Environmental Impacts on Historical and Cultural Monuments. Measures to Protect Cultural Heritage

Armenia is a country with a rich cultural heritage whose roots rise through the depth of the centuries. About 33 000 historical and cultural monuments are found in 4 500 complexes with a total territory of 20 000 hectares.

The protected monuments in the Republic are defined as local or Republican. Especially important and significant are monuments of historical, architectural, scientific, artistic and cultural value, of which there are 80 complexes (with about 400 architectural monuments). In the past, these were included in the USSR's list of cultural and historical significance of all-Union value.

The UNESCO World Heritage List, which since 1963 has identified more than 630 historical monuments and natural areas all over the world, includes several sites on the territory of Armenia: Hakhpat Abbey complex, Sanain Abbey and old bridge, and the historical centers of Echniadzin, Zvartnoc and Gegardavank. Other Armenian sites have been proposed for the UNESCO List: the Noravank Abbey complex, the Persian Blue Mosque and the historical capital of Armenia, Dvin.

The main and permanent factors of risk for the country's cultural heritage include numerous natural and anthropogenic environmental factors.

Earthquakes, landslides, rising groundwater levels, the environmental crisis with alarming pollution emissions and deposition, formation of smog in cities, pollution of streams, catchment basins and lakes, degradation of soils, and the absence of drainage systems leads to the destruction of cultural, historical, archeological and religious monuments, as well as more recent engineering works (e.g., bridges, aqueducts).

The most destructive is the impact of natural catastrophes such as earthquakes, which occur frequently in the country. There are many bibliographic notes and graphic images of these events. For example, part of the city wall of Ani fell in 1064; during the earthquake of 1319 the drum and dome of the main cathedral in Ani collapsed. The most destructive was the earthquake in 1679: it destroyed the cathedral in Garni, numerous churches in Yerevan, Kanaker, Nork, the Ararat valley and Gokhtan village, as well as the cathedral in Echniadzin, the churches of St. Hripsime and the Abbey of Gayane.

The architectural monuments of northern Armenia suffered during the destructive earthquake in 1988 in Spitak. Almost all churches in the Akhuryan, Artik, Ani, and Ashot districts were partly damaged. To a lesser degree the churches of Gugark, Stepanavan and Tallin districts were damaged.

Humidity also causes major damage to monuments, which can be noted very often near the base of construction.

To isolate monuments from humidity, it is necessary to protect rooves and walls, drain surface waters from the surrounding territory, and block the expansion and intrusion of humidity into the foundations and walls from the ground surrounding the monument.

Irrigation and watering in fields, gardens and vegetable gardens near monuments can lead to waterlogged ground and the intrusion of humidity.

Extremely damaging is the intrusion of humidity in the walls and roofing structures through damaged coverings. Accumulated humidity can form in holes in the walls, freezing in the winter, melting in the spring, and destroying mortar, thus separating internal and external layers and weakening the structure of buildings. This mainly causes damage to the south and in part the western walls of monuments, whereas northern and eastern faces usually remain less damaged as a consequence of smaller temperature fluctuations.

A useful measure for the removal of the underground waters from the area surrounding a monument is the creation of drainage systems. Irrigation canals near monuments are another cause of humidity.

During the centuries, the penetration of groundwater in the stone buildings of Gegardavank has had a destructive impact, especially near the bottom of stone walls. This impact has been to a great extent addressed through the construction of a drainage system, directing underground water from the northern part of the protective wall towards the Azat River. Such measures can possibly also address problems of underground water level increase.

A major problem is the prevention of high humidity levels in the monuments of the city of Echmiadzin. Most buildings in the city are cultural and historical monuments, and the lower parts of their walls, up to a height of 1.5 to 2 meters, are damp. The humidity also damages such buildings as cathedrals, the churches of St. Gayane and St. Shogakat, church fences of St. Hripsime and the cells of Yeremyan, Kazarapat, and Trdatatur. There were no such problems in the past. The situation arose with the closure of the old water supply system, which had vertical cisterns in the ground and a connecting network of underground canals. It was used until 1930. After the installation of metal pipes for the city water-supply system, the old system was buried and forgotten. Due to this closure, drainage of underground waters was also blocked, and these began to intrude into the foundations of buildings. Humidity is a serious threat for the Zvartnoc complex also. Even more exposed are architectural fragments located on the ground. A program for the partial reconstruction, strengthening and territorial improvement has been prepared: it envisages the protection and exhibition of 1500 fragments.

In recent years, the number of multi-stage accidents has increased, in which one natural disaster leads to another, resulting in fatal consequences in the social, economic, urban and environmental fields as well as in the sphere of cultural heritage. Many regions of the country are characterized by a simultaneous exposure to environmental risk factors that often mutually strengthen each other. In some districts (such as Ijevan, Noyemberyan) of Shirak Marz, the earthquake of 1988 has increased land slide processes.

Soil creep is very typical for Dilijan, or rather its separate areas; it damages national architectural monuments as well as capital buildings. Soil creep has caused damage also to the Abbey of Jukhtak-Vank, located not far from this city in the Bldan-Chay Valley, resulting in cracks in the main church. For this reason, the whole volume of the church was encased in a metal structure, and with the efforts of geologists the land slide process was halted. Soil creep occurred also under the northern part of Makaravank Abbey. To stop the soil creep process here, the soil was fixed with concrete poles and plants at the bottom of the land slide area. Soil movements have been aggravated by extensive irrigation and related works.

In the 1980s and 1990s, Armenia was characterized by climate fluctuations beyond the limits of normal variation: there were in turn sudden temperature increases in winter, temperature decreases and snowfalls in spring, long-duration strong winds and other climatic anomalies, causing major damage to cultural and historical monuments.

Strong winds; eroded wind-blown soils; and the transfer of bacteria, microfauna, fungi and other organisms that accumulate on the walls and rooves of buildings, especially in holes in stone walls and in seam connections, and can then expand and spread: all these create damage, separating stones from mortar and bringing monuments closer to their destruction. This is a problem also for mosses, grasses and bushes, in particular in cracks and corners, where it is easy for dust to accumulate and act as humus. The numerous headstones, *khachkars*, of notable

medieval sculptural and architectural value, are also affected. Fungi and mosses accumulate on khachkars and spread on their surface, sometimes close to valuable writings, bas-reliefs and ornaments.

An extremely dangerous problem arises when the roots of nearby trees intrude into the foundations of monuments or their walls, sometimes spawning trunks and roots inside. These problems are seen especially in monuments located in the dense forests of Armenia, in the Lori, Tavush and Syunik Marzes. It is necessary to separate carefully tree trunks and roots from the walls, then restore the damage and block possible further intrusion of tree roots and other plants.

It is obvious that the mechanical removal and chemical treatment of plants covering monuments will be effective only if this work is undertaken parallel to regular surveys to understand the process of humus accumulation. Also dangerous are organic materials such as excrement droppings, which are bad from aesthetic, chemical (the acid mixture damages the stone) and hygiene points of view.

Significant damage to monuments also arises from broad-scale formation of wetlands and soil salinity processes.

Changes and damages to many monuments have arisen from mineral build-up (white accumulations, which most likely are the result of water leakage), and soil accumulation, with crystallization taking place on the stone surface, and on the closed soil crystals.

In addition to a number of negative anthropogenic impacts on cultural monuments, there are the geological disturbances affecting the Tolors village in Syunik Marz, near reservoirs, and the 5th century church near Pogos-Petros, located on the Aparan Reservoir.

A large number of Armenian monuments are located in city environments. Their conditions to a great extent are affected by anthropogenic impacts, first of all pollution. Air pollution leads to the formation of chemically aggressive conditions that damage natural building materials. (Examples include cement plants in the cities of Ararat and Razdan and copper smelters in Kapan and Alaverdi).

Yerevan's problem have become catastrophic due to the fact that construction projects and plans are undertaken without the determination of protected zones and the dislocation of architectural monuments: stage-by-stage projects for city reconstruction were elaborated without consideration of historical and cultural factors in planning; these not only were not oriented towards the preservation of historical districts of the city, but in fact did not foresee them at all. The current, uncontrolled situation is connected with rising risk factors in the historic zone of Yerevan. Among most problematic situations are visual impacts on the landscape created by unregulated construction within the protected zones of monuments (the Opera House, memorials for Avetik Isahakyan, Mikayel Nalbandyan, Vardan Mamikonyan, etc). It is necessary to separate and isolate monuments from built-up areas, with the help of urban planning decisions and methods, and reduce intrusions and interference in the protected zones of monuments, as these disturb the integrity of monument complexes and the surrounding landscape.

Urban foundations for the preservation and reconstruction of historical environments should be the corner stone for the system for the preservation of the country's architectural heritage, since architectural monuments are an inalienable part of their ensemble or complex. The most important elements that national heritage adds to modern life include the uniqueness and beauty of cities, their historical centers and architectural ensembles, planning structure and green areas.

Recommendations for necessary measures:

1. Analyze the possibility of implementing measures to improve the environment and preserve and restore Armenian historical and cultural monuments.
2. Offices responsible for urban areas, for environmental protection and for historical and cultural monuments protection should elaborate basic environmental and urban plans, identifying environmentally unfavorable territories and creating programs of environmental activities.
3. In the elaboration of general plans, detailed plans and projects, it is necessary to consider their possible negative impacts and separate these from the protected zones of cultural and historic monuments (historic, administrative, and natural boundaries), regulating built-up zones and protecting natural landscape zones.
4. Near zones for protected historic and cultural monuments, projects reviews should be the basis for detailed planning and construction of territorial districts and other settlements. Construction and other works, as well as economic activities within such zones, should be implemented only with the permission of the authorized state body.
5. It is necessary to investigate existing geological and related conditions surrounding monuments, in particular those, such as environment pollution, causing damages.

Since the Spitak earthquake in 1988, 15 years have passed and new earthquakes have occurred, but their impact on monuments has not yet been studied. The resolution of this problem will provide an opportunity to obtain information about the present condition of monuments. It is necessary to undertake new research to understand the conditions of monuments, as in the current process of land privatization in Armenia, as instances have occurred in which architectural monuments have been destroyed.