Baghdad flood Residential zone exposed to inundation by Mosul dam Hypothetical failure

Prof. Dr. Kareem Hassan Alwan¹*, Eng. Hadeel Yassin Abbas²
¹Center of Urban & Regional Planning for Post Graduated Studies, University of Baghdad, Baghdad, Iraq
²Master student in Center of Urban & Regional Planning for Post Graduated Studies, University of Baghdad, Baghdad, Iraq
*Email: kareem.h@iurp.uobaghdad.edu.iq

Abstract. Lately most of institutions in the world interest in floods states and the impact of inundation on the cities and land use that content of, because it’s important to realize the amount of hazard that will be faced when the flood occur by any case (Pluvial flood and dam failure flood) ,Which make the habitants understand how to deal with this flooded area each according to its location and conditions, In this paper we will confine the Residential zone in Baghdad city that exposure to flood causing by Mosul dam failure, GIS technique help us to observe, understand and calculate the areas of land use in cites that exposed to inundation hazard to study the scenario to deal with and treat this area, and understand how suitable the location planning of this land use ,By using the Hypothetical dam’s failure model of Mosul dam which built from the Digital Elevation Model and the cross sections of the rivers (That done by Iraqi ministry of water resources using HEC RASS program), Intersection this model with the Layers (shape files) of Baghdad city Residential zone, the analysis’s layer (the result layer) will show the damaged areas and it’s percentage to Residential use.

1. Introduction
The flood caused by the dams failure much extend and destructive than the rainfall or Torrents, so we have to study the Hypothetical dams failure model of all dams and its effects on the cities downstream it. The most common cause of flood-related deaths is People drowning in their own properties, or when travelling to or from their properties [1]. Less common causes of death are heart attacks and electrocution. Despite all the benefits and positive aspects of dams, it is rare for a dam issue - especially dams built on major rivers - to be devoid of some inherent risks or damages and negative effects, especially on social and environmental aspects, and if we start with the side effects, the most prominent of them can be summarized in the following points:
- The displacement of the communities located in the area of the construction of the dam, including disrupting the demographics and damaging the stability and existence of these communities.
- Removing natural habitats, some of which may be the nursery for some endangered animal and plant organisms and organisms, as well as causing the disappearance of some aquatic organisms as a result of the dam's seizure of them and their inability to continue their journey across the riverbed to the downstream [2].
We can see that forecasting of these kinds of flood is so hard and complicated. This paper will analyzes the spatial location of urban Residential zones and its impact on the disasters that hit and
confront the city, [3] and Classifying the lands of the city on the basis of the extent of the threat to which it is exposed by Mosul dam failure, Test the effectiveness scenario of the current land use.

In the literature, various researchers have applied in Mosul dam failure, but there is very few studies specialized in how it effect on Baghdad land uses.

2. Study Area

2.1. Baghdad

It is the capital of Iraq locate between 44°10’ E, 33°28’ N and 44°36’ E, 33°11’ N (figure 1) in the middle of Iraq country, its connect and distribute all the roads with Iraqi governments.

In 1973 first comprehensive development plan of Paul Surfs was revised to revitalize Karkh and Rusafa as central areas of the capital Baghdad [5] Baghdad has (9) Municipalities, 8 Million of population lives there.

The Tigris River flows through Baghdad city. The population has begun to settle along the river banks. And they quickly spread to larger areas, River is served the city in many ways, especially in meeting the huge demand for water for 24 percent of the country's population and those residing in Baghdad city of and its suburbs.

Figure 1. Baghdad location
Sources: Researcher, depended on Iraqi Ministry of planning data
Figure 2. Baghdad Land use
Source: The comprehensive development plan for the city of Baghdad

Baghdad is consider as semi-flat area where the level is between (36-34)m.s.l

Figure 3. Baghdad Digital Elevation Model
Source: Researcher depended on Iraqi Ministry of water resources data
The Residential use in Baghdad city showed in figure (4) Illustrate that (40509) Hectares are the area of residential use occupies around 54% from Baghdad city land use as official residents:

![Baghdad Residential land use](image)

Figure 4. Residential zones in Baghdad
Source: Researcher, depended on Iraqi Ministry of planning data

2.2 Mosul Dam
Mosul dam is the largest dam in Iraq and the fourth largest in the Middle East, Built in the middle eighties of the twentieth century to avoid flooding of the downstream, generate electricity and support the agricultural sectors through irrigation, Baghdad city less dependent on the energy generated and provided by the Mosul dam. Its regulated the flow of the Tigris River in its upper course, There is no doubt that Baghdad benefited from it to avoid frequent Seasonal floods [5].

The dam was built on related materials high solubility in water (gypsum, anhydrite, and lime sand), and it has about 11 billion cubic meters of water, from start of work on the dam in 1985, progressive concerns arose regarding humanitarian issues and bridging gaps. This required permanent monitoring and constant maintenance (injection of cement and nabutite) at the foundations of the dam [5].

Therefore the flood of dam failure might be effect as inundation only without a devastating collapse of buildings.

With the passage of time, Iraq suffered from exceptional circumstances and abnormal conditions: Such as wars, insecurity, weakness or absence of experiences. And the lack of materials and equipment necessary for maintenance. The lack of budget, all of these combined factors severely affected the periodic maintenance work. Which threatened the stability of the dam and its structural integrity. And it was difficult to maintain the necessary pace of maintenance, exacerbating the risk of dam failure.

The government realized the seriousness of the problem and the huge consequences of the collapse of the dam, which affects millions of people along Tigris River, Including Baghdad Governorate

Therefore, in 2016, the government of Iraq hired the international company, (Trevi), which has technical expert repair, maintain, upgrade and the dam structure, Equipment, monitoring systems, knowledge transfer, and building local expertise and capabilities for dam maintenance. The
intervention of international technical expertise is expected to have made a positive contribution to enhancing the durability of the dam and reducing the risk of its failure.

The failure of the Mosul Dam implies catastrophic repercussions in the form of a high tsunami-type water wave (ranging from 4 meters to 55 meters high) with destructive power. Sweep all that stands in the way. The strength of the waves, their height, and the volume of the water gradually decrease downstream. The waves may weaken in Baghdad, which is further away about 450 km from the dam. And that's due to the nature of flat ground. However, the spread will be much wider and cover large areas of Baghdad. And the flow will sink [4].

There is important point we should focus to study the foundations of the buildings of inundated land use in city and the extent of its withstanding exposure to submersion:

Baghdad is one of the cities that expanded and change the land use (sometimes out of masterplan that prepare by experts)

The bellow figure (6) illustrate the Hypothetical Mosul dam failure model in Baghdad, When the maximum water depth in lake in 319 m [6], The level of water classified in to 4 classes: (0-2m, 2.1-5m, 5.1-10m, 10.1-20m)
Figure 6. Hypothetical Mosul dam failure model in Baghdad, where the maximum water depth in dam lake is 319. Source: Researcher depended on Iraqi Ministry of water resources data.

The other figure (7) illustrates the Hypothetical Mosul dam failure model in Baghdad, when the maximum water depth in lake is 335 m. And also the level of water classified into 5 classes: (0-2m, 2.1-5m, 5.1-10m, 10.1-20m, 20.1-20.8m)
Figure 7. Hypothetical Mosul dam failure model in Baghdad, Where the maximum water depth in lake is 335 m

Source: Researcher depended on Iraqi Ministry of water resources data

3. Methodology
By using ArcMap v. 8.1 we convert vector of residential layer to Raster figure (8). Then we reclassified the flood model in to four classes figure (9).
Figure 8. Raster layer of residential zone
Source: Researcher, depended on Iraqi Ministry of planning data

Figure 9. Reclassified flood model layer
Source: Researcher depended on Iraqi Ministry of water resources data
Figure 10. The process of (Weight overlay) by ARC MAP

Then making (Weight overly) with reclassified flood layers as showed in figure (10). We use the weight of flood 100% that effect in residential use in Baghdad city. The result layer from this process, are two maps of inundation residential zones in Baghdad city, Figure(11) when the maximum depth of lake water is 319m, and figure(12) when the maximum depth of lake water in 335m.
Figure 1. inundation residential zones in Baghdad city, when the maximum depth of lake water is 319m

Source: Researcher after apply (Weight overlay) process

The areas and the ratios of the flooded residential zones estimated as below table:

Table 1. Areas and ratios of flooded residential zones, when the maximum depth of lake water is 319m

| Level of flood water(m) | Area of flood Residential zones(Hectares) | Ratio Of residential zone |
|------------------------|------------------------------------------|---------------------------|
| 0-2                    | 31687.5                                  | 78%                       |
| 2.1-5                  | 7959.27                                  | 19%                       |
| 5.1-10                 | 833.29                                   | 2.5%                      |
| 10.1-20                | 6                                       | 0.015%                    |
Figure 1: inundation residential zones in Baghdad city, when the maximum depth of lake water is 335m
Source: Researcher after apply (Weight overlay) process

The areas of and the ratios of the flooded residential zones estimated as below table:

| Level of flood water(m) | Area of flood Residential zones(Hectares) | Ratio Of residential zone |
|-------------------------|------------------------------------------|---------------------------|
| 0-2                     | 12740                                    | 31%                       |
| 2.1-5                   | 18238                                    | 45%                       |
| 5.1-10                  | 1000                                     | 2.5%                      |
| 10.1-20                 | 338.52                                   | 1%                        |
| 20.1-20.8               | 8192.48                                  | 19%                       |

4. Scenario Analysis
The flooded area concentrate along the river banks and the low level ground, in first scenario we noticed that the highest percentage of the areas exposed to flooding (78%) are submerged with a low level of water (0-2m).

While the lowest percentage of the areas exposed to flooding (0.015%) are submerged with a high level of water (10.1-20 m).
Second scenario clarified that highest percentage of the areas exposed to flooding (45%) are submerged with level of water (2.1-5m). While the lowest percentage of the areas exposed to flooding (1%) are submerged with level of water (10.1-20 m).

5. Conclusions and Recommendations

5.1 As the result map illustrated we can conclude the flowing points:
1. The flood sink the residential zone in Baghdad city in different ratios, when the water in dam’s lake level is low then the area of low inundated use is bigger than the high inundated areas, In the other side, when the water in dam’s lake level is high the area of high inundated use is bigger than the low inundated areas, that’s due to semi flat ground level of Baghdad city.
2. The maps obviously showed that the sectors along the river are the most exposure to flood specially the low level ground.
3. GIS technique is approximately the most accurate technique that applied (weight overlay) to estimate the effect of flood in residential zone in the city, However we can apply this technique with all other land uses of city.
4. Rusafra side specially (Aladhmiyah city) is the most inundation area will exposed to flood due to its low ground level and its location near to river, thus why the urban planner team has to take into consideration the level of ground and the location when planning the master plan of cities that locate along the rivers.

5.2 The paper recommend the flowing points:
1. Dams are so useful, But it is necessary to study and review its engineering and construction condition in order to know the extent of its tolerance and the safety of the cities that locate downstream dam’s lakes.
2. Creating scenarios for dam’s failure is a preventive and necessary process because it gives a complete perception of the state of land use downstream the dam to make it easier for the planner to take prior Procedures to reduce human and material losses.
3. When the urban planner do the comprehensive plan for cities, consideration must be given for location of the city and to study the percentage of its exposure to any kind of risk and study the location of land uses and infrastructure according to the percentage of risk and this is called (critical planning).

Reference
[1] Alawn, Dr. Kareem Hassan, Water Supply System Assessment in Urban Areas Using Geospatial, IOP Conf. Series: Materials Science and Engineering 745 (2020)
[2] Mufdhul,Muhammed Waheed, Dams, its types and failure hazard, Aljazerah magazine 2017.
[3] Muhammed, Usama Aldin Mustafa , Assessment of the change in land use in the city of Kassala, PHD thesis, Al Sudan 2010
[4] Ashraf Abdelkarim , Ahmed F. D. Gaber, Ahmed M. Youssef and Biswajeet Pradhan, Flood Hazard Assessment of the Urban Area of Tabuk City, Kingdom of Saudi Arabia by Integrating Spatial-Based Hydrologic and Hydrodynamic Modelling, 2019.
[5] Study of the Iraqi Ministry of Planning of the Hypothetical dam failure model of Mosul Dam2018.
[6] Jadaliyya magazine, The Master Plans of Baghdad: Notes on GIS-Based Spatial History, 2016. Techniques: A Case Study of Baghdad City
[7] Iraqi Ministry of water resources , the strategic study for land and water resources, 2014 .
[8] Iraqi Ministry of Planning, National Development Plan 2018-2022
[9] Web site (ESRI) https://desktop.arcgis.com/en/arcmap/