

## **Natural disasters and sustainable housing requirements in Libya-The case of Daniel Tornado in Derna**

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**Abstract.** Natural hazards, such as valley floods and hurricanes, constitute one of the types of environmental crises in modern times, as a result of the population's encroachment on existing urban regulations and plans, which produces residential complexes that lack the rules of systematic planning and the requirements of balanced sustainable development. In this research, we will discuss the effects of Hurricane Daniel on the city of Derna, overlooking the Mediterranean Sea in eastern Libya, which was subjected to a storm that left thousands of victims and caused floods that swept away large parts of the city, being the largest natural disaster to have struck the country.

Libya was often exposed to natural hazards, as agreed upon by references in paleoclimatology and the history of the region. In 1941, the Derna Valley was subjected to a major flood that submerged parts of the city and swept German military vehicles into the sea. During the period between 1959 and 1969, the region was exposed to several similar incidents that left hundreds of victims, which confirms that it is a dangerous region in terms of natural disasters.

We will also determine the arrangements required to achieve sustainable housing that ensures the necessary conditions for embodying a safe built environment, including the organization of urbanization that takes into account the natural and Social and economic development, and integrating climate diversity according to the features of the National Housing Policy between 2014-2033 (Ministry of Housing and Utilities, 2013). The illegal overuse of available natural resources, especially real estate, to the point of depletion, and failure to respect the rules of prevention and security, leads to... "This leads to the establishment of unsustainable residential complexes that are constantly exposed to risks." ( Julian gargani, 2016).

**Keywords .** Natural hazards, sustainable development, sustainable housing, forecasting, Darna

### **Introduction**

The housing sector in Libya has undergone several transformations since the

country gained independence. Housing production did not keep pace with demand. This is due to several reasons, the most important of which is the forced increase in the population, as Libyan society is characterized by a high rate of annual increase in the population, which reached more than (4%) in some residential censuses (General Authority for Information, 2008). The lack of sufficient financing also played a role in the housing crisis. “For example, the funding sources for the housing sector declined from (26%) of the budget in 1970 to (9.1%) in 1992, and then less than that in 2018” (Central Bank of Libya, 2019).

Thus, there was a delay and a severe shortage of sites allocated for housing. It is natural for residents to try to find solutions on their own that are far from the rules of urbanization and the complexities of administration. Random and informal construction appeared in the valleys without taking the necessary precautions or the rules of sustainability, especially in the environmental, organizational, and structural aspects (Khalafallah.b, 2023). Thus, the entire region becomes vulnerable to the dangers of natural disasters, which are considered “crises resulting from sudden and rapid change” (Hassan Ahmeida, 2022). In the constant presence of natural disasters in the world, which greatly confuse the housing sector, came Hurricane Daniel in Libya, which almost completely destroyed the city of Derna, where urban development requirements were not respected, leaving thousands without shelter. This is consistent with Burton’s definition of a natural disaster, which he asserted is “a unique situation in a region, resulting in material damage costing about a million dollars or the death and injury of more than a hundred people” (Sabri Mahsoub and Med Ibrahim Arbab, 2000).

### **Materials and methods**

#### **Natural disasters in Libya**

Throughout its history, Libya has known many natural disasters, such as torrents and floods, as a result of several reasons, the most important of which is the lack of respect for the laws and rules of reconstruction and construction and the failure to take into account the requirements of sustainable urban development in housing projects by the population during the past decades, which caused many losses in buildings and lives that were significant. They encroached with buildings, roads, and facilities on the banks of valleys in several areas, and established residential neighborhoods in areas that are not suitable for construction. The infrastructure of many Libyan regions is generally not qualified to deal with extraordinary natural disasters.

Among the natural disasters that Libya experienced, we mention the earthquake that struck the city of Al-Marj, east of the country, in February 1963, and whose magnitude reached about 5.3 on the Richter scale. The epicenter of the earthquake was the “village of Sidi Dakhil” near Talmitha, which caused the death of 243 people and injuries. Hundreds of residents. Libya has also witnessed many storms and hurricanes over the past decades, including the “Maximo” storm, which struck the western coast in 1982. It was followed by the “Celino” storm in Sirte in January 1995. At the beginning of the century, the “Zeo” storm passed along the Libyan coast in December 2005. Then then the “Rolf” storm in 2014” (Arab Climate Centre, 2016). The “Casylda” storm coming from Greece also passed through the coast of Libya in September 2020, and in the following year, some of the coasts of eastern Libya, especially the Hamama region, witnessed the “Tornado” storm, or mini-hurricane (Arab Climate Center, 2023).

## **Sustainable urban planning requirements**

The foundations of sustainable urban planning are the factors influencing urbanism and architecture in cities that fall within the requirements of the comprehensive concept of sustainable development. This means that it is a set of factors that allow achieving compatibility between urban planning and the needs of residents, as defined by some researchers (Frey, 1999; Williams, 2000). Which:

- A - The possibility of easy access to the end or final destination
- B - Bringing people together for rational consumption of space, which means reducing the distances that individuals must travel daily to be able to fulfill their needs.
- C - Merging and blending functions within residential areas and creating mixed areas capable of meeting the greatest amount of requirements.

Another researcher (Barton, H, 1996) added two elements to it:

- D - Housing units are formed around the active elements
- F- Drawing a clear strategy for energy use, in which the designer attempts to take into account the rules of rationality or urban economics.

A careful reading of these elements leads us to conclude their compatibility with human needs as follows:

- Determining the size of the city and its population, thus reducing the need for transportation
- Achieving self-sufficiency in services, and independence for residential formations, even if only partially
- Achieving the social, cultural and environmental goals of the population, by providing comfort and security, and taking into account privacy and environmental safety.

## **The Study Area**

Derna is a mountainous, eastern Mediterranean coastal Libyan city bordered to the south by a chain of Jabal al-Akhdar hills. It is divided into two halves by the Derna Valley, which is located on its banks and at its mouth in the Mediterranean Sea, i.e. the delta. The distance between Derna and Benghazi is estimated at about three hundred kilometers to the west (Figure 01).



Fig n°1, Situation of Derna (Source: Wikipédia, visit on 12/12/2023).

Derna is known for its fresh water flowing from two springs: Ain Al-Bilad and Ain Bou Mansour, known for its waterfall. Like the cities of Jabal al-Akhdar and the Cyrenaica region, the city of Derna is known for its beauty (Figure 02), the elements of which include the abundance of trees and fresh water, as well as the fresh sea and mountain breezes, characteristics that are rare in Libya, where trees cover only (10) percent of its area. Derna's climate is considered Mediterranean, with moderate hot summers and cold winters, with a tendency toward moderation in both seasons. Temperatures during the winter in the city range between 9 and 20 degrees, while in summer they rise to more than forty degrees. The average annual rainfall is about 600 mm, which is a significant rate that enables the water table to be nourished with significant quantities that are reflected in the fresh water sources , and the streams formed by the flow of this water.



Figure n°2 Image of the city, (Source: Wikipédia, visit on 12/12/2023)

The population of Derna is estimated at more than 100 thousand people, according to several sources. Many civilizations succeeded it, it was inhabited by different peoples, it was occupied several times, and it was exposed to many natural disasters, the most recent of which was Hurricane Daniel, which struck the city on September 10, 2023. Due to this strategic location and its location on the coast, which gave it, a diversity of views(Fig No. 03). The city suffered from pressure on the housing sector. After the hurricane, adapting this sector to the requirements of sustainable development became an urgent necessity.



Fig n°3, beauty and diversity of landscape (Source: Wikipédia, visit on 12/12/2023)

## Daniel Tornado, and its results on Derna

In 2023, the city of Derna witnessed a powerful, destructive hurricane called (Daniel), which is classified as a medium-level hurricane compared to other hurricanes. It also takes the shape of a spiral with an empty center, called an eye, and is accompanied by dense clouds, air, and very heavy rainfall. The city has previously been exposed to a number of natural disasters, including: In 1941, a flood occurred in Wadi Derna, hitting the city and leading to German war equipment and military vehicles being swept into the sea, in addition to major material damage and massive loss of life. In 1959, a flood occurred due to the rise in the valley's water level, causing deaths and injuries and destroying many homes. Between 1968 and 1969, several floods were recorded, but they did not cause deaths or cause significant damage.

In 2011, the valley flooded as a result of the opening of a dam to drain heavy rainwater, and the city was about to drown at that time. In this hurricane, the coast witnessed very heavy rainfall in less than two days, amounting to about 414 mm, in an area classified as semi-arid in climate, and receiving an annual rainfall rate of only 200 to 250 mm. This means that what had been falling over the course of two years fell in less than 48 hours, leading to severe floods in an area filled with valleys. Thus, the water flooded large parts of the city, causing the destruction of the fragile infrastructure and the collapse of two dams, holding large quantities of water behind them, which increased the mass of water and the size of the floods, which led to doubling the size of the disaster (Fig 4,5).



Fig n°4,5, inondations (Source: Authers 2023)

This table summarizes the natural disasters that the city of Derna has been exposed to since the 1940s:

History of the disaster	flood	strong winds	Material losses	human losses
1941	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>
1959	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	Yes
1969	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	No
2011	<u>Yes</u>	<u>No</u>	<u>Yes</u>	No
2023	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	Yes

Fig n°6, Catastrophes Naturelles (Source: Authers 2023)



## **Factors that led to high losses in Daniel**

In addition to the size and strength of the hurricane in the city of Derna, there were other factors that caused the high material and human losses, which were:

- Unlicensed construction of entire residential neighborhoods in the valleys without taking into account safety rules and sustainable development requirements
- Absence and ineffectiveness of warning and monitoring systems (Report of the United Nations International Meteorological Agency, 2023)
- Destruction of the marine ecosystem as a result of chaotic exploitation - The phenomenon of urban heat islands that affect cities, as an indirect factor in increasing the severity of the storm in the city, due to the absence of green areas
- Soil erosion due to the lack or absence of green areas, which reduces the possibility of storing water resulting from rain, which helps stabilize the soil and prevent its erosion.
- The collapse of the two dams that were supposed to protect the city, due to the lack of continuous maintenance and monitoring, especially after cracks appeared in them since 1986.

## **Results and discussion**

Sustainable housing development seeks to improve living conditions for all the world's population, without increasing the use of natural resources beyond the planet's carrying capacity. Different measures may be required in each region of the world to prevent natural disasters. To achieve sustainable housing, since January 2016, Libya has tried to officially implement the sustainable development goals in accordance with the goals set by the United Nations for the 2030 Development Plan, which was adopted by world leaders in September 2015 at an international summit. But these decisions remained a dead letter, making Libyan cities, including Derna, vulnerable to these dangers, especially because “they do not have an integrated warning system because benefiting from advanced advance warning systems remains limited to half of the 193 countries participating in the World Meteorological Organization” (Wikipedia, 2023).

To ensure future sustainable housing in the city of Derna in the future, the following must be respected:

- Ensuring the selection of sites qualified to receive residential projects using the application of multi-criteria analysis based on AHP
- A comprehensive study of the valley in terms of flow and speed of flow according to the seasons, and preparing forecast maps using Arc-GIS technology
- Identifying risk areas by studying the following factors: proximity to areas of surface runoff and floodplains, the average annual and monthly amount of precipitation, soil type, geological structure, and distance from residential areas
- Ensuring a significant increase in vegetation cover to avoid heat islands, and intensive afforestation in order to stabilize and cohesion the soil and reduce siltation.
- Hydrological models are commonly used to evaluate potential areas of inundation and flood damage for decadal repetition periods

## **Conclusion**

Daniel hit the city of Derna, and its consequences caused the collapse of residential areas and greatly affected the authorities' preparations and readiness to deal with natural disasters. Despite scientists' warnings about this matter as a result of climate change, and global summits to move towards clean energy, the authorities did not make every effort in this regard. Hurricane Daniel coincided with heavy rains that the country had not witnessed in more than 40 years. Thus,

the water level rose, the Derna Valley flooded, and the city's two dams collapsed, leading to material and human losses and the disappearance of about 10 square kilometers of the Derna area from the geographical map. This matter requires seriously reconsidering the course of city management in order to understand geography and proactive preparedness to deal with climate change with early warning systems linked to monitoring, and plans that simulate the evacuation of residents in times of natural crises to avoid a rise in casualties.

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