Risk Assessment at Heritage Sites: A Case Study of Tripoli Old City, Libya

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Abstract
There is a large number of important archaeological sites around the world that have fragile properties, and face different challenges. Old city of Tripoli is one of those sites which are under a variety of risks. Natural disasters, development, tourism, pollution, looting, conflict and inappropriate site management are merely some examples of these risks. Generally, the risks to heritage sites depend on nature, specific characteristics, inherent vulnerability and the geographical environment of the site. Ultimately, it depends on the nature of external threats that affect the heritage itself. However, the level of the qualitative approach to risk is determined based on the intensity of the effect and the frequency and potential damage occurs. In this study, mainly seven risks were analyzed and assessed. The results demonstrated that the main critical risk is the risk of migratory movements and changes in the population. It has a catastrophic priority with risk magnitude (RM) of 14.5. Ranked second the risk of weak management and state regulatory bodies and the risk of Lack of knowledge of restoration techniques with RM of 13. Whereas, the risk of insufficient skilled staff has the lowest RM of 6.5 and low priority.

Keywords
risks at heritage sites, old city of Tripoli, heritage sites, risk management, risk assessment

1. Introduction
Many definitions of risk are existing in the literature. As underlined by Sotic and Rajic (2015), some of the risk definitions are based on probabilities, others on expected values, some on uncertainty and others on objectives. Some authors regard risk as subjective and epistemic, depending on the knowledge available, some regard it as aleatoric, due to the probabilistic character of certain parameters, while yet others give risk the ontological status independent from the person assessing it. Nevertheless, the traditional definition of risk in the context of engineering is led by the authors Wilson and Crouch (1982); risk equals the product of probability and severity. However, risks to heritage sites are also dependent on the specific characteristics of each site and its inherent vulnerability. Conversely, risk management is the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability or impact of unfortunate events (Hubbard, 2009). Risk control and risk management decisions regarding the mitigation strategies might be based on financial, operational, legal, political, environmental, social and other criteria. Thus, reducing, anticipating and managing risk are all part of the daily grind for organizations that have integrated risk management into their business strategy. That's why they often turn to ISO 31000 on risk management to support themselves in this task (The revision of ISO 31000 on risk management, 2015). However, several studies applied risk management in different fields have been published in the literature. For instance, recently, Elkhweldi and Elmabrouk in 2015 presented risk management strategies in aviation sector and Elmhedwi et al (2015) offered a practical risk management plan of a Wi-Fi network deployment.

2. Historical and Heritage Sites Risk Management
To heritage sites, risk management is the process that involves managing losses and impacts in order to minimize them and to reach a balance between opportunities gained and lost. In 2015, Jigyasu presented that the floods have caused enormous damage to cultural heritage properties around the world. One example is the Balkan floods in May 2014, which caused enormous damage to many historic towns and villages. Such a damage was witnessed previously in Rome (Italy) and Beverley (UK) during floods in December and June 2007 respectively. Similarly, floods in Pakistan

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in August 2010 caused damage to many traditional settlements and archaeological sites along the Indus River (Jigyasu, 2015). Moreover, Jigyasu (2015) reported that the climate change is increasing the number of disasters and their devastating impacts on cultural heritage. Climate change impacts on cultural heritage are illustrated by several incidents such as flash floods in Uttarakhand in India in June 2013, as a result of which many temples and other historic structures along the river were severely damaged. The cloudburst in Leh, India in August 2010 suffered from flash floods due to unprecedented heavy rains which caused destruction of vernacular adobe heritage. As mentioned before, the storms in Western Europe in 2007 flooded many historic town centers such as Rome (Italy) and Beverley (UK). Undoubtedly, climate change is increasing the number of disasters and their impacts on cultural heritage.

Waller (1995) proposed four recognized steps to using a risk management approach to preservation issues; 1) Identifying all risks to heritage 2) Assessing the magnitude of each risk 3) Identifying possible mitigation strategies, and 4) Evaluating the costs and benefits associated with each strategy.

However, one of the international standards of the risk tool is ISO 31000:2009 Risk Management Principles and Guidelines. Fig. 1 shows the main six steps in the historical and heritage risk management cycle (context, identify, analyze, evaluate, treat, then monito). This risk management principle was considered in this study.

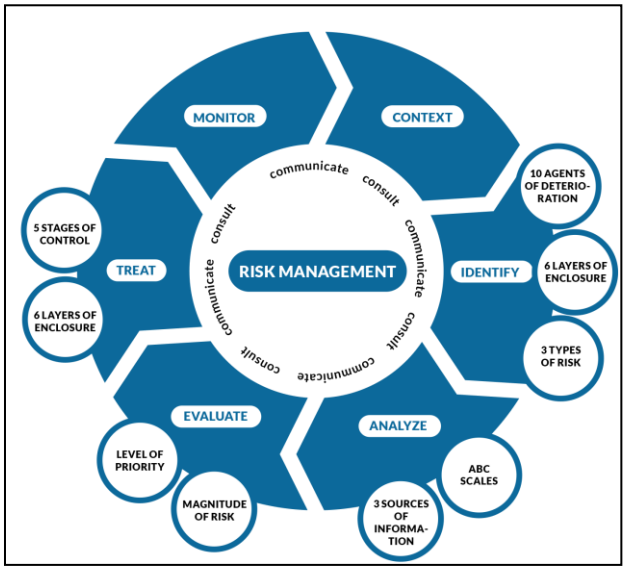

Fig. 1- Heritage risk management cycle (ICCROM, 2016)

2.1 Context

It is important to understand all relevant aspects of the context in which the heritage asset is situated. This includes its physical, administrative, legal, political, socio-cultural, and economic environments. The scope of the site should be determined before the risk assessment begins. The scope of risk management needs to be specific in terms of extent, effects and structures to be included in the assessment, the level of detail the time period and the status of the persons concerned.

2.2 Identify

Risks to historical and cultural heritage may stem from exposure to one or more hazards and other determinants. This also implies the need to understand the inherent link of physical vulnerability of both movable and immovable cultural heritage to that resulting from social, economic and development processes. Therefore, addressing risks to cultural heritage requires much deeper thinking both with regard to the underlying vulnerability factors that put cultural heritage at risk and also to their long-term implications. Therefore, this step consists of identifying the risks that threaten the heritage collection, building, monument or site. However, if the different risks that affect the heritage sites are not identified, the decisions and use of resources will be based on an incomplete picture and will therefore be less effective.

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As a result, risks to historical and cultural heritage cites may be classified into seven categories; natural, nature of the cite, anthropogenic, loss of information, inability to access, economical context and political context. This classification is illustrated in Fig. 2.

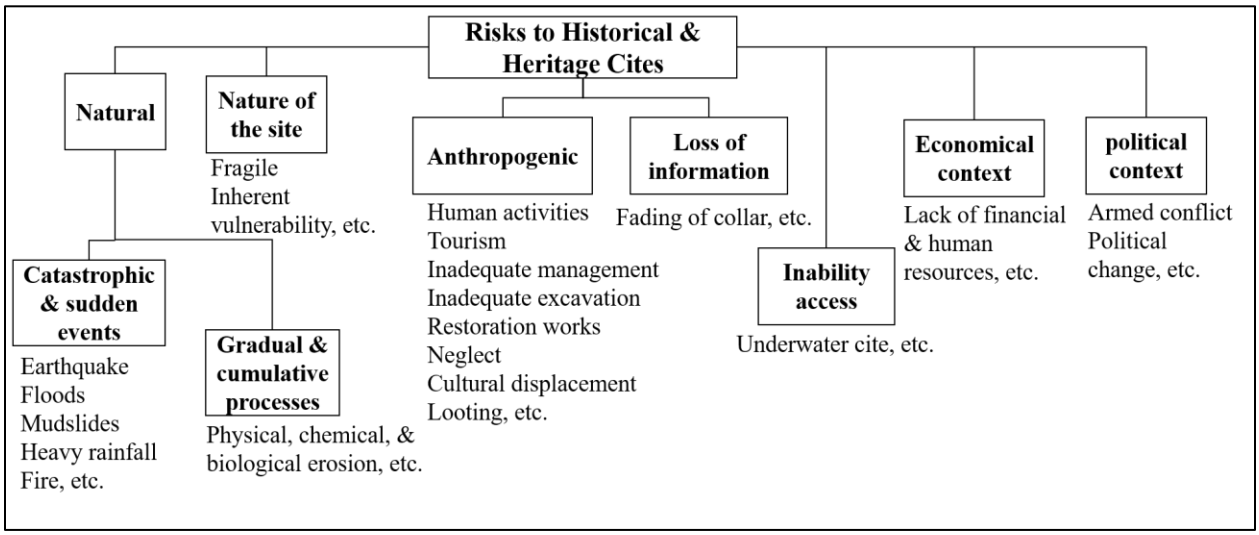

Fig. 2– Flowchart illustrating the categories of risks to historical and cultural heritage cites

Another useful approach for a complete identification of risks is to consider the three different types of risk occurrence, as indicated in Table 1. Moreover, as emphasized by Demas (2002), the outcome of a condition survey is an archive of valuable graphic and written documentation representing baseline data about the site, which can be used to make recommendations for its future use and treatment and to monitor change over time. As she also suggests, the condition assessment consists of three basic stages: (1) collection of information and historical documentation, (2) visual assessment and condition recording of the current physical condition, and (3) analysis and diagnosis of the condition.

Table 1- Identification of heritage risks

Rare events	Common events	Cumulative processes
"Rare" events occur less often than about once every 100 years. As a result, rare events are not part of the direct experience of most heritage organization staff. From the perspective of the total heritage of a nation, such events may happen every few years, and from a global perspective, these events can become routine.	Common events occur many times per century. These are events that are part of the direct experience of many heritage organization staff or of people in the vicinity of the heritage organization.	Cumulative processes can occur continuously or intermittently. Over the years, most heritage organization staff will have observed the cumulative effect of one or two such processes on some items, that is to say, they will have seen the item "age." Very frequent events can also be considered as cumulative processes for risk analysis.
Examples: Floods Damaging earthquakes Large fires Theft Visitor knocking over a special item	**Examples:** Water leaks Damaging earthquakes (some parts of the world) Small fires Collapse of overloaded furniture Many handling "accidents" "Petty" theft	**Examples:** Yellowing of newsprint Fading of some colours Corrosion of metals Erosion of stone Wear and tear of textiles that are handled daily

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As an alternative procedure for a complete identification of risks considered by Middle Eastern Geodatabase for Antiquities-Jordan (MEGA-J), disturbances are current detectable, negative effects on the site or site element by natural forces or human activities and threats are detectable phenomena, whether natural forces or human activities, that appear to predict a future disturbance to a site or element. Threats and disturbances as classified and defined in MEGA–J fall into six main categories: (1) agricultural, (2) development, (3) human, (4) natural, (5) site management and (6) other impacts, as described in Fig. 3 (UNESCO Amman Office, 2012).

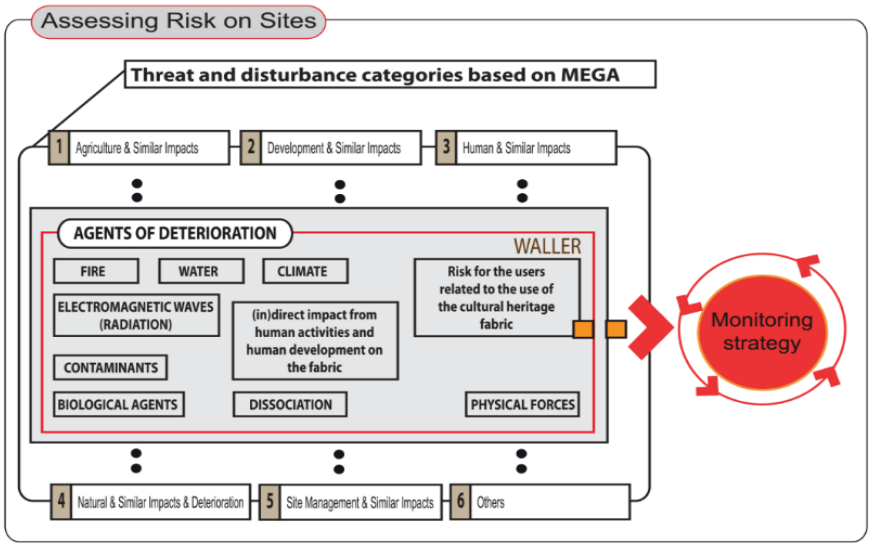

Fig. 3- Risks and agents of deterioration potentially affecting the integrity of heritage sites (UNESCO Amman Office, 2012)

Another suitable approach for a complete risks identification is to concede the ten agents that can cause of deterioration and loss which proposed by International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM, 2016) as illustrated in Fig. 4.

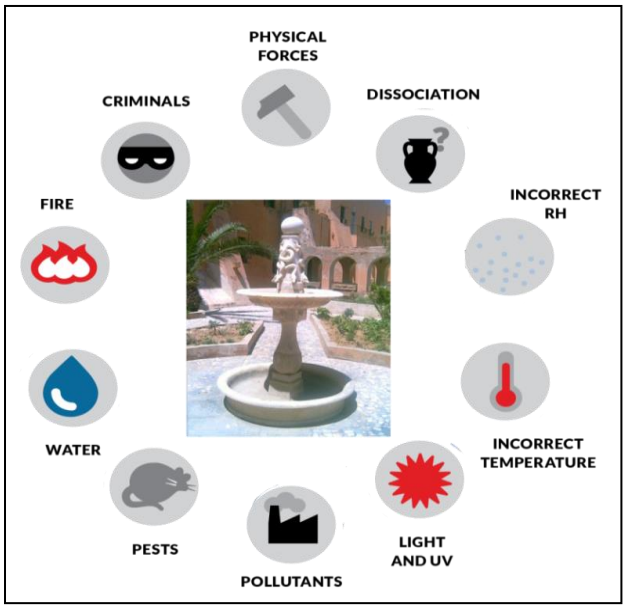

Fig. 4- The ten agents that can cause deterioration and loss to heritage items

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2.3 Analyze

This step involves the comprehension of each risk that has been identified. This can be recognized by estimating how often occur and their expecting impact. The impact of risks to cultural heritage is expressed in terms of the expected loss of value to the heritage asset. As a result, quantitative and qualitative of each risk presents in this step. Risk quality describe the magnitude of the severity and the potential damage that occurs. In quantitative approach, the risks criteria expressed by numerical values. The level of the qualitative approach to risk is determined based on the intensity of the effect (moderate, severe, catastrophic) and the frequency and potential damage occurs (rare or sporadic, continuous).

In the quantitative approach, the level and magnitude of risk can be calculated based on three score criteria; score A: probability or extent of damage happening, score B: degree of loss of value and integrity as a result of the impact, and score C: fraction of the assessed area susceptible to the threat, and the extent of its vulnerability. Based on the ICCROM–CCI–ICN (UNESCO Amman Office, 2012) risk assessment in Fig. 5 provides A, B and C scales and guidance on how to calculate and quantify the magnitude of specific risk. Each of these criteria (probability, A, loss in value B and fraction susceptible C) is evaluated based on a scoring system from 0.5 to 5. The three components (A, B, and C) are discussed in Figs 6, 7 and 8. However, adding the scores for A, B and C gives a number representing the magnitude of risk (RM) for the specific threat.

$$\text{Risk Magnitude (RM)} = \text{A (probability)} + \text{B (loss in value)} + \text{C (fraction susceptible)}$$

Prediction of the loss of value to the heritage asset is studied during the risk analysis stage. However, this is a mere prediction and thus contains some uncertainties, which can be reduced with further information and a higher level of knowledge of the matter.

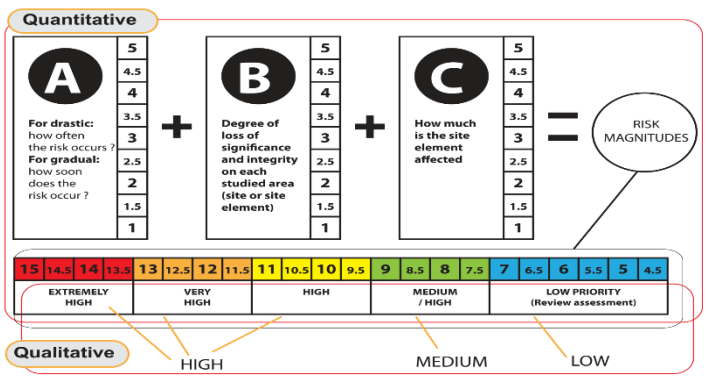

Fig. 5– Magnitude of risks based on ICCROM–CCI–ICN, 2007

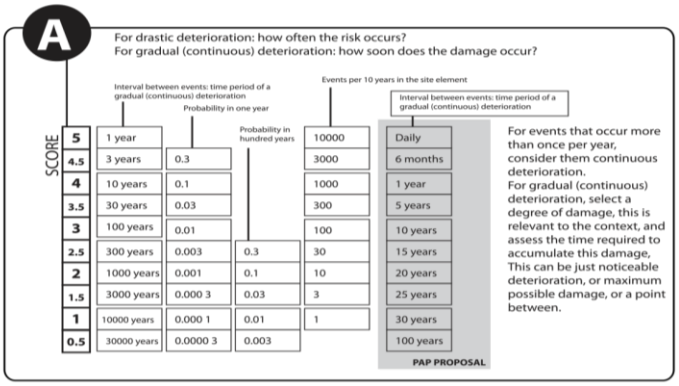

Fig. 6- Probability of score A describes how often the risk occurs based on ICCROM–CCI–ICN (2007)

B

Degree of loss of significance and integrity of the studied area (site or site element)

Use the average loss across all site elements affected in the studied area.
For continuous deterioration, be sure to assess the damage at the point of time selected for A

SCORE	Definition	Ratio of equivalent loss
5	Total, or almost total, loss of significance in the studied area	1:1
4.5		1:3
4	Substantial loss of significance in the studied area	1:10
3.5		1:30
3	Small loss of significance in the studied area	1:100
2.5		1:300
2	Tiny loss of significance in the studied area	1:1000
1.5		1:3000
1	Miniscule loss of significance in the studied area	1:10000
0.5		1:30000

Fig. 7– loss of value score B based on ICCROM–CCI–ICN (2007). Value of B can vary from total loss to tiny or trace loss. It indicates the size of the loss of value that expected in each item of the heritage asset affected by the risk. To estimate the B value first, it needs to visualize the type and the extent of damage they will suffer. Then a judgment about how much this damage represents in terms of loss of value in each item can be made.

C

How much is the area (for group of elements) or the site element (for individual element) affected

SCORE	Definition	Fraction	%	Decimal
5	All or most of the site element significance	1	100	1
4.5		1/3	30	0.3
4	A substantial fraction of the site element's significance	1/10	10	0.1
3.5		1/30	3	0.03
3	A small fraction of the site element's significance	1/100	1	0.01
2.5		1/300	0.3	0.003
2	A tiny fraction of the site element's significance	1/1000	0.1	0.001
1.5		1/3000	0.03	0.0003
1	A minuscule fraction of the site element's significance	1/10000	0.01	0.0001
0.5		1/30000	0.03	0.00003

Indicate in the assessment the measurement unit used for calculating the fraction:
Counting: number of site element , or groupings such as site element types (like caves or tombs,...) , areas(based on geographical location), etc.
Area occupied: area, volume, etc
Relative significance: how much of the total site element significance is in the affected part?

Fig. 8– fraction susceptible score C based on ICCROM–CCI–ICN (2007). This score indicates how much of the heritage asset value is affected by the risk. Does the risk affect the entire heritage asset, a large part, a small part or just a tiny part of it? How important is the part of the heritage asset affected by the risk?

2.4 Evaluate

The purpose of risk evaluation is to evaluate the outcome of risk assessment in order to manage risks and decide which risks need to be mitigated and in what priority and assessing the costs and benefits associated with each strategy. This can be implemented by means of risk matrix. The 3x3 risk matrix can be applied to evaluate the outcome of risk assessment. Three main types of risks can be identified according to their severity and impacts repeat: type 1: catastrophic and rare, type 2: medium and intermittent, and type 3: moderate and steady. Fig. 9 shows the 3x3 risk matrix, which can be used to manifest each agent and threat in one or more of the three types of risks.

Usually, in heritage risk management 5x5 risk matrix is utilized. Risk mitigation strategies or responses can be reviewed once all risks have been identified and their magnitude has been assessed and evaluated. Table 2 provides risk level priority (evaluation) of a 5x5 matrix. Accordingly, the risks and their magnitude are determined with their priority to the heritage asset. Thus, effective measures can be utilized to eliminate or reduce those risks in the next step.

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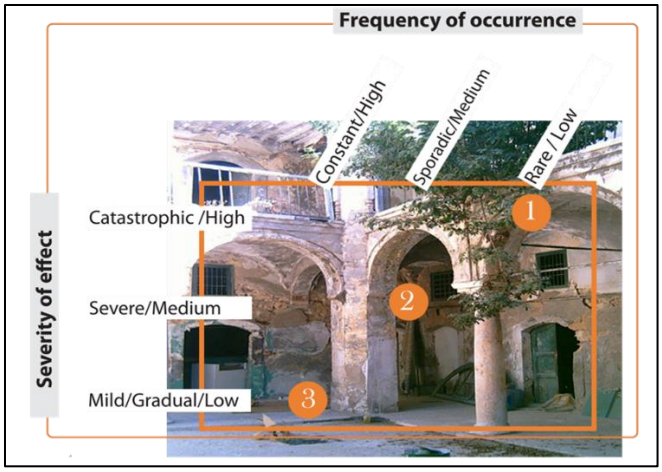

Fig. 9- Illustrated the 3x3 risk matrix of severity and frequency. Using this matrix, each agent and threat can be manifest in one or more of the three types of risks. (Pic of Quranic school of Ahmed Pasha Al-Qurmanli)

Table 2- Risk evaluation by a 5x5 matrix

Level of priority	RM		Description
	from	to	
Catastrophic priority	13½	15	All or most of the heritage asset value is likely to be lost in a few years.
Extreme priority	11½	13	Significant damage to all the heritage asset, or total loss of a significant fraction of the heritage asset, is possible in approximately one decade. All or most of the heritage asset value can be lost in one century
High priority	9½	11	Significant loss of value to a small fraction of the heritage asset, or a small loss of value in most or a significant fraction of the heritage asset is likely in one century.
Medium priority	7½	9	Small damage or loss of value to the heritage asset over many centuries. Significant loss to a significant fraction of the heritage asset over many millennia.
Low priority	7 & below		Minimal or insignificant damage or loss of value to the heritage asset over many millennia.

2.5 Treat

After risk ranking and selecting the most effective options to treat the priority risks, the next step is to make a plan for their implementation. In this plan, a realistic timetable illustrating the time length, measurable outcomes illustrating the changes and improvements will be able to notice, to measure, clear roles and responsibilities for the persons and sectors of the organization to be involved in the treatment of each risk, and necessary resources. However, there are five different options to control the risks; avoid, block, detect, respond, or recover.

1) *Avoid*: eliminate the sources and attractants of the agent of deterioration. one procedure designed to eliminate a threat without any intervention is put some signs such as 'Do not climb on the archaeological remains.' Other example, avoid food and other attractants for pests in collection areas.

2) *Block*: If it is not possible to avoid the risk, establish protective barriers to block all access and paths of the agent of deterioration. For instance, block unauthorized entrance of visitors in fragile areas of a heritage site.

3) *Detect*: the agents of deterioration and their effects on the heritage asset. It is important to monitor the different agents to react quickly in case they threaten, or begin to damage, the heritage asset. Detection alone is not enough; it needs to respond effectively whenever a problem is detected. One example is installing security cameras to detect the presence and movement of people inside and around the museum building.

4) *Respond*: Respond to the presence and damaging action of the agents of deterioration on the heritage asset. This stage includes all planning and preparations to enable a quick and effective response. Detect and Respond should

always be considered together when developing options to reduce risks. As example, stabilize the structure of a traditional wooden building at risk of collapsing because of termite infestation. Use inert gas on objects infested by harmful insects.

5) *Recover*: recover from the damages and losses caused to the heritage asset. If everything else fails, the only option is attempting to recover the items or parts of the heritage asset affected by the agents of deterioration. Various actions can be taken to ensure successful recovery (complete and update documentation of heritage items, budget allocated for emergency, insurance, expertise identified and contacted in advance of any event, etc.) An associated element is to reconsider what went wrong and plan improvements.

2.6 Monitor

Risk management is a continual process and a repeated cycle that needs continuous attention to determine significant changes that may occur. These can be changed in the context of the heritage asset or the value assessments; it can be also the appearance of new important risks, or the availability of new knowledge that may modify the results of the risk analysis and the prioritization of risks. When these changes occur, a review and modification of the decisions should be made to maintain the effectiveness in reducing risks to the heritage asset.

3. Case Study of the Ancient Tripoli Old City, Libya

Old city of Tripoli (Fig. 10) is one of those sites which are under a variety of risks. Natural disasters, development, tourism, pollution, looting, conflict and inappropriate site management are merely some examples of these risks. Implementation of the mitigation strategy to treat the risks is based on the results of the risk assessment. This study outlined how to design a risk management methodology that will enable the systematic identification of disturbances and threats to a site, assessing their impact and the vulnerability of the monuments and other features of the site. Therefore, the site managers and concerned authorities can plan more in-depth assessments for the most significant monuments or areas at risk. This process provides a framework for deciding appropriate mitigation strategies, based on cost-benefit analysis. For preventive conservation, risk management can provide a framework for decision making.

Fig. 10- Tripoli oil city, Libya

The ancient Tripoli city in Libya that has preserved its features and architectural and artistic styles, and its unique urban features are unique. The salient elements of ancient cites date back to the civilizations of the ancient world, 2700 years ago. It is the ancient center of Tripoli overlooking the Mediterranean Sea. Surrounded by a wall and containing a number of shops and cafes, the old city contains a large number of historical buildings, some of which date back more than 500 years. However, the largest proportion of these buildings dates back to the Ottoman and Italian occupations. These few parts with their old landmarks and styles remain a sanctuary for researchers in order to attempt to understand how the city looked like.

The spread of modern buildings, which are rarely in harmony with the surrounding heritage buildings, are on the north along the waterfront and in several points in the old city. As a result of these developments, the city Committee decided in 2009 to launch an ambitious project to rehabilitate the old city of Tripoli on the basis of a long-term vision and in

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accordance with the UNESCO standards that guarantee the rehabilitation of the heritage buildings under the best technical and scientific conditions. The project is based on the rehabilitation of the old city on a comprehensive and integrated approach divided into three axes that overlap accurately: (1) *structural axis*: work on infrastructure, restoration, maintenance, reconstruction and public spaces, (2) *the humanitarian dimension*: economic, social and cultural work, and (3) *management axis*: intelligent management of transport and other urban services.

3.1 Step 1: Context

In this case study, the delineation of property boundaries, the scope of work, GIS vector layers, coordinates of existing border points, land-use and zoning, technical mapping, and photographic documentation for each border points was identified and descripted. The scope of the site and site elements presented in Fig11. Additionally, Fig 12 shows the location of the historical and heritage sites according to their importance. The dark blue sites in the figure are the most important heritage building, while the red sites are building constructed after 1950. Also, mapping, analyzed of the borders, land-use and zoning is illustrated in Figs 11, 12 and 13. Though, the site is divided into six administrates divisions as shown in Fig. 14.

Besides, according to the general population census in 2006, the population of the Tripoli old city is1490 families and 7626 individuals, occupying 1400 residences (70% of the city's dwellings). More than 50% of the population are foreign migrants, 42% of the population of the site are illiterate and 21% have completed the primary school. 73% of the dwelling are in poor conditions.

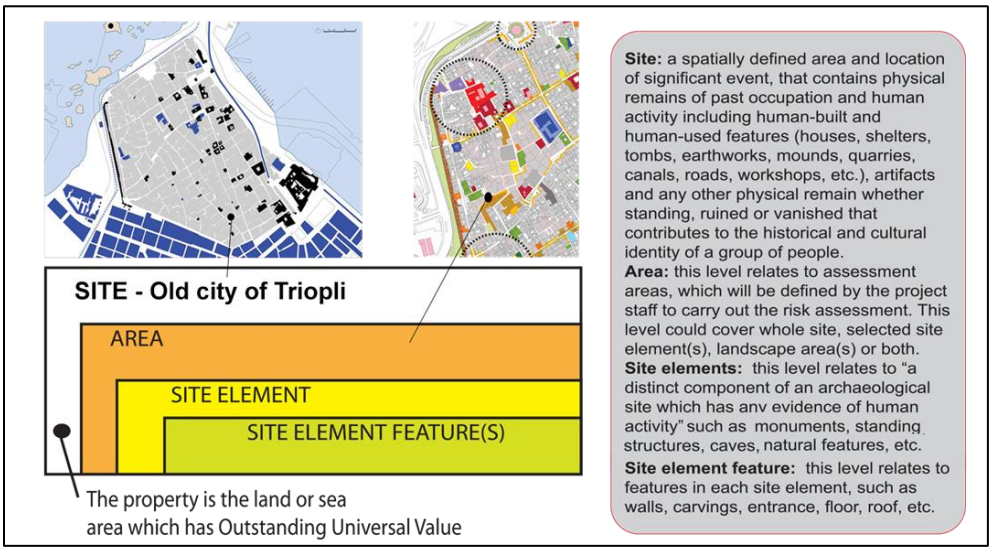

Fig. 11- Levels of detail for risk assessment

3.2 Step 2: Identify

Tripoli old city was threatened by a number of different risks from different sources. Natural risks such as weathering, flooding, and biological degradation. Anthropogenic such as human activities, vandalism, theft, lack of maintenance, tourism, neglect, and lack of regulation on vehicle transportation. These risks are coupled with the vulnerability and fragile sites, inadequate restoration works and lack of the site management system. However, the migration movement and population change along with the poverty are the most important risks. As a result, the identified risks summed up into seven risk categories; (1) migration movement and population change, (2) week management and state regulatory body, (3) spread of rainfall and sewage effects, (4) inadequately defined roles and responsibilities, (5) insufficient skilled staff, (6) politic context, and (7) lack of knowledge of restoration techniques. The pictures presented in Figs 15 to 18 explaining some of those risks.

3.3 Step 3: Analyze

Based on 5x5 risk matrix, the identified risks were analyzed and evaluated as explained in Table 3. the values of A, B, and C score were evaluated and signed in the risk registration log as described in Table 3. Then the quantity and the quality magnitudes of each identified risk were obtained.

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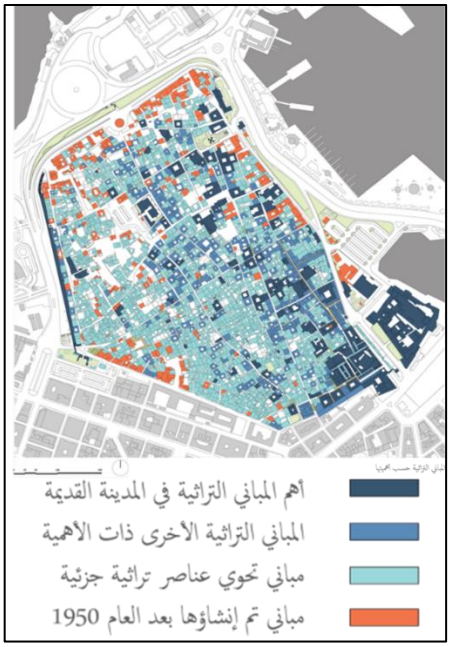

Fig. 12- Historical and heritage sites according to their importance

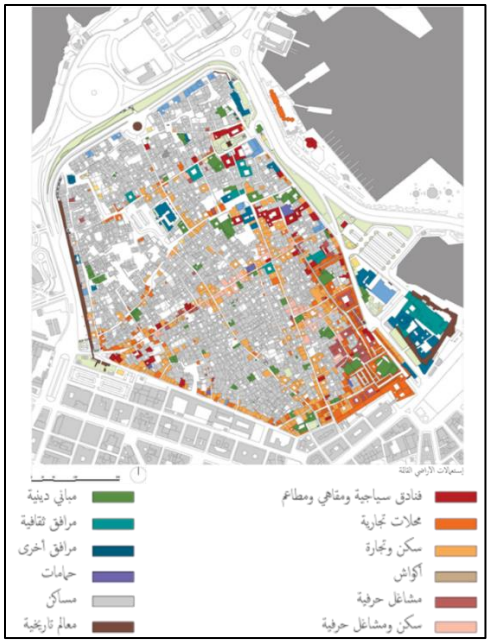

Fig. 13- Mapping of analyzed sites. Land-use zoning

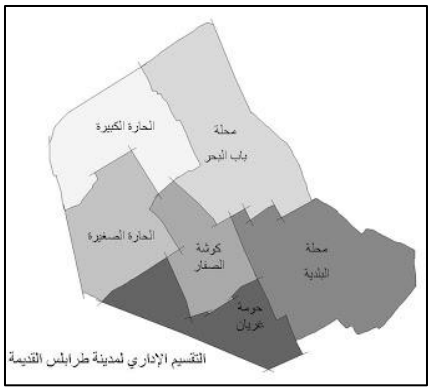

Fig. 14- Administrative Division of the Old City

Fig. 15- Deterioration of building

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Fig. 16 - Remnant of the Bin Al-Tayf Mosque with modern buildings behind

Fig. 17- Ruins of the Danish Consulate

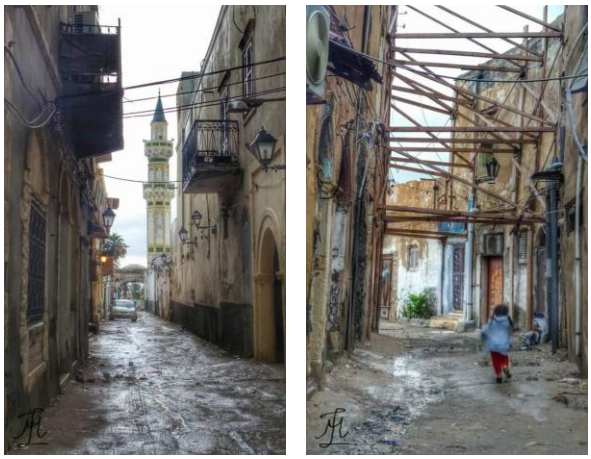

Fig. 18- Rainfall and sewage effects

3.4 Step 4: Evaluate

In Table 3**,** a scale of RM values classified according to their level of priority: catastrophic (in red color); extreme (orange); high (yellow); medium (green); and low priority (blue). The biggest possible value of RM obtained with the A, B and C scales is 15. The main critical risk is the risk of migratory movements and changes in the population. It has a catastrophic priority with RM of 14.5. Ranked second the risk of weak management and state regulatory bodies and the risk of Lack of knowledge of restoration techniques with RM of 13. Whereas, the risk of insufficient skilled staff has the lowest RM (6.5) and low priority. Fig. 19 demonstrated to compare, prioritize, and show all the risks that affect the heritage site. The graph presents the risks magnitude. It shows seven risks to a historic Tripoli old city.

Conclusions

This applied methodology of risk assessment is aimed to provide guidelines for risk management at historical and heritage sites. The scope of work, GIS vector layers, coordinates of existing border points, land-use, zoning, technical mapping, and photographic documentation for each border points were utilized as tools to identify the proposed risks at Tripoli old city in Libya. The magnitude of each specific risk is obtained based on ABC scaling method for risk analysis and 5x5 risk matrix. Afterward, the identified risks are summed up with seven main risk categories; (1) migration movement and population change, (2) week management and state regulatory body, (3) spread of rainfall and sewage affecting, (4) inadequately define roles and responsibilities, (5) insufficient skilled staff, (6) politic context, and (7) lack of knowledge of restoration techniques. Accordingly, ranked first place the risk of migration movements and population changes with RM of 14.5. Two Risks ranked second place; the risk of weak management and state regulatory bodies and the risk of Lack of knowledge of restoration techniques with RM of 13. Whereas, the risk of insufficient skilled staff has the lowest RM of 6.5 and low priority.

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Table 3– Risk registration shows the quantity and quality analysis of the identified risks

Risk		A score	B score	C score	RM	Risk Importance
R1	Migration movements and population changes	5	5	4.5	14.5	Extremely High
R2	Weak management and state regulatory bodies	5	3.5	4.5	13	Very High
R2	Spread of rainwater and sewage affecting buildings	3	2.5	2	7.5	Medium
R3	Inadequately defined roles and responsibilities.	4	3.5	3	10.5	High
R4	Insufficient skilled staff.	2	2	2.5	6.5	Low
R5	Political risks.	2	3	3	8	Medium
R6	Lack of knowledge of restoration techniques	5	4	4	13	Very High

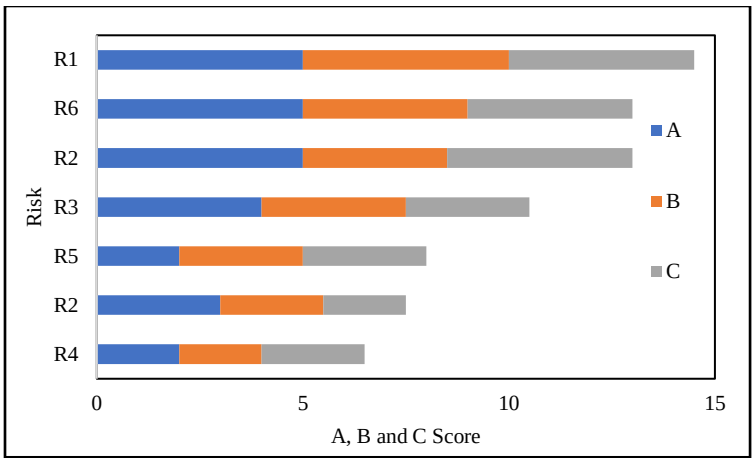

Fig. 19- risk priority

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