the accelerated effects of floods and landslides along with the mismanagement of land use and rivers on vernacular heritage at a district scale to inform decision- and policymakers on needed actions.

1. Introduction

Natural and anthropic pressures, which are enhanced by climate-induced factors, are threatening cultural heritage sites [1,2]. Climate change impacts on rising temperatures, precipitation levels, humidity, and wind has been an emerging topic in the cultural heritage sector as its effects are impacting many forms of cultural heritage including tangible (built) heritage [3], e.g., cultural landscapes, archaeological sites, monuments, buildings, objects, intangible heritage, and natural heritage properties. Climate-induced impacts such as sea-level rise [4], extreme rainfalls [5], storm surges [5], flooding [6], landslides [7], gully erosion [8], and multi-hazard threats [9] have already been observed in many cultural heritage sites [10], which caused structural damage, displacement, and loss of lands and traditional local knowledge [11]. Depending on the location, the impacts of climate change and disasters on cultural heritage sites differ. Therefore, it is significant to address these impacts on cultural heritage at local and regional scales explicitly to implement adaptive and flexible strategies at national and global levels [12]. This paper considers flooding and landslides as responses to natural and

anthropic activities impacting the environmental situation of the selected case area.

Impacts of climate change on cultural heritage have been intensively discussed by many scholars, particularly in the context of World Heritage Sites [13–16]. Much of the existing literature focuses on identifying the vulnerabilities of World Heritage Sites under changing climate by using GIS software [16] to highlight coastal hazards [17], floods, and landslides due to heavy rain [18], whereas little attention is given to nationally and locally listed or unlisted cultural heritage [19], particularly when it comes to vernacular built heritage. One reason behind this situation is a lack of complete documentation on this vernacular built heritage [20] and recognition of the historical significance and value of it, particularly in the context of developing countries. In addition, vernacular built heritage, in most cases, is not protected or listed, so it is therefore difficult to detect the implications of changing climate on these buildings at a local scale.

The built vernacular heritage—at the intersection of cultural, natural, and intangible heritage—is recognized as a part of cultural landscapes with its generational cultural practices, traditional construction

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systems, and crafts [21]. Vernacular settlements were built in specific physical, social, economic, and cultural conditions by local people relying on techniques passed on by previous generations. Vernacular sites are mostly encountered in rural areas, though they can also be part of urban areas. Vernacular built heritage reflects the pre-industrial period of living; thus, although the heritage and the lifestyle were abandoned, they still hold significance for some local people. Rural populations, comprised of land and homeowners, still live in these types of settlements. Despite its local unpopularity, vernacular built heritage attracts tourists interested in rural destinations and activities, such as hiking and camping, and provides employment, such as artisanship, for local people [22].

Vernacular built heritage is widely considered to be resilient and sustainable [23]. Its historical value, integrity, and significance can be adversely affected by exposure to changing and extreme climate conditions [24]. For example, maladaptation, loss of heritage, and traditional knowledge are among such deteriorations. Another implication of these events can be climate migration with increasing displacement of agriculture-driven communities from rural to urban areas [25]. Imbalance in economic investments and benefits between cities and rural areas already triggered the depopulation of hinterland globally. Rural populations, particularly in mountain valleys, are already susceptible to slow onset events like desertification, land and forest degradation, increasing temperatures, crop failures, threats on livestock, and abandonment [26].

There are several threats to vernacular sites that are not being considered in larger spatial/regional planning efforts. The aim of this paper is to identify vulnerable vernacular built and natural heritage sites in the hinterland of Fındıklı in Rize, Turkey, which are threatened by floods and landslides. The location of vernacular heritage sites was pinpointed from archival sources and literature and the changes in land use were investigated by geo-referencing historical maps on contemporary satellite images through ArcGIS. The findings of this paper will highlight river corrections and deforestation as worsening the risks of flood and landslide disasters in the traditional vernacular landscapes of Fındıklı in Rize. The results will present these issues in order to improve policies on disaster management of the vernacular landscapes and related heritage. The objective is to inform decision- and policymakers about the site-specific climate-induced and anthropic pressures on cultural heritage sites and incorporate that knowledge into local and regional climate action plans. The method used and later explained in this paper of identifying the issues and site-specific solutions can be transferred to vernacular built heritage in other locations with a similar approach.

1.1. Literature on land use/cover changes in the city of rize

Changes in land use and land cover along with other natural and anthropic pressures resulted in environmental disasters such as flooding and landslides [27]. Recurring floods and landslides cause extensive damages to regional economies, such as from loss of properties and facilities, in addition to loss of human lives in the East Black Sea region [28,29]. In Turkey, the city of Rize receives the highest levels of humidity and precipitation, which has a major influence over the concurrent events of floods [30] and landslides. Although geographical, topographical, and climatological factors in the area contributed to the formation of the landscapes, climate-induced and anthropic pressures accelerated the disasters and their impacts on the built environment. Anthropic pressures, including deforestation, changes in land-use, consumption habits, population growth, and urbanization, played a significant role in increasing natural disasters. Existing literature regarding the case city heavily focuses on the assessments of land-use/cover and vegetation in relation to the landslides by using GIS separately from the studies on flooding.

In the literature, GIS software was commonly used to map areas prone to landslides by using aerial photographs from 1973 to 2002

based on the landslide conditioning factors of lithology, slope gradient, slope aspect, vegetation cover, land class, climate, rainfall, and proximity to roads [31]. Similarly, landslide susceptibility maps [32] were prepared by combining GIS software with remote sensing methods [27]. Two landslide inventory maps of the study area, which were created in GIS, suggested that 109 landslides were identified in 1983, with ten additional landslides in 1995 [32]. Studies reveal landslide locations with associated factors proving their contribution to the occurrence of the events [33].

Furthermore, land use/cover changes between 1976 and 2000 were analyzed by using remote sensing and GIS with the integration of LANDSAT images to depict the transformation in the land cover as a result of deforestation on larger scales [34]. According to the study, it was discovered that the farmland area (mostly fields of green tea) was increased to approximately 13,700 ha whereas forested area was decreased to approximately 12,100 ha [27]. Land use mapping of tea croplands with the use of GIS-based Land Parcel Identification System suggested a better enforcement of the policies and legislations in tea agricultural development [35].

Remote sensing, GIS, and in-situ techniques identified “Green Corridors” in the coastal cities of Trabzon and Rize. These corridors are green spaces with ecological, recreational, and cultural purposes and value [36]. Although the city of Rize is known for its abundant green areas, the study revealed the fragmentation of the corridors in the city due to rapid urbanization [36]. A study analyzed the phenomenon of the landscape fragmentation using Digital Elevation Model (DEM) and GIS to analyze the landscape characteristics of the city [37]. It suggested that the annual income from tea plantations catalyzed urbanization, thus resulting in the changes on the coastal landscape [37].

The extensive studies on land use and cover and changes of cultural landscapes of Rize produced both qualitative and quantitative measures and analysis. One study examined the components of the cultural landscape of Rize, e.g., roads, urban settlements, buildings, rivers, forests, and farmlands, through the analysis of the historical aerial photographs from 1955, 1989, and 2009 in GIS in combination with face to face interviews with relevant stakeholders [38]. A rehabilitation project of 164,222 ha of forested area conducted in the region between 2003 and 2016 revealed that the city of Rize was the least to benefit from it [39]. Therefore, there is a need to update the land cover and land use information of the city in order to understand future implications of climate change and disruptions to the water sources [39]. Meteorological data from the observation stations show that the trend of increasing precipitation and humidity will likely increase the severity and frequency of flooding and landslides in the city of Rize [40]. Studies demonstrated a need for participatory approaches to achieve a climate-responsive development and overcome the local challenges of urbanization, human related issues, and tea production [41].

<https://elsevier.proofcentral.com/en-us/landing-page.html?token=c8526b880d02182f89c350bf17c15a> 2007 in combination with GIS and FRAGSTATS™ [42]. By using the scattering technique with Sentinel-1 SAR data, land reclamation was detected and monitored mainly on the city center and one rural area [43]. An increase in the number of buildings in Ayder plateau in the city of Rize was emphasized through the use of the maps from 1974, 1989, and 2008 to demonstrate that tourism also contributed to the urbanization of rural areas [44]. Many of these examples quantify the landslides and their susceptibilities along with changes in land-use/cover, vegetation, tea plantation area, and coastal developments without considering the implications of these changes on the vernacular heritage in the hinterland. There are, as of yet, no studies that detect the risk-prone cultural heritage sites and link it to changes in land use and river transformations in the selected case area.

The vernacular heritage, including natural, tangible and intangible aspects, in Fındıklı is under the threat of rapid landscape changes with expanding monoculture of tea plantation and regional development plans, such as the construction of hydroelectrical power plants [45].

Inland areas were altered by anthropic changes with the cultivation of tea crops, hazelnut, and corn fields, which enhance the consequences of climate change. The residents' agricultural activities are contributing to the land degradation, which affects cultural and natural heritage. However, national and regional projects have more impact on the land. Identification of vernacular heritage sites that are prone to direct and indirect impacts of flooding and landslides can fill the gaps in the official datasets of relevant stakeholders, scientific articles, and policy recommendations on the management of heritage sites.

2. Description of the case study area

The study area covers part of the district of Fındıklı in the province of Rize, located in the northeast part of the Black Sea Region in Turkey (Fig. 1). The borders of the Fındıklı district of Rize are drawn at $41^{\circ} 16' 28''$ North latitude and $41^{\circ} 9' 3''$ East longitude. The district has a population of 16,678 [46] and covers an area of 409 km² [47]. Two reasons behind the selection of the case study area are: (1) the province of Rize

experiences frequent and severe floods and landslides [48] and (2) Fındıklı is rich in vernacular and natural heritage [49].

The city of Rize is located within the Kaçkar Mountains, with a highest elevation of 3,937 m, with the high range of mountains and hills losing elevation toward the south of Fındıklı [50]. Fındıklı has 31 villages and neighborhoods in which many settlements are scattered and sparse in the hinterland. Fındıklı has river plains and valleys that were formed by the main three rivers of, from west to east, Arılı, Çağlayan, and Sümer.

This topography and the proximity to the sea contribute to a rapidly changing climate, with high levels of precipitation and intense, seasonal river flows. The province of Rize receives the highest precipitation of any province in Turkey, with an average annual precipitation of 231 mm [51].

Due to the steep terrain and narrow strip of coast, arable lands are quite limited. The local economy of the district of Fındıklı primarily relies on tea and hazelnut cultivation, as well as on fruit farming, fisheries, beekeeping, and livestock cultivation. There are many tea



Fig. 1. The boundaries of the district of Fındıklı and the city of Rize in Turkey. Fındıklı is one of the twelve districts of the city of Rize.

factories in the city of Rize, while in Fındıklı, tea is cultivated by small land holders. Among all the agricultural activities, the tea plantation has become an especially important economic income as the city of Rize alone meets the tea demand of the country. The plantation was introduced to the area to solve the issues of unemployment, migration, and economic downturn [52]. After its introduction in 1924, the tea plantation became the main source of income for locals.

Fındıklı in Rize is rich with vernacular built heritage, such as mosques, stone bridges, traditional stone-infilled timber houses (Fig. 2), mills, barns, kilns, and archaeological sites; natural heritage, such as waterfalls, plateaus, and forests; and intangible heritage, such as timber artisanship, stone masonry, coppersmithing, basket making, weaving, hawk eagle raising, and corn bread making, in addition to other representations of the area's food culture [53]. The coastline settlements are more densely populated except during the summer months, especially July and August, when the population migrates toward higher plateaus for agricultural activities and animal breeding [54].

The conservation of cultural heritage in Turkey is based on a law (decision number 2863 of July 21, 1983, "Kültür ve Tabiat Varlıklarını Koruma Kanunu"). Based on this rule, the Regional Board Directorate for Protection of Cultural Heritage in Trabzon lists the vernacular buildings according to conservation status. The 1st degree listed buildings are usually grand mansions and buildings, whereas the village houses are listed as 2nd degree [55]. The exterior and interior of the first-degree buildings are protected, whereas the building owners can modify the interior of their buildings when listed as 2nd degree. If the vernacular building is not designated, the destruction and damage of the building does not legally bind the building owner [55].

The rural heritage in this area is referred to as vernacular heritage since it is a result of local adaptation in building practices to the climate, topography, and culture. These privately-owned buildings and historically important settlements not only represent the identity of the area and its intangible values but also bring economic benefit for the local community. Vernacular houses are—even though they survived

approximately 250 years—particularly vulnerable to changing climate along with other pressures, such as economic development, decline in rural population, and abandonment [56]. These vulnerabilities manifest in the loss of knowledge in local construction materials and techniques used at the time of their creation. For example, the increase in humidity and precipitation causes timber to decay faster while excessive rain-water damages roof structures. As part of a broader ongoing project of the author, interviews with locals revealed that eight people mentioned the detrimental impacts of climate change on vernacular heritage whereas six interviewees out of fourteen [57] experienced damages to their buildings, e.g., façade deterioration, loss and damage of storage houses, and building materials. Though the locals mentioned the resilience of the historic buildings, they also emphasized their vulnerabilities to the changing environment and climate. However, changing maintenance regimes and the use of concrete in the renovation of the historic buildings is disrupting their structural behavior.

3. Materials and methods

3.1. Materials

ArcGIS software, along with archival sources, historical records, images, and maps, can reveal disappearing heritage sites [58] and sites under threat. Historical maps contribute significantly to monitoring of changes in land use [59,60] and natural changes (e.g., floods and land erosion) [8,61]. The data gathered from historical maps offer reliable sources for the disaster risk assessment of cultural heritage [62] and management of these sites [59]. Past traditional landscapes can be traced through historic maps, images, aerial photographs, cadastral, and military maps, though their distortion in ArcGIS is difficult to quantify and rectify even with a diversity of control points [63]. However, the data regarding the floods, landslides, and locations of heritage sites in rural areas are usually inconsistent and vary depending on the inventories of different institutions. The aerial photographs used in this



Fig. 2. Typical vernacular heritage in the region with (a) stone-infilled timber mansion, (b) timber house and storage houses, (c) timber mosque, and (d) stone bridge.

paper were obtained from the General Directorate of Mapping (HGM Turkey) [64].

The aerial photos, which were selected from the district of Fındıklı in Rize, were taken in 1956, 1959, 1969, 1970, 1973, 1975, 1982, 1989, and 2002. The oldest aerial photograph in the archives of the institute, dating back to 1956, was not used due to its low resolution and its scale of 1/60.000. Furthermore, many of these photos focus on the coastal part of Fındıklı. In a similar study, these maps were slightly offset from the base map [65]. Thus, the aerial photo of 1969 in TIF format is used as it includes the inland areas with the majority of the built and natural heritage sites. The data on vernacular and natural heritage sites on both historical maps of 1969 and 2019 were combined with the data on flooding, landslide, and disaster-prone areas obtained from different institutions (Table 1). The main indicators of river correction, coastal change, urban sprawl, and deforestation in the past 50 years were analyzed through the overlapping of the two maps in ArcGIS 10.6.

3.2. Methods

The aerial photographs are not coordinated. These photos are monochrome, and their quality depends on the altitude and performance of the camera, the weather, and technological conditions on that date, as well as on the photographic processing of negatives and their scanning. For the scope of this research, the data were obtained from several national, regional, and local institutions to crosscheck accuracy and precision. Additionally, the aerial image dates back to 1969 in the scale of 1/30.000 and as such experienced some deteriorations and loss of visibility. A few parts of the aerial image were damaged, and the quality of the contrast was an obstacle to the accurate mapping of buildings.

Moreover, the shape files of flooded and eroded areas in Fındıklı in Rize were obtained from the General Directorate of Hydraulic Works (DSI), while files related to disaster-prone areas were collected from the Ministry of Interior Disaster and Emergency Management Presidency (AFAD). The polygons representing disaster prone areas were historically recorded by AFAD. The data on the landslides from DSI were combined with the data on the disaster landslide prone areas from AFAD, as the data from the two institutions overlap in some areas. The data for this paper is from both institutes, although the data from the AFAD is an updated documentation of the landslide areas. In addition, the landslide areas were overlapping with the map provided by the General Directorate of Mineral Research and Exploration [66].

Furthermore, names and locations of the natural and built heritage of Fındıklı in Rize were collected from two different sources: (1) the document of the Rize Provincial Ministry of Culture and Tourism [49] and (2) the Eastern Black Sea Development Agency (DOKAP) project of Black Sea Culture Inventory known as “Karadeniz Kültür Envanteri” [67]. The data from the DOKAP project is a more recent documentation of the historic sites, which includes museums and cultural and natural heritage sites, while the document of the ministry only includes the historic mansions [49]. Thus, the data used in this paper primarily rely

on information from the DOKAP project [67]. The geographical locations of 85 vernacular buildings and six natural heritage sites were entered in a Microsoft Excel spreadsheet in the format of longitude and latitude. Then, the spreadsheet was imported into ArcGIS to identify the exact locations of the heritage sites on the maps. Due to the boundaries of the historic map, only 58 vernacular buildings and one natural heritage site were included in the analysis. These layers were digitized using TUREF TM 42 as its projection. The forward-inverse residual shows that the total value of RMS error is 0.0782363. Vernacular heritage predated the first aerial picture since it was built, in some cases, 300 years ago, thus appearing on both past and present aerial images.

The Regional Board Directorate for Protection of Cultural Heritage in Trabzon is the public agency responsible for the identification, designation, and documentation of the cultural and natural heritage sites of Rize. However, the inventories of vernacular heritage in the area are often outdated, incomplete, and inconstant and they do not give a precise image of the existing historic sites through being digitized. There are more than 150 vernacular houses scattered into, sometimes, inaccessible lands in the hinterland. Every institution has a variety of different inventories, e.g., DOKAP and Kültür Envanter Atlası [68], and the conservation office in Trabzon. As the identified sites in the spreadsheet rely on the aforementioned institution, it may not reflect the complete information about existing vernacular heritage in the district.

The aerial photograph of 1969 has been rotated, georectified, and adjusted to overlap the aerial and satellite image of 2019, according to points that have not changed over the 50 years. The border of the case area, within the district of Fındıklı, is determined according to the rotated aerial image of 1969. Thus, the Sümer River of Fındıklı was left out of the map as it includes a few cultural heritage sites according to the inventory of the Black Sea of DOKAP project. The data outside of these borders were not involved in the analysis. In order to maintain consistency, each set of data was analyzed within the borders of the oldest picture.

Once the old image was geo-rectified reasonably well by adding control points in reference to the 2019 map, polygon features were used to illustrate the elements analyzed for the purpose of this study. With this approach, a line feature was created for the coastline and a polygon was used for the main rivers and deforested areas, whereas buildings were illustrated using symbols. The flow diagram highlights the steps taken for the methodology of this paper (Fig. 3). The line feature for the coastline and polygons for rivers represent the modifications on the rivers and coastline. The buildings constructed in 1969 and 2019 were counted in ArcGIS. While deforested areas were clearly visible on the current map, the white patches in the forestry map from 1969 were accepted as the deforested sites. However, the black and white aerial image from that year made it difficult to identify them. The white patches were understood as recent deforestation where nature did not have time to regrow. The vernacular sites located on or nearby the landslide-prone areas were determined to be threatened. Through estimation of the composition of the surface squares of the patches, the extent of the deforestation was measured over a period of 50 years. Through this process, an overview of vernacular sites at risk of flooding and from landslides was displayed at a local scale. GIS-based methods can be used as a source for generating risk assessment maps of cultural and natural heritage sites in the area and beyond.

4. Analysis

4.1. River correction and coastal change

The records on the flooding of the major rivers of Fındıklı, Abu (Çağlayan) and Arılı, date back to 1974, according to the Watershed Management in the General Directorate of State Hydraulic Works [69]. Records indicate that 24 flood events affected the village of Çağlayan in Fındıklı in June 2002 [69] and 23 river flooding events were observed in September 2012. Historically, over the past 46 years, the district of

Table 1
The details of the data used in this paper.

Data	Year	Source
Aerial photo	1969	HGM Turkey ^a
Flooding	2019	DSI
Landslides	2019	DSI
Disaster prone areas	2019	AFAD
Natural heritage	2019	https://karadeniz.gov.tr/harita/https://karadeniz.gov.tr/harita/
Built heritage	2019	https://karadeniz.gov.tr/harita/https://karadeniz.gov.tr/harita/
Imagery basemap	2019	ArcGIS World Imagery

^a The General Directorate of Mapping <https://geoportal.harita.gov.tr/>.

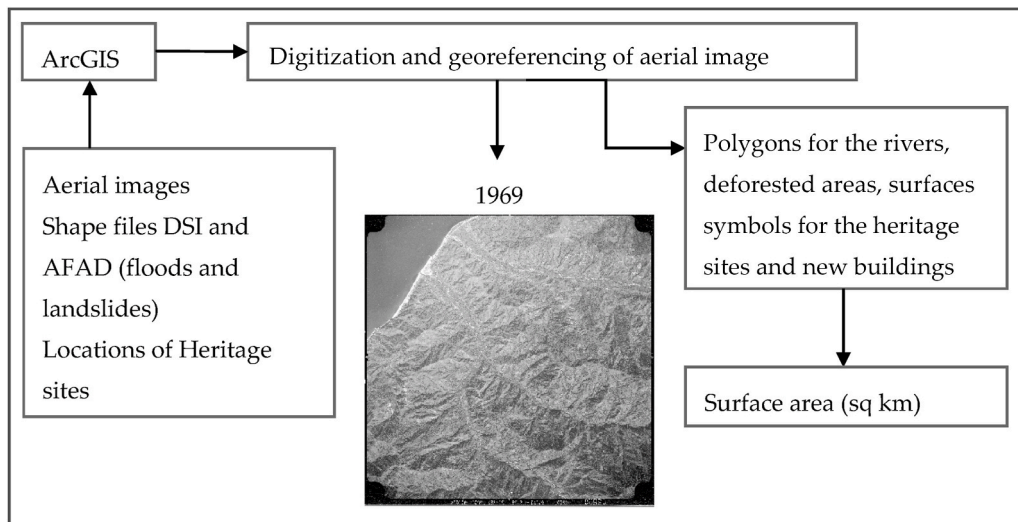


Fig. 3. Flow diagram of the methodology used in this study.

Fındıklı of Rize has been experiencing river flooding and landslides subsequently in the months of June and September. As a result, people lost their lives, many villages were evacuated [70], and buildings were damaged, including historically important structures.

The Çağlayan and Arılı valleys, which were designated as 1st degree natural sites in 2008 [71], are now listed as important sites to protect (decision number 29959 of October 25, 2017, “Doğal Sit Alanları Koruma ve Kullanma Koşulları İlke Kararı”). Due to their vulnerabilities and exposure to natural risks, these areas must be preserved. Thus, the 2017 decision does not allow any intervention to the ecological integrity of the area. However, the rivers of Fındıklı are under the threat of land reclamation and construction of water dams. A hydroelectrical power plant (HES) is planned for the Solarez riverbed along the Çağlayan River. The construction of a water dam in this area will likely exacerbate the

current issues of river flooding.

Increases in precipitation, rainfall, and humidity in recent years have accelerated the frequency and severity of the river flooding [28]. Yet, heavy rainfalls, which inundate the valley, may not be the only reason behind overflowing rivers. Riverine areas are also exposed to anthropic pressure and local scale modifications to rivers may influence the up- and downstream fluvial processes [72]. Often, the alterations of the rivers cause imbalances in water flow and velocity. For instance, through the enlargement of the water channels and the increase in the diversity of cross-sections where stream restoration is limited, the velocity of the river flow and discharge capacity of the river will be more natural. These river plains are now exposed to major developments of infrastructure and new buildings supported by policies opening these areas to construction.

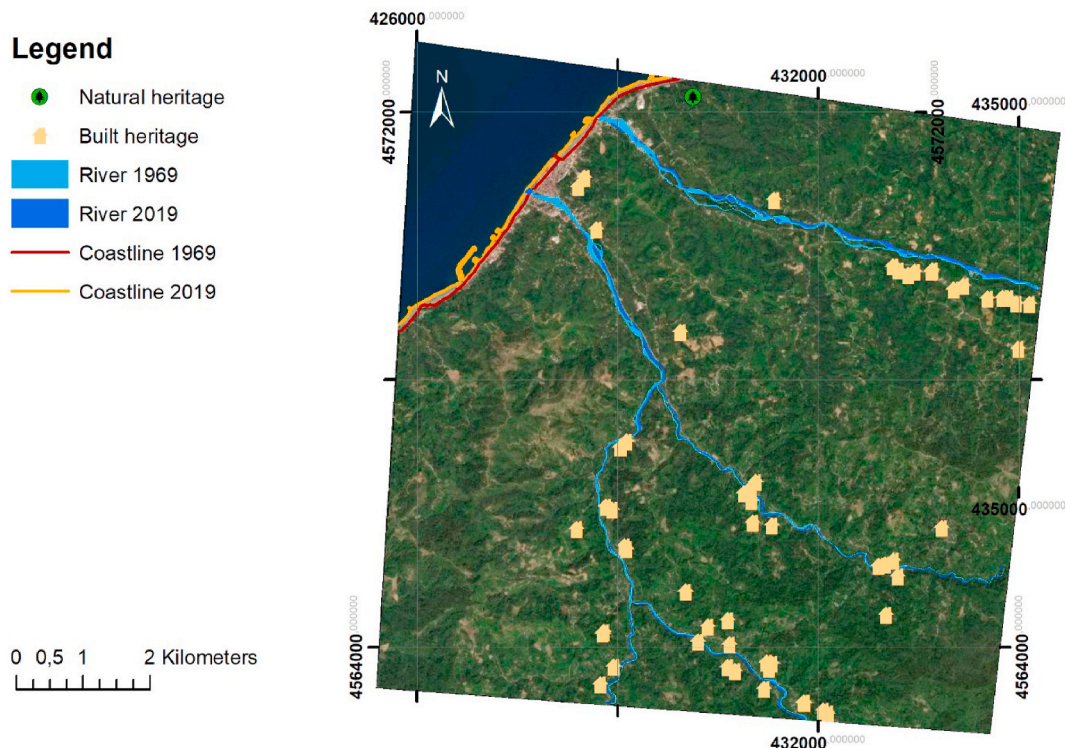


Fig. 4. An image of the coastline and major rivers of Fındıklı, Arılı, and Çağlayan, along with the locations of natural and built heritage sites in 1969 and 2019.

Since 1969, there have been major interventions to the rivers of Çağlayan and Arılı. In 1969, the riverbeds of Arılı and Çağlayan were wide enough to accommodate sudden fluctuations and changes in the natural flow of the rivers (Fig. 4). Later, both rivers expanded toward the sea to form estuaries. The river flow was levelled by the converging tributaries in 1969, and were merged and realigned with the downstream channel in 2019. However, the morphology of Arılı has been slightly modified on two diverging streams.

The river of Çağlayan used to have diverging tributaries—comprising a large watershed—that have been substantially realigned and corrected (Fig. 4). According to the map, the division of the streams was altered completely by keeping a straight channel, which increased the pressure of the water flow. One implication of this was a densification of flood plains, which eventually put the nearby newly built houses at risk of river flooding. Concrete buildings with many floors were constructed near the riverbeds where the urban densification increased. The major reason behind the river flooding, according to DSI reports, was the discarding of rubble into the riverbeds during the construction of the new houses. This led to the blocking of the water flow, particularly in curves and under bridges. Although this is also an important factor to consider, the influence of extreme shifts in channel shape cannot be overlooked.

The riverbeds of Çağlayan were branching out and widening to a larger area where only one vernacular house is located. Unlike its 1969 shape, today the river flows rather straight, allowing access to cars via bridges and roads along the river. The site selection of vernacular houses was not arbitrary, since they were built far from river flood plains. However, in 2019, the river was narrowed by concrete walls to allow the construction of new houses along the river. This increased the vulnerabilities of the vernacular houses along the river by changing the location of flood-prone areas—thus placing the previously safe structures in the path of flooding. Furthermore, the alteration led to the destruction of many newly built houses on both sides of the river where the river modification was major.

The infilling project of the coastline of the Black Sea, known as Karadeniz Sahil Yolu (Black Sea Seaside Highway) (Fig. 5), connects the coastal cities of the Black Sea region in Turkey [73]. Although the highway officially opened in 2007, the foundation of this infrastructure was initiated by Russians after their invasion of the city of Rize in 1916 during the Ottoman Empire period, with the opening of a one-way road. The construction of the highway not only obstructed the sea access of local residents but also caused the destruction of historically important coastal settlements. As part of this project, the city grew toward the sea

and rocks were used to claim new lands. A new coastline was created to support the creation of additional public spaces [73].

On this new territory, the maps reveal the extension of harbor facilities with new seawalls along the coast. The erosion of rocks underneath the infrastructure has become an issue of land reclamation in the coastal area of Rize [43]. Coastal planning and developments along with river modifications increased the risks of flooding on coastal lowlands and riverine areas. Both coastal and inland flooding are affecting the surrounding settlements and infrastructure. Although the geographical location of the vernacular heritage in the hinterland seems to be far from these developments, the pressure of the coastal and central area are reflected on the hinterland, as a result of construction in the hinterland due to land scarcity on the coast and the drastic reduction of the riverbed to allow urbanization.

4.2. Deforestation

The mismanagement of wood resources in rural areas is an important phenomenon to analyze, since deforestation is not the only consequence. The disappearance of local forests is also affecting biodiversity, which protects other resources and many livelihoods. In the rural area of Fındıklı, the urban expansion started in 1969. Forests in Fındıklı have been exploited since the 19th century, because timber was used as a means for trading. Chestnut timber was commonly used for the construction and furnishings of the vernacular houses. In the 1969 map, there were 871 buildings, excluding the historic buildings in the area (Fig. 5), whereas in 2019 the number of newly built houses rose to 3,227. Along with the growth of sparsely populated areas, planned and unplanned large-scale clearings took place, especially in forests. However, as the increasing number of houses went hand in hand with an increasing demand in wood, the depletion of forest areas grew in scale.

Vernacular house owners who also hold private land ownership of small-scale tea, hazelnut, and vegetable gardens deforested small areas to open roadways for their vehicles and grow crops. Aside from the local agricultural activities, economic and political benefit in the area also played a significant role in the deforestation.

However, the great deforestation of vast expanses of forests started with the sale of forests at auctions to private companies, who then depleted the area for economic developments, such as large-scale building of houses. This type of major destruction cannot be done by the public but only by planning policies. One example is the national project of ‘Green Road’ that started in 2016 to connect high plateaus in the hinterland and support rural and nature tourism. It led to a vast deforestation of lands in the district and in the region.

The overlay of the maps revealed that most of the former deforested areas match with contemporary ones and are growing in scale at an alarming rate (Fig. 6). The distribution of these small patches was sparse in 1969, while in 2019 the deforested areas densified in the northwest direction. Many settlements located around these patches, including the vernacular houses, will likely be affected by landslides caused by this deforestation (see Fig. 7). There are already observable damages at the building scale, such as the complete destruction of undocumented vernacular houses and storage buildings. Snow cover on top of the mountains melts in the summer season, which also accelerates the flow of the rivers. Combined with the heavy rains of June and July, river flooding becomes more intense, forcing residents of historic buildings to abandon their houses, according to the interviews with locals [76].

While climate projections signal a trend of increasing humidity and rainfall in the area, the rising effects of floods and landslides due to anthropogenic interventions call for attention to cultural heritage sites. Landslides frequently accompany floods, while heavy rains trigger floods. Following the heavy rainfalls and river flooding, tea plantations and deforested areas cannot hold the soil anymore, provoking land slips in the hinterland, which can have detrimental effects on vernacular houses.



Fig. 5. The Karadeniz Sahil Yolu (Black Sea Seaside Highway) in Fındıklı of Rize. The photograph was taken by the first author, Gül Aktürk, on July 1, 2019.

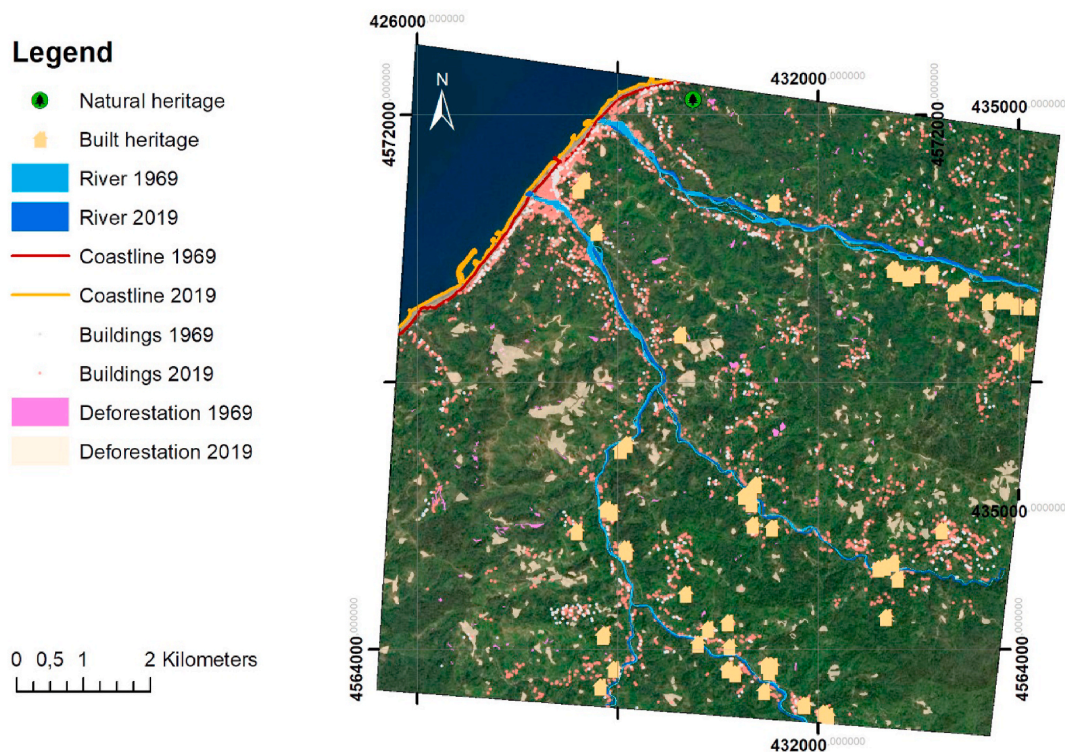


Fig. 6. Image of the coastline and major rivers of Fındıklı along with the locations of natural and built heritage sites, and buildings in 1969 and 2019. The map identifies areas of deforestation in 1969 and larger-scale deforestation in 2019.

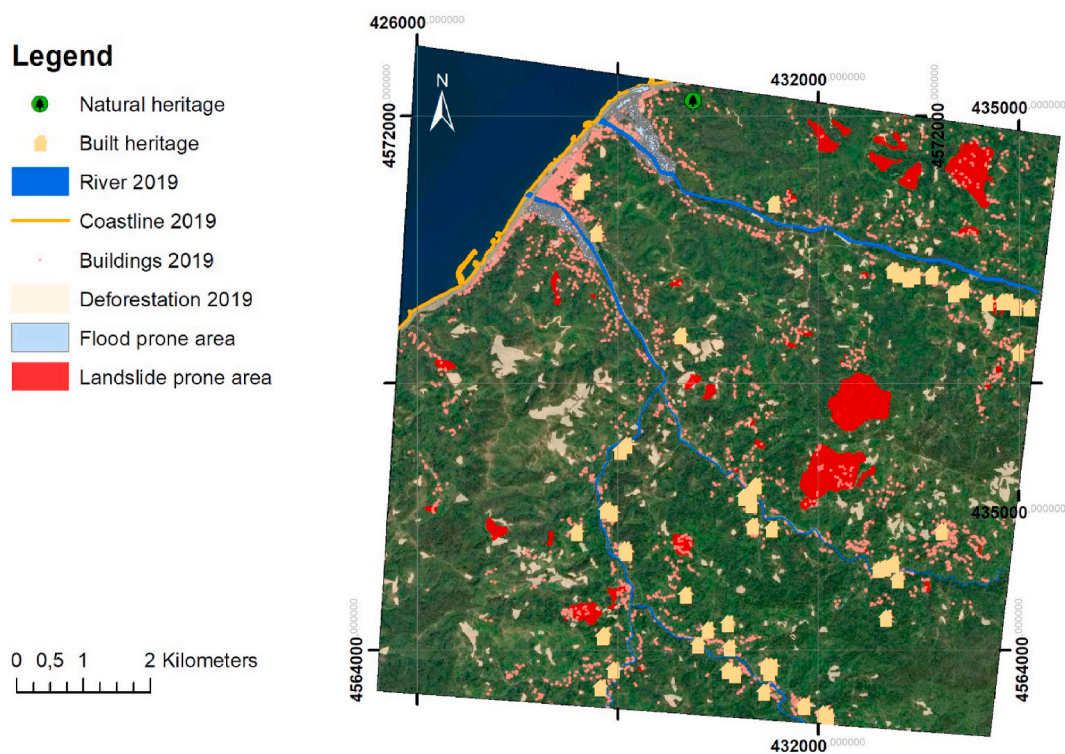


Fig. 7. The flood- and landslide-prone and deforested areas in the selected area of Fındıklı in 2019.

5. Results

5.1. Site-specific threats on the vernacular settlements

Results obtained from the maps indicated that not many vernacular and natural sites are under threat of floods and landslides, compared to the new buildings. The greatest disaster-prone surface is located between the valleys of Arılı and Çağlayan and the northeast part of the Çağlayan River.

Although Beydere Village is highly affected by the floods and landslides, the flood map provided by DSI does not include flooding data beyond the coastal area. Flood defenses formerly focusing around Beydere Village were extended to Çağlayan Village due to increasing and intensifying effects of floods. The DSI 22nd Regional Directorate determined these extensions based on estimation of the construction cost and the material and on the height of the flood protection and control structures according to the slope and width of the streambed [74]. Vernacular houses near flood defenses in lowland villages such as Çağlayan reveal that grand mansions—such as the one in Fig. 2—are also in danger.

According to the map, the deforested areas in some cases intersect or precisely overlap with the risk-prone areas, supporting the argument of being a multiplier risk through, for instance, landslides. One natural heritage site known as Sarıcam Forest, which has not been listed, is part of the deforested area. In addition, the clusters of newly built houses are located in landslide-prone areas shown as red patches (Fig. 8). It is especially visible in a zoomed-in view of the map that one historic building, namely Sevketybeyoglu House, is positioned at the intersection of the deforested and landslide-prone area (Fig. 8b), whereas a few houses, such as Sulak Village House (Fig. 8a) and Sevkety Atac House, remain in close proximity to landslide-prone areas (Fig. 8b). The two houses of Sevkety Atac and Sevketybeyoglu are located side by side in the deforested and landslide-prone area. As shown in the figure, the threatened sites are located in Çağlayan and Sulak villages. Three out of 58 vernacular built heritage were situated in the landslide-prone areas (Table 2).

The vernacular heritage was built with consideration for the local climate, topography, and other factors, which is why these sites are considered to be disaster resilient. Most were constructed upstream on high grounds to avoid damages from river flooding. Therefore, the builders of the vernacular houses knew about the environmental risks of the place and adapted to it, rather than trying to adapt the environment to their needs. However, as deforestation grows in scale, flooding will trigger more regular landslides and more historic buildings will become exposed to natural disasters.

In addition to the growing construction pressure and settlement of hydroelectric plants along the river, there is also an increasing demand for land for the construction of new buildings through the opening of roads that surround the historic sites. This combination of interests makes it difficult to safeguard the areas. All of these factors contribute to

Table 2

The locations of the most endangered vernacular houses at risk of landslides.

Heritage sites	Latitude	Longitude
Sulak Village House	41.217700	41.203300
Sevkety Atac House	41.255300	41.222500
Sevketybeyoglu House	41.255300	41.221500

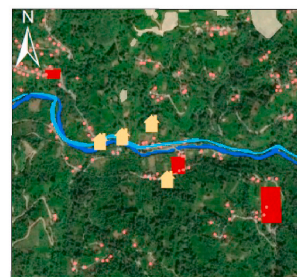
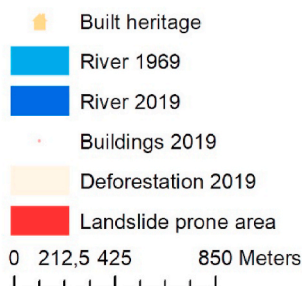
the artificialization of the land and to the creation of buildings or urban areas in risk-prone zones. According to the calculations in ArcGIS, the deforestation areas in 1969 cover an area of 0.325789 km², whereas they expand to an area of 2.598385 km² in 2019. Landslide-prone areas determined by AFAD and DSI revealed that a total of 3.367975 km² are identified as at-risk areas. It can be easily seen that one house from the first image (Fig. 8a) and two houses from the second image are located nearby the landslide-prone areas (Fig. 8b).

In interviews, locals mentioned damages on vernacular buildings, e. g., façade deterioration and loss (Fig. 9). The maps from the institutions



Fig. 9. The degradation of the rear façade of the Sevkety Atac House due to landslides in Çağlayan Village in Fındıklı of Rize. The photograph was taken by the first author, Gül Aktürk, on January 12, 2019.

Legend



(a)



(b)

Fig. 8. (a) Sulak house (b) Sevkety Atac and Sevketybeyoglu houses under threat of landslides.

and local administrators' reports overlook the presence of threats on the historic buildings, though interviews with locals prove otherwise. Historic houses outside of this boundary have been detected in disaster-prone areas, as well. The villages of Derbent and Beydere, which are known to be located within disaster areas, are indeed matching with the maps and the interviews. Karaali Village does not seem to be within a disaster-prone area, although interviewees mentioned that it was also severely affected with damage to historic houses. From this viewpoint, prior studies regarding the area have not focused on disasters affecting vernacular heritage sites; thus, thorough research needs to be done for this selected case area at the city and regional levels to identify the site-specific risks.

6. Discussion and conclusion

The analysis of this case study relied on the availability of data from the relevant stakeholders' databases regarding the locations of the heritage sites, floods, and landslide-prone areas. The challenge of gathering data and aerial pictures of high enough quality to effectively map the area was an obstacle for this research. Since aerial images were mainly focused on the coastal area, few images were available to map and analyze the hinterland where threatened historic buildings are located. In addition, data on contemporary disasters or changes in land use were inconsistent with official sources of various institutions as they were not accordingly overlapping, complementary, completed, or explained. Despite these limitations, maps produced through this diversity of sources provided an overall picture of the existing landslide risk to the natural sites and vernacular settlements.

The accelerating rate and scale of deforestation in the district put additional pressures not only on the newly built facilities but also on the resilience of vernacular buildings. As emphasized earlier, the builders of vernacular houses more than two hundred years ago planned their construction according to the humidity of the area and their knowledge of regularly flooded lands. Therefore, these structures are considered to be more resilient to natural hazards. The analysis revealed that three out of 58 of these vernacular buildings are now located in disaster-prone areas and the homeowners are now left to deal with pre- and post-disaster situations. In a similar study on the impacts of avalanches and landslides on the 60 cultural heritage sites in Upper Svaneti of Georgia, two hazard susceptibility maps were created with the classifications of low, moderate, and high risk for Ushguli and Chazhashi villages [6]. The risk assessment of the sites in Ushguli revealed that 19 out of 30 objects show low susceptibility and three of them are highly vulnerable [6]. Meanwhile, in the case of Chazhashi, 12 out of 30 objects have low susceptibility and four are highly vulnerable [6]. The results show similar findings that reveal a few sites under the risk of landslides.

Construction of the new houses both in the flood-prone and landslide-prone areas caused an increase in the number of the hazards in the city. The northern estuary of the two rivers studied is a great example, since public authorities allowed the urbanization of most of its land. This already dangerous area became densely populated and limited any available space next to the rivers. The modifications of the rivers by public authorities (involving concretization and artificialization) did not consider risks inherent to river flows in mountainous areas near the sea. New roads and bridges along and across rivers are not only channeling them but also putting obstacles in the riverbed. When heavy rainfall occurs, the decreasing forest cover enhances landslides and river flows, creating more violent streams that carry materials like wood and rock, which can block rivers around bridges. These obstacles and blocked paths in turn increase water levels upstream, aggravating the flooding of newly built areas along rivers. By supporting the urban development of the coastal area and the settlement of buildings along the river, authorities neglected the effects of their modifications on the river flow rather than accepted that these areas could be dangerous.

The maps and the data show an overlap or closeness between deforested lands and landslides. The link to increasing floods is indirect

but also present considering the impacts of forest over the capture of water during rainfalls and its slow release into rivers. Forests contributed to the regulation of river flows on top of preventing landslides [75]. The removal of forests also influenced the humidity levels of the zone, which vernacular buildings were adapted to. The growth in the scale of development-led deforestation should be reconsidered in the context of designated heritage sites and should be aligned with the growing number of policies on reforestation around the world. This would help meet the targets of increased biodiversity, reduced landslide risks, and increased water capture, which in turn reduces and regulates the flow of rivers.

The deforestation of the environment in which the historic buildings are located caused the loss of traditional construction materials and knowledge. The relationship between water, land, and settlements has been weakened by the coastal and inland developments. Maladaptation in the historic environments decreases the value of the heritage sites and speeds their deterioration. Adaptation practices of the past, such as those related to materials, design, and techniques, are no longer aligned with the changing external conditions of climate, land, and present living standards.

6.1. Recommendations for the safeguarding of vernacular heritage in Findıklı

The results obtained from the assessment of vernacular heritage sites in Findıklı revealed that three vernacular buildings are now exposed to the risks of landslides due to the urbanization, deforestation, and modifications along rivers and coastal areas. Although the spatial data shows that there are a few sites that are directly and indirectly affected by the landslides and flooding in this specific area, onsite observations and interviews revealed the extent of damages on the vernacular sites. Vernacular heritage, along with its values in terms of artisanship, agricultural practices, and structures, was abandoned in the hinterland after industrialization. The risk assessment, particularly in the context of vernacular heritage in developing countries, is not yet established or valued.

There are fundamental issues to overcoming the barriers, gaps, and challenges on the way to safeguard vernacular heritage, particularly in the case of Findıklı in Rize. The data on the geographical locations, character attributions, historical background, and past and present images should be correctly, consistently, and precisely documented. Heritage value of vernacular sites should be reassessed to prioritize the significant elements in times of climate crisis. Based on the studies on the site, the present and expected hazards should be identified and a database for hazard monitoring and mapping should be created through the use of GIS and/or remote sensing technology. As an integral part of cultural landscapes, vernacular heritage, along with natural heritage sites, should be included in mapping and monitoring plans. In addition, there is a need for creating awareness about cultural heritage in the context of disaster management among various stakeholders, including local communities. In addition, conservation plans should include potential risks and hazards and the susceptibility of the vernacular sites to landslides and floods. The building capacity to recover from the hazards can be determined as a result of such disaster risk management plans. For the future of these sites, it is critical to adapt vernacular heritage sites and their environment to the risks.

Importantly, after landslides, retaining walls were built in some of the vernacular sites in Findıklı, although a majority of these buildings remain unprotected. There is a need for the construction of terracing around sites where landslides pose risks. The controlling and management of construction of new buildings, infrastructure, tea plantations, deforestation, and rural and natural tourism in the development of hinterland is needed to prevent further damage, while the objectives of policies should be reassessed. The contribution of local communities to reforestation is equally important. However, public and private institutions cause the most environmental damage through deforestation.

Therefore, collaboration with these groups and the implementation of policy to help protect vernacular structures is critical to preserving and protecting these important sites for the future.

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Author contributions

Gül Aktürk: Conceptualization, Methodology, Validation, Formal analysis, Resources, Writing – original draft, Writing – review & editing. Stephan J. Hauser: Software, Investigation, Data curation, Writing – review & editing, Visualization

Declaration of competing interest

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