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## Coping with Rainwater Disasters: Saudi West Coast Cities Urban Planning Case study

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### Abstract

The research addresses the problem of disasters resulting from the flooding of rain water in the cities of Saudi Arabia, especially the cities of the West Coast, and the lack of future expectations for its urban planning, management and implementation. So the research aims to study and analyze the most important causes of these rain disasters and the resulting floods, and how to address them from the perspective of urban planning and its determinants by following the historical and analytical scientific method to monitor the phenomenon in time and follow-up, and to conclude compatible solutions according to the foundations of urban planning, however, the problem of flood disasters that occurred in most cities of the Kingdom, especially coastal cities could be controlled through its urban planning and its long-term future expectations. One of the results of the research was the need to make comprehensive long-term treatments for the drainage of rainwater and a comprehensive re-planning of the urban areas individually or conjunct as a whole integrated according to the determinants and foundations of urban planning.

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### Keywords:

Rainwater Disasters;  
Rainfall Streams;  
Flood Disaster Treatment;  
Urban Planning;  
Rainwater.

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### 1. Introduction

During the past few years, there have been many rain disasters in various cities of the Kingdom, including the cities of the West Coast, and it is noted that most of these disasters were due to the uncalculated human intervention. Whether voluntary intervention is the result of leniency and inadequate understanding of the magnitude of the problem or involuntary due to rapid urbanization and complexity of problems and limited knowledge, but most of them from the point of view at the moment, was the inevitable result of a defect in urban planning and management, because most of these public plans, and expectations of the future, details and management of implementation over the past few decades, some shortcomings have been accompanied by planning, implementation and management. The speed of urbanization and the Urban Sprawl associated with it and the random construction in the areas and the main natural valleys of the discharge of the rains of rain were the most influential factors on what happened from the disasters of rain and floods. We can also say

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that there is a continuous imbalance between the speed of urban and economic development and social and cultural variables and the level of urban planning unbalanced with planning, implementation and management. The aim of this research is to link the interrelationship between the disasters of floods that have occurred in the past years and the importance of utilizing them to reorient the urban planning of these cities, in order to develop possible plans and solutions, especially since most of them are the result of a defect in the general urban planning and its details and management of implementation that can be overcome and reduced in the future.

The research is divided into six sections, this introduction is the first section, and then presented the research problem and methodology followed in the next section.

In the third section, the causes of floods and floods in the cities of the west coast of the Kingdom were reviewed. In the fourth section, the phases of flood and flood disaster planning were explained in detail, while in the fifth section the city of Al Lith was taken as a case study of the research and at the end of the research a presentation of the summary and the conclusion in the sixth section.

## **2. Research problem and methodology followed:**

### *Research problem:*

The main problem of rain and flood disasters in most of the cities of the west coast of the Kingdom lies in the deficiencies of the general urban planning and detailed plans and in the management of its implementation, and its inability to absorb the discharge of the water of these direct and movable rains. The rapid urbanization and the rapid urban growth associated with uncontrolled outside the boundaries of planning, and building on depressions, valleys and streams flood, has hampered the flow of rainfall in its natural streams, and then diverted into cities, which led to disasters that have occurred and are expected to occur in the future, especially in The cities of the west coast of the Kingdom, if not reconsider the planning and re-planning of those cities according to a new vision that takes into account the accumulated experiences and developments, and all related studies.

### *Research aims:*

The research aims to link the problem of disasters and floods of rain floods and address them in the future, through the work of a comprehensive long-term strategy for urban planning and re-planning of these cities with their suburbs and regions, according to integrated studies that take into account all the results and studies of specialists related to this, in order to address the problems of the current situation and expectations of city expansion Future, especially since most of the rain disasters that occurred were at normal rainfall levels, some of which resulted from a lack of understanding of the relationship between the speed of change and the extent of knowledge of its implications and adaptation planning and as a result of rapid urbanization systematic and random accompanied by imbalance urban planning imbalance with the speed of urbanization and urbanism, which this research seeks to discuss and put some proposals to address them.

### *Research hypothesis:*

*The research hypothesized that sound urban planning based on integrated studies, can avoid the cities of the Kingdom, especially the cities of the West Coast bordering the Red Sea, many of the disasters of rain and flood, similar to what happened, and in the worst case reduces the risk of rare heavy rainfall to the lowest level, and achieve high levels of Security, safety and safety provides a great national wealth.*

### *Research Methodology:*

The research followed the descriptive analytical scientific method by tracking the historical nature phenomena derived from the results of the relevant sciences and analyzing them and extracting the useful ones.

It also follows the scientific methodology of the foundations of contemporary city planning and the expectations of its balanced development with the current urban expansion, especially the rapidly expanding cities and urban development, and analyze them and conclude the determinants and elements that can be followed and benefit from them when conducting the planning and re-planning of the existing cities.

## **3. The reasons for the occurrence of rain and flooding in the cities of the west coast of the Kingdom**

### **3.1 General reasons:**

Typically, rain and flood floods occur as a result of heavy rains that exceed the normal range of rainfall, or potential cyclical forecasts that are taken into account when preparing the city's urban master plan to accommodate it in feeding the green areas and discharge the surplus to the designated sewers, whether surface or infrastructure networks. To drain rainwater, and when the heavy rainfall and the resulting floods exceed all these planned limits, flood disasters occur and are very rare. [3], [6]

In the cities of the western coast of the Kingdom, it is believed that the level of heavy rainfall did not reach those unexpected high levels, and is in the case of proper urban planning in the normal expected level that can be faced and addressed planning and management. This does not mean criticism of deficiencies in

the previous urban plans, but that the speed of urbanization and urban growth exceeded the limits of the expectations of the plans of this stage, in addition to that the lack of rain during the rapid urbanization phase was limited, which gave messages to the public, especially to the engineers and planners of the stage that the level of Rain and drainage are still under control, which is reflected in the detailed plans and management, until the floods and floods in the city of Jeddah on 27-11-2009 [9], [10] and the subsequent message can be absorbed to reconsider and consider not only treatment and re-planning of water discharge Rain for the current cities that got out Disasters, but a more comprehensive message of urban planning and re-planning of these cities and all coastal cities and even all the cities of the Kingdom, and in the cities of the west coast of the Kingdom can be summarized the causes of rain and flood disasters in three main types:

**The first type:** direct rainfall on the city and the surrounding areas, which rains on the different areas of the city and is supposed to be taken into account when planning, as part of the absorption of land allocated to gardens and green areas of various types and discharge surplus easily and except in very rare cases, and when Increased rainfall than usual limits can temporarily hinder movement, and in theory this stage won't be reached unless there is a planning and administrative defect of some kind.

**The second type:** the rains that occur on the plains and the eastern mountains away from the cities and collect water forming large floods and moving through the gaps and valleys between the mountains to meet and gather the main valleys at the beginning of the western plateau forming large floods heading west (to the coasts of the Red Sea), and in other natural areas Torrential disasters are rare because the valleys are still normal since time immemorial, but when they head towards urban areas, cities have changed their historical main streams (valleys, canals and streams) as a result of sometimes uncontrolled urban growth, Or failure to Slums in the planning, management and implementation, disaster floods occur.

**The third type:** The most dangerous is when rapid heavy rains occur or for long periods of time in both urban areas (cities and its environs) or in the plains of the Tuhama and the eastern mountain ranges of the Red Sea coast, and when these rains accumulate and flow quickly to the western urban areas, where the soil is Saturated with rainfall, the disasters of torrential rains and torrential rains combine causing great loss of life, property, infrastructure and superstructure.

Rains and floods are considered as the most important stages that should be studied from all relevant disciplines in the long term and considered the criterion that should be considered as a determinant of the capacity of the streams of rainfall and discharge when preparing the overall master plan of cities or re-planning.

This means that the urban planning of cities must take into account the historical natural valleys passing through urban areas and prove them when planning and re-planning, to accommodate those floods coming from outside the city and at the same time to accommodate the discharge of rainwater within the various areas of the city to go to, in addition to planning other means of backup To address the expectations of increase, and then when the detailed plans are improved and refined and beautify the landscapes and urban spaces on both banks to meet the new urban requirements.

### 3.2 Schematic reasons [4]

The deficiencies are the urban planning of the city and the management of its implementation, which includes the following:

- 1) Lack of specific studies of the valleys of streams and the paths of floods coming from outside cities, and expectations of their future effects.
- 2) Deficiencies in the detailed plans, which are supposed to determine the paths of the floods at the district level and direct them to the general sewer of the city specified in the general plan of the city.
- 3) Lack of implementation and management of public plans and their details.
- 4) Rapid population growth within cities and more rapid urban development associated with it, which sometimes precedes planning determinants and expectations, and is affected by the market mechanism and is characterized by relative randomness.
- 5) Economic conditions that sometimes force some people to build in depressions and streams, either because they are empty land that is not owned by individuals or because they are cheap, especially in the rare areas of rain, whose impact only appears late.

### 3.3 Geographical reasons

Almost all of the world's traditional cities lie beside dry rivers or valleys, created as a result of fertile land and provide easily accessible surface and groundwater, but he chose their locations on creeks or elevated areas of the floodwaters.

With the contemporary urban growth and the subsequent rapid urbanization, and the urban planning intervention with the new concept, it is cities that took all these considerations into account and clearly

defined their future development plans, including those who neglected or tolerated solutions and their gradual and rapid urbanization expansion without a clear future vision. Depressions or streams directly caused mostly by individual economic investment, which subsequently caused such disasters.

The locations of most of the cities of the west coast of the Kingdom, especially the cities that were accompanied by very rapid urban and urban growth were among the cities that were exposed to rain and flood disasters, also some coastal cities that are still limited in size and growth may follow the same trend if feedback and lessons learned from all previous planning experiences are not taken into account.

### 3.4 Economic and social reasons

It is represented by the high level of income and living of individuals, the speed of general and urban population growth and the associated rapid urban growth sometimes exceeding the limits of the expected annual growth and the limits of the assumed planning, which is accompanied by the increasing demand for housing and lack of supply or that the housing supply is outside the income capabilities of low-income people, forcing some to occupy Some state land and individuals or purchase land in dangerous areas as a result of their low prices and then build on their housing and stability.

### 3.5 Impacts from floods in urban areas.



Figure 1: Jeddah disaster in 2009

Torrential rain floods are natural disasters that cause many losses in lives, property and pollution of the environment, and may be natural or man-made as shown in figure 1.

It requires efforts to address the magnitude of these disasters, and not so long ago the extent of the disasters that have occurred in some cities of the Kingdom, especially the cities of the West Coast such as the cities of Jeddah and Al Lith,

In 2009 and 2011, the floods in Jeddah left 113 people dead, hundreds injured and more than 10,000 homes, 17,000 vehicles and other commercial and industrial property damaged. [8] In recent years, the city of Al-

Lith has been hit by similar but less impactful disasters. We summarize the main effects of the flood rain disasters as follows:

- Endangering the lives of the inhabitants of those cities.
- The constant fear of the inhabitants of cities that are always exposed to the dangers of floods from those disasters.
- Destructive effects in buildings, facilities and vital and industrial facility.
- Exceeding the water level to its natural limits and the occurrence of floods.
- Causes many damage to lives and property on land inhabited by man as a result of the difficulty of control.
- Damage to facilities, means of transport, buildings and industrial and agricultural facilities.
- Damage to infrastructure facilities.
- The state treasury costs a lot of money that affects future development plans

## 4. Stages of flood and torrents disaster management

Urban planning is considered one of the most important urban sciences for organizing cities as it is the main tool to achieve a balance between land uses for different uses and the overall development of the city. Determining the division and use of land must meet the requirements of security, safety and security, which means avoiding dangerous places, including those exposed to rain floods of various expectations. It must also meet all security and safety requirements while providing the appropriate environment for economic and social development.

Many of the problems of rain and flood flooding in the cities of the Kingdom can be addressed through the comprehensive urban plans for those cities, which can be summarized as follows:

### 4.1 Urban planning of new cities or expansion of existing cities: [4]

The planning is done through the usual integrated studies in the overall planning of the cities by planners and engineers specialized in planning and with the participation of various disciplines related to planning from geographers, topographers, geologists, economists, etc.,

Everything related to the city is studied, including the annual rainfall and the rare heavy rainfall, and then take advantage of all this information and reflected in the urban plans, which in this case is less expensive and more economical in the short and long term and reduce its risks with urban planning.

In the new urban planning can be studied and predict their level and size in advance, before any expected rain disaster occurs as a result of rain floods can be faced and resolved in the normal situation.

#### 4.2 Urban Re-planning

Re-planning, improving or repairing existing cities requires the provision of all necessary information from specialists geographers, geologists and others and then integrated in the processes of urban re-planning, which requires the repair of many of the obstacles accumulated in time, including:

- 1) Removing many of the buildings that were built in the valleys and the flood streams.
- 2) Re-polishing and deepening the rainwater and flood paths.
- 3) Diverting some of the valleys to remote places to reduce the flow of these floods to densely populated places or perennial places.
- 4) When re-paving the streets, the tendencies of the rainwater paths are reoriented to the main paths within the cities with a more comprehensive view and according to an integrated planning for the discharge of surface torrents or underground drainage networks.
- 5) Raise the standard of the green areas of various levels and defined by (public parks - parks - islands beside the streets and sidewalks and the interfaces surrounding facilities and housing and reduce the paving and paving those spaces. [5]

#### 4.3 Urban Planning and Re-planning of Existing Cities:

Urban planning and re-planning is a science that combines the foundations and determinants of planning, new and reform or improvement in an integrated planning process, and is the planning principle followed in the planning of existing cities, by integrating new planning for the expansion of existing cities in the peripheries and suburbs to meet the expectations of expected urban growth and future urban needs, Planning existing areas and integrating them as an integrated planning unit, which is needed by all the current cities on the west coast of the queen (Jeddah - Yanbu - Al Lith - Qunfudah and others), a more comprehensive planning and addresses the city as a whole, including the treatment of drainage of flood water and patterns Heavy rainfall at all levels within the predicted forecast, thus avoiding the city from the disaster of floods of natural rains - similar to what happened in some cities of the Kingdom.

#### 4.4 Planning remedies for rain disasters

*There are many standard planning treatments to cope with heavy rains and floods, including the long-term and comprehensive urban plan based on integrated studies, according to the foundations and principles and criteria that take into account all the possibilities expected in the future, and are one of the most important determinants of the master plan, and some of them address the current situation by benefiting from nutrition Revised for planning in general and for treating the discharge of rainwater flooding within cities and suburbs in particular, which is usually done as facilities for re-planning existing cities.*

#### 4.5 Partial remedies for rain disasters in existing cities

*The most important remedies for flood disasters in the planned cities are summarized as follows:*

- 1) Re-planning and gradually implementing the flow of floods according to integrated future plans.
- 2) Increasing the areas of green areas and natural lands prepared for agriculture.
- 3) Reducing the tiling and paving rates of lands allocated to green areas and gardens.
- 4) Gradual trend towards addressing them and increasing the area of green areas through the re-planning of cities according to the visions and plans of medium and long-term.
- 5) Implement and asphalt the streets according to the correct technical methods and directing tendencies towards the slopes and drains.
- 6) The work of the rainwater drainage network according to planning requirements.

*In other words, future comprehensive remedies for drainage and flooding in coastal cities are carried out through urban planning and re-planning, with an emphasis on annual and seasonal rainfall and rare rain cycles, which occur over long periods of time that may exceed 50 years.*

#### 4-6 Future treatment and management of rain flood planning procedures.

In preparing the master plan for any city, there are many technical planning measures taken to deal with the discharge of rain water and to face the potential disasters resulting from it or other disasters, based on integrated specialized studies, and here is a very brief reference to some of them and the most important:

- 1) Maintaining, treating, refining and improving the historical natural valleys passing through urban areas to accommodate the amount of rainfall in the rainiest period during a certain period of time based on the results of integrated studies of specialists and relevant authorities.
- 2) Pre-reservation of the valleys of these valleys with fever around them and at certain distances on both sides in both directions and at a distance of not less than 100 meters from the axis or edges of those valleys as protection for them, and according to their planning task, and at the same time used as arterial strip gardens and vents for the population that penetrates urban areas and cities, and is considered lung and breathing For the city, it can be calculated from within the public open spaces and areas to the green at the level of the city's overall scheme. It is a process followed in the planning of many cities of the world.

3) The general plan for contemporary cities, especially large and transcendental cities, should include the division of their land uses into large gardens commensurate with their size, such as reserving lands for regional parks with large areas;

May exceed hundreds of hectares, one of the United Nations proposals or recommendations that have defined parks at the city level of 200 to 400 hectares [12],

Some of them are comprehensive gardens that contain all activities, including large and suitable artificial lakes.

It is made through drilling and backfilling (drilling of lakes, collecting dust by engineering design methods and forming it as mountains), and then diverting some rainwater to it in certain technical ways, and it will be an auxiliary solution for mitigating flood disasters while at the same time utilizing them to mitigate the atmosphere and improve the environment, recreation and breathing space for urban residents. And, most importantly, the land stone for the benefit of the future of cities and their inhabitants will have many social, economic, environmental, and aesthetic benefits.

4) Raise the standard of green areas and land allocated for afforestation of different types and levels by not less than 30% of the total area of the city, a global standard followed environmentally and planning, and its importance lies not only beautify cities and improve social relations between the population and raise public taste, but also has environmental objectives And other social and most important: 1) its relative contribution in the filtering and purification of air from impurities and exhausts of cars. 2) Contributes relatively to the absorption of a proportion of rainwater. 3) As open spaces for emergencies of various potential and unexpected disasters.

#### 4-7 Streams of flood rain related to urban planning

Focusing on the locations of the cities of the West Coast of Saudi Arabia bordering the Red Sea coast, through Google Maps and other maps, note the main valleys coming from the Tihama plains and from the eastern mountain range to the west and towards the Red Sea coast. these valleys main varying between 5 and 12 kilometers, and almost rarely more than that, according to these dimensions or estimated distances (which require deeper and more comprehensive studies, because it may derive from certain laws benefit urban planning of coastal cities). According to these dimensions between the major valleys to be left gaps of these valleys penetrate urban areas and cities, with the need to make certain planning treatments for them and their sides, and are among the determinants of urban planning for the cities of the west coast of the Kingdom, and the constants of the preparation of urban planning, such as mountains and rivers Absolutely, it is in fact a dry river that is usually reserved for monsoon rains and rare occurrences.

According to a study on the events of the floods that occurred in the city of Jeddah (2009-2011) identified the main valleys that connect the city with 15 valleys starting with the valley of villages and Alasla in the north and up to the valley of Alkhomra in the south, some converge to form a main valley penetrating the city, and divided drainage basins affecting the city With three sections north, center and south [2].

When analyzing the city of Jeddah as a model of this natural phenomenon, as a large city and the largest city on the west coast of the Kingdom, it is noted that taking these valleys into account in their planning according to their current situation is not planning schematically, although the city extends longitudinally along the coast from the north to the south planned distance It is currently more than 70 km long, with a width from east to west ranging from 12 km to more than 25 km.

Theoretically, based on the naturally defined distances between the main valleys along the city, it means that it penetrates the city from east to west by at least five major dry valleys devoted to direct and transmitted rain floods (Figure 3), Detail and accuracy of this is done jointly with the specialists, and planning that these valleys can be considered as determinants of the urban planning of the city, and gaps that penetrate the city from east to west surrounded by sides with striped green areas, according to the visions of future planning for the future, are coordinated as breathing spaces for the city and the parks breathe the city from It will also have other planning benefits in the future development of the city. While the application of this in the perennial areas is impossible because of its great potential, but the lessons learned from it remain very important, not only to re-urban planning and rehabilitation and reconsider the planning of future urban areas in both the north and south of the city. It is even more important to take them into account when planning and re-planning urban fast-growing small cities such as Al Lith, Qunfudah and other West Coast cities.

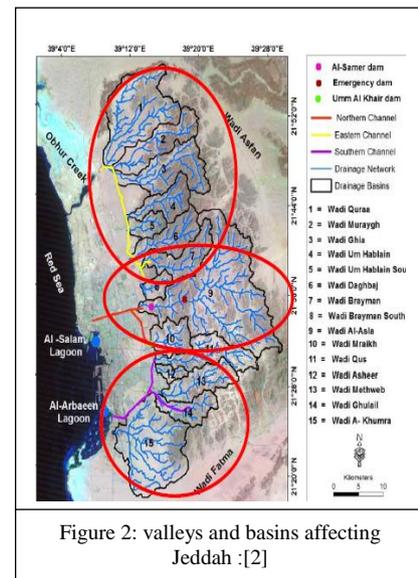
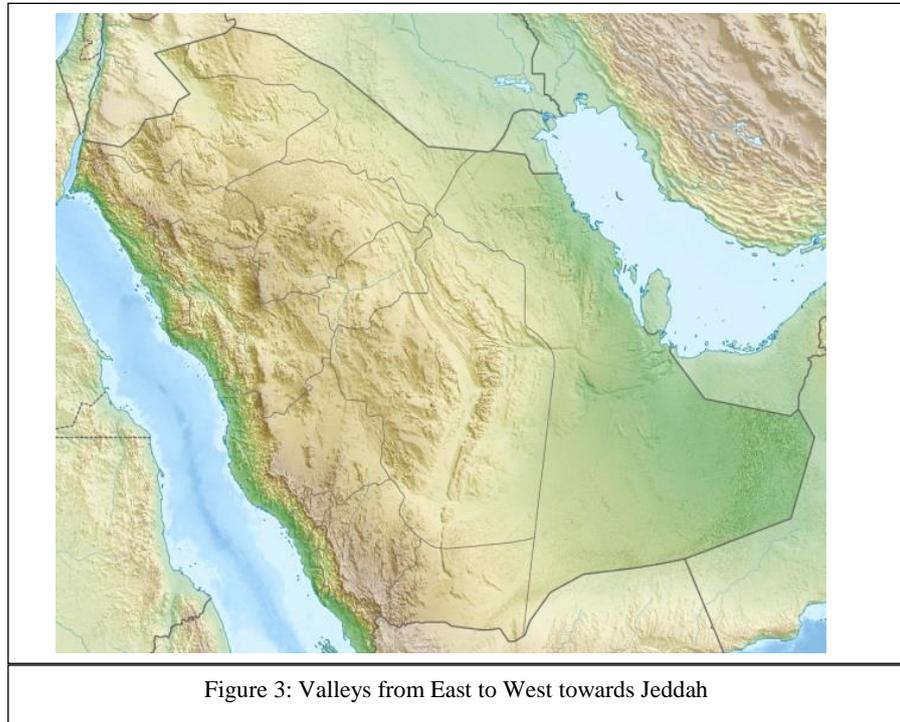


Figure 2: valleys and basins affecting Jeddah :[2]

In an accurate analytical comparison, how Jeddah was 50 years ago and how it is now, it is possible to deduce the projections of the development of Jeddah and the rest of the West Coast cities 50 years from now, especially all the indicators show that the future development prospects will be more attractive and successful in coastal cities, which is what many future studies indicate the development of cities.



### 5. The city of Al Lith and the frequent disasters of flood: case study

Al-Leith is a small city overlooking the Red Sea and is located about 200 kilometers south of Jeddah. It has a surface area of 2.8 square kilometers [11] and a population of 80,818 people, of whom 16% are non-Saudis.

It was selected as a model for the small cities that are expected to grow in the future due to its location on the Red Sea coast, and also according to the future comprehensive development plans of the Kingdom which focus on the development of coastal cities and the balance of urban development. It is also frequently exposed to rain disasters and followed the comparison by analyzing its future urban planning in the near term, as implemented, which was read, analyzed and calculated from the reality of Google Earth's aerial maps of 2018 as a reality, and then analyzed the extent of its achievement of security and safety requirements. Especially with regard to the disastrous rains of floods, both direct and movable which are heading to it from the main valleys coming from the Tihama plain and the eastern mountain range of the city.

#### 5.1 Urban planning and rain disasters

The analysis of its urban planning relied mainly on Google Maps legacy [10] as a visual reality of the current scenes and pension through the implementation streets and land divisions, and also through direct field exploratory field visit to the city. From the analysis it is clear that the perennial area is approximately 2.8 square kilometers, while the planned area exceeds 7.5 square kilometers, which means that the area of perennial land only constitutes only 37% of the total planned area.

When analyzing the nature of its urban planning and the growth of the city, it is clear that the length of the planned area adjacent to the coast from north to south is 7.2 km while its average width is less than 1.5 km.



It is clear that their urban planning is similar to other coastal city planning, where its main growth spans are by sea while supply

It remains limited, and was focused on discussing the efficiency of its urban planning in the treatment of drainage of direct rain water on the city and its environs, and the disasters of rain floods transmitted from the plains of Tihama and the eastern mountain range of the city, and noted from the urban planning of the city that the maintenance of the continuity of two The main valleys penetrate the city and its flow from east to west, with a width of approximately 100 meters in addition to the main streets of different widths on both sides of the Hungary, which means that its urban planning took into account and identified and proven schematically, and theoretically is able to accommodate the flood Expected.

However, the safety of its implementation and linking it to the network of arteries of the main and secondary streams and their management, compared to the torrential rains that occur frequently in the medium and long term, make it difficult to judge them and their efficiency to absorb these torrents, especially since during the past four decades there have been many disasters of rain rains on the city, especially Floods rains carried from the plains and eastern mountains of the city, which led to major disasters in lives and property, the last of which was in Rabi I of 1440 AH (23 -12-2018). This means that its integrated urban planning or implementation and management still needs to be updated and reviewed, through analysis, evaluation and re-planning, especially since a high proportion of land is not implemented, and the size of the city is still under control, and must be planned, repair and treatment before the city expands and accumulates and complicates its problems By benefiting not only from the flooding disasters that have occurred, and similar cities on the west coast of the Kingdom are many, but also from global experiences in dealing with disasters of rain and floods, and it's normal what is said about the city of Al Lith and the city of Jeddah also applies to the rest of the Kingdom, especially coastal cities . In order to clarify the picture of the disasters of floods, the city of Al Lith and its environs in recent history, we review examples such as that shown in figure 5.

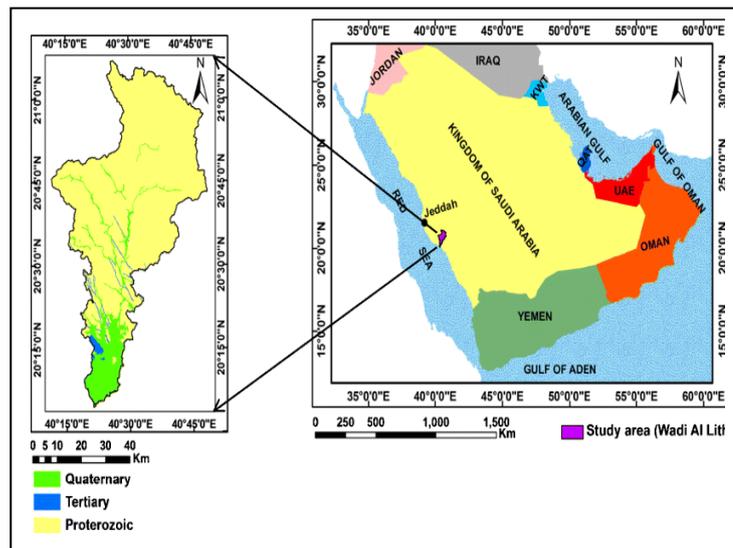


Figure 5: Flood mapping in Wadi Al Lith

### 5.2 The city of Al Lith and the recurrence of flood disasters

From tracing the disasters of rain in the city and its suburbs in the recent history of the city in the past four decades, it is clear that these floods (considered a heavy guest to the city is not welcome), are constantly repeated leading to major disasters in lives and property, the most important [7]:

1) In 1398 AH, the governor raided large floods coming from the Valley of the Al Lith concentrating its danger of completely destroying the village of 'Amika' and leaving human casualties.

The village was then relocated.

2) In 1410 AH floods swept the city of Al Lith, but the impact was limited.

3) In 1412 AH and in 1413 AH, large and huge floods raided the city of Al Lith movable coming from the basin of the Al Lith Valley, and led to disasters in lives and property as a result of which closed streets and houses and destroyed many of the property of the population and remained painful effects in the memory of the people until now.

4) Then in the middle of Rabi I 1440 AH flood came from the eastern areas of the city and despite the direction of the bulk of them to the channels of drainage water south and north of the city, but they

overflowed, and some entered the city and disrupted the movement and sent terror to the population, although the impact remained limited.

From the study of the recurrence of floods disasters of the city and its environs, it is clear the importance of the studies of this phenomenon in more detail by specialists in this field, and then reflect all the results and treatments assumed for these phenomena and various studies related to urban planning of the city, and the generalization of similar with other cities, in order to reach To final solutions to their expectations of occurring at least at the levels considered during the time periods of approximately 50 years or more.

## **6. Summary and Conclusions**

### *6.1 Summary*

It is clear that the problem of rain disasters is linked to the roots of urban planning, considering that the treatment of one of the most important requirements, which must be considered and studied in all respects when preparing a comprehensive urban plan for any city, and therefore must be fully reviewed the determinants of the preparation of comprehensive urban plans for cities, which It should include the integration of both urban planning and re-planning into an integrated urban plan for cities and their suburbs according to a comprehensive long-term vision that takes into account all the latest accumulated experiences locally and globally related to them, including the rapidly growing West Coast cities that should be Its main objectives are to provide security, safety and safety from the danger of rains and disasters resulting from them, either direct or potential rains transferred to and coming from the Tihama plain and the eastern mountains of the city or from other areas by virtue of its location.

### *6.2 Conclusions*

The results of the research are summarized in the work of comprehensive long-term remedies for the discharge of rain water at different levels according to the predictions of the most frequent periodic rainfall, over a relatively long period of time, and the integration of treatment through the planning and re-urban planning of urban areas individually or conjunct as a whole integrated according to the determinants and foundations of urban planning and standards and most important:

- 1- At least 30% of the urban area should be left as green areas of different types and levels, which is a global environmental and planning standard requirement, an area capable of absorbing a large percentage of direct rainwater coming down on urban areas, and detailed analysis of urban planning standards in the Kingdom. In fact it contains more than this ratio.
2. The natural valleys that have been identified by the torrents for thousands of years must be preserved in accordance with their size and the related planning and design requirements.
- 3 - Urban planning and re-planning with its inherent potential, not only able to address the discharge of rainfall in the areas of new expansion, but also able to address even the old areas that did not apply the standards of the foundations of contemporary urban planning, and must be through the adoption of long-term urban plans and legislation .
- 4 - Planning and design of gardens at the level of major cities and regions large areas on the outskirts, in accordance with the approved standards, it is desirable to contain lakes, parks and recreational places for the population is provided by diverting the flow of some seasonal torrents to them through engineering design methods.
- 5- The correct scientific methods should be followed by implementing the main and secondary streets network, commensurate with the discharge of rainwater and the resulting torrents and their different levels.
- 6 - Activating all adopted urban planning laws, which are related to security, safety and safety in its comprehensive and detailed concept, and work to study and address the gaps through which many of the security planning imbalances occur.

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