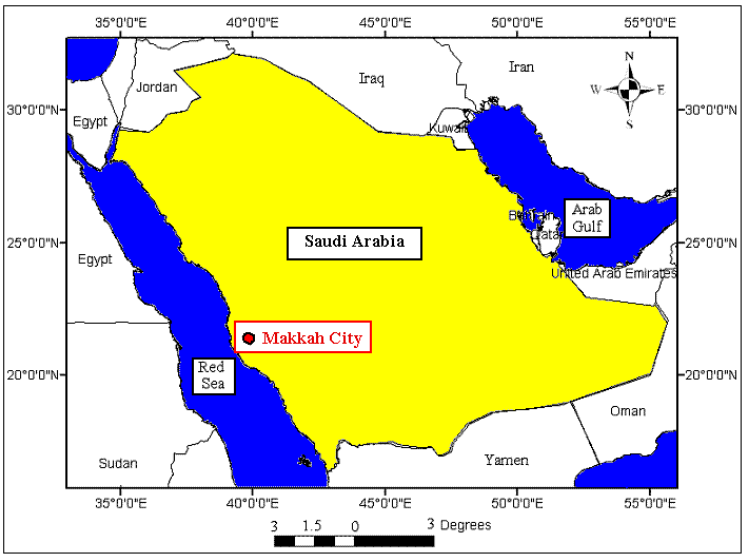
FIG WORKING WEEK 2012
May 6–10 2012
Rome, Italy

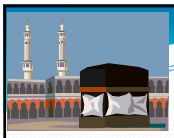
GIS Evaluation of Urban Growth and Flood Hazards: A Case Study of Makkah City, Saudi Arabia

Khalid Al-Ghamdi, Meraj Mirza, Ramze Elzahrany, and **Gomaa M. Dawod**

Umm Al-Qura University, Saudi Arabia

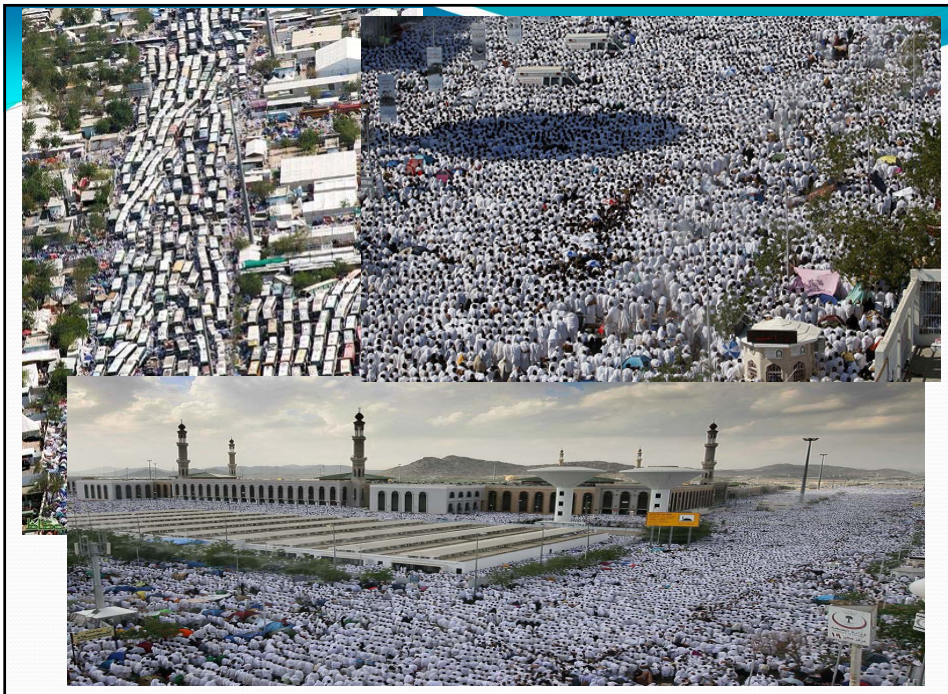
Saudi Arabia





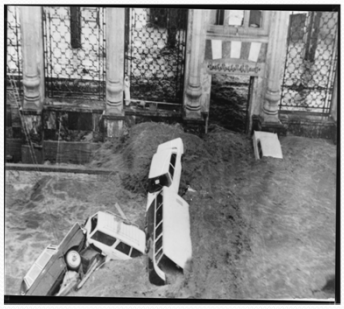
Makkah City

- It is a unique city for Muslims all over the world, since it contains the holly mosque.
- From a religious point of view, a Muslim should perform pilgrimage (called Hajj, i.e., visiting Makkah in specific days in the year) once in his/her life.
- Thus, hundreds of thousands Muslims are gathered in Makkah yearly.
- This is an important factor to be considered in analysing the urban growth of this city.



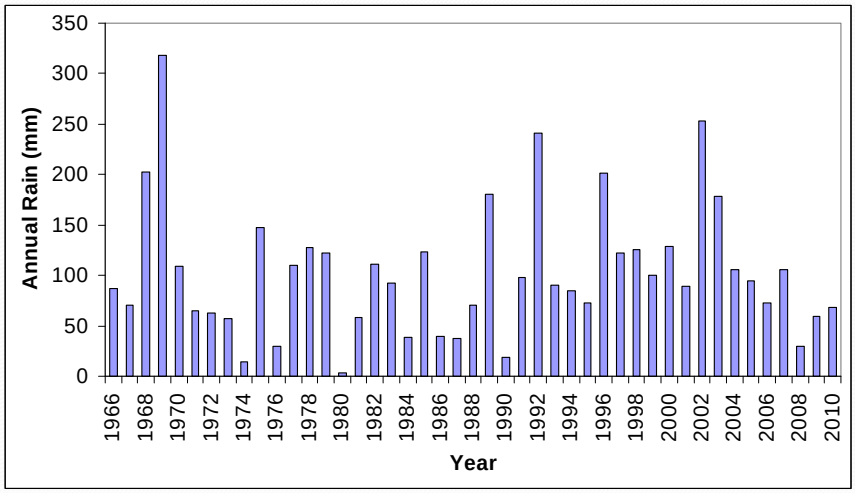
Floods in Makkah

- Periodical
- Flash (high intensity in short time)
- Dangerous



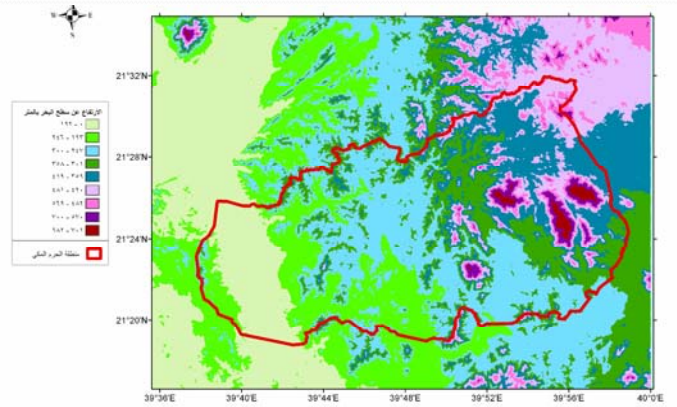
7

Rainfall History



Topography of Makkah

- Mountainous rigid topography
- Heights: 138 to 982 m (average: 276 m)
- Runoff comes <u>mainly</u> from interior wadis



9

Objectives

<u>Utilizing GIS:</u>

1. To monitor and quantify the spatial urban sprawl of Makkah city 1947-2010
2. To estimate flood hazards' increase over the same period
3. To investigate the urban sprawl -flood hazards' increase relationship.

10

Available Data

Maps:

1. Topographic map of Makkah city in **1947**
2. 105 cadastral maps (AutoCAD files) for **1990**
3. A land use map dated **2010**

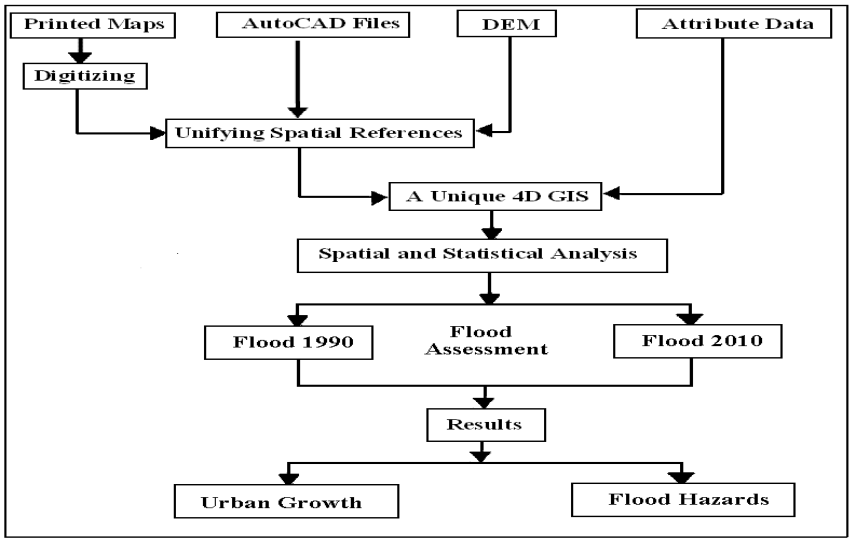
and

- A national 5-meter resolution **DEM**

Flood Estimation

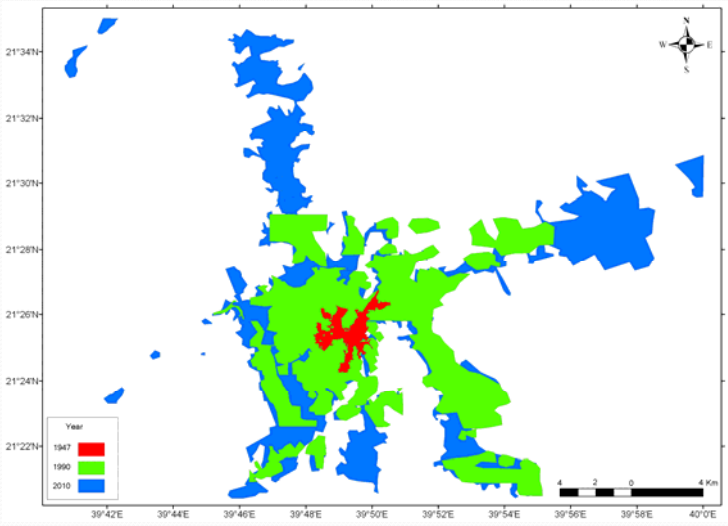
- Using the U.S National Resources Conservation Service (NRCS) ***Curve Number (CN)*** methedologloy.
- It utilizes ***geological/Soil/Land use information*** to assign a unique CN coefficient for each sub-basin
- CN used to estimate the surface runoff depth and the peak discharge magnitude.

Processing Workflow



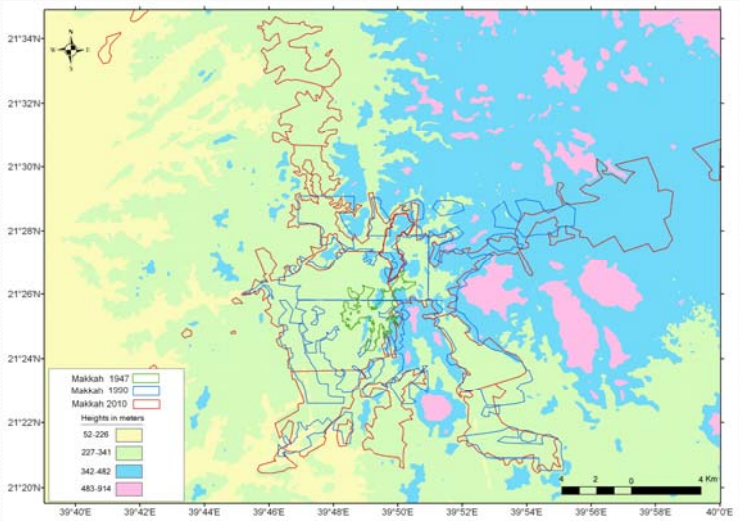
Results

1. Urban growth:



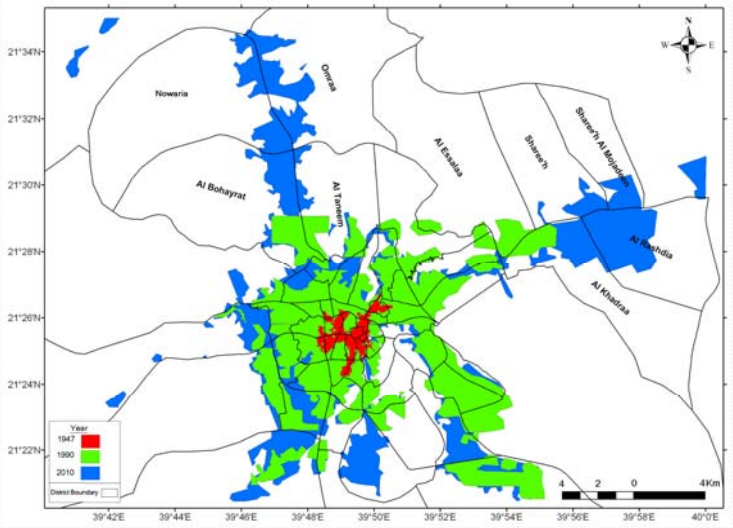
Results

2. Urban growth and topography:



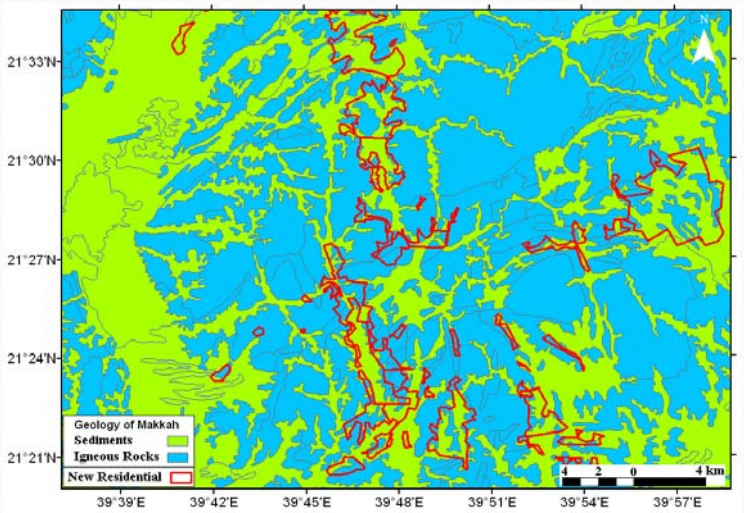
Results

3. Urban growth and road network:



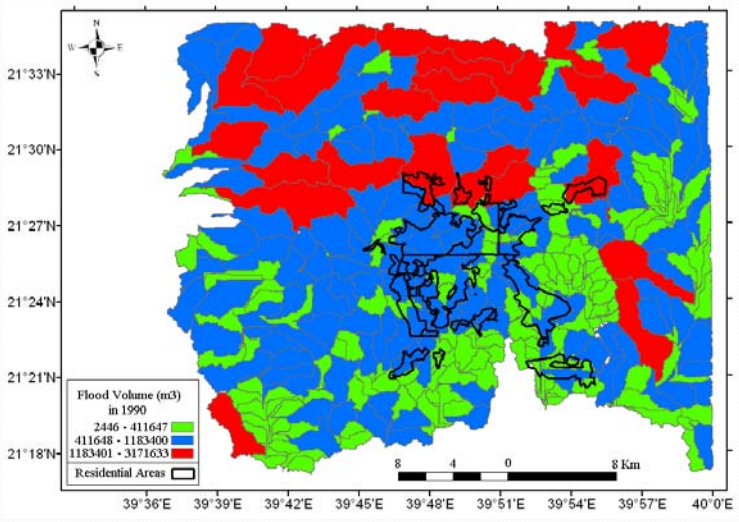
Results

4. Urban growth and geology:



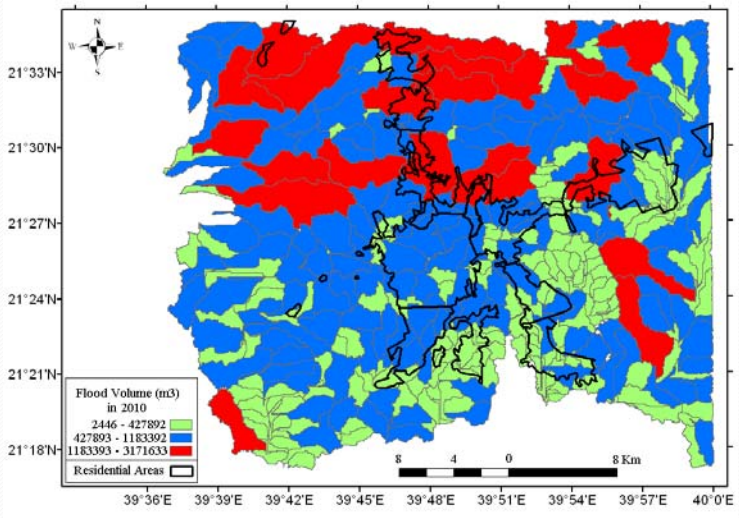
Results

5. Floods in 1990:



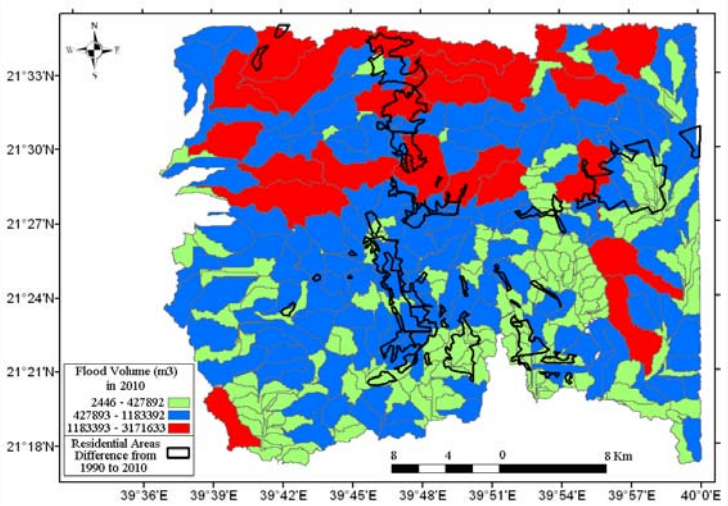
Results

6. Floods in 2010:

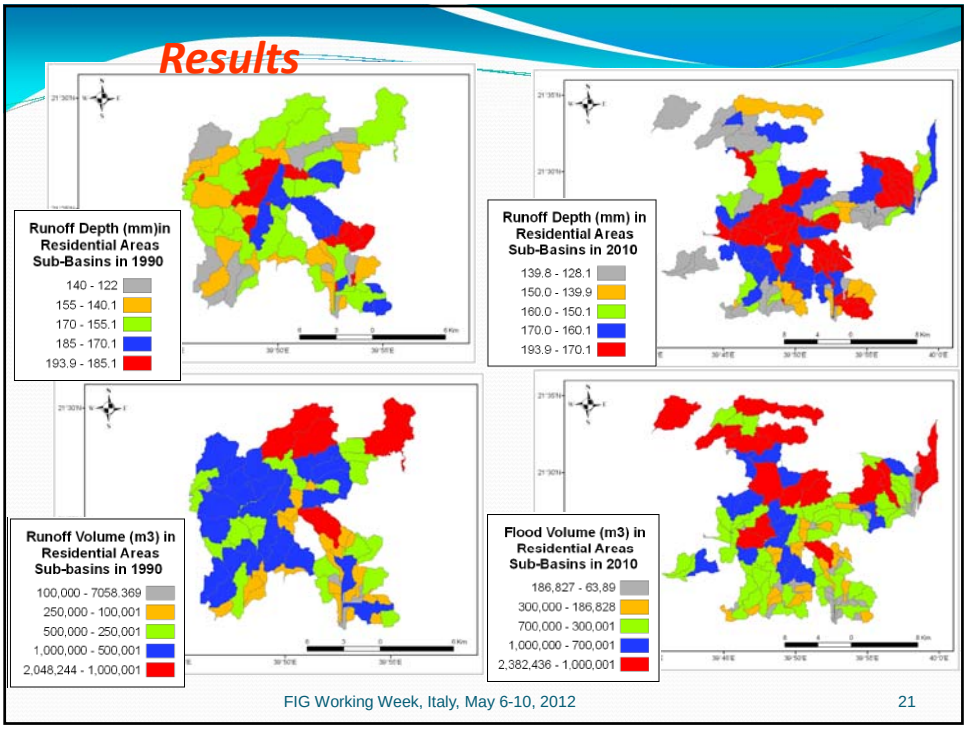


Results

7. Floods vs. Urban growth (1990-2010):

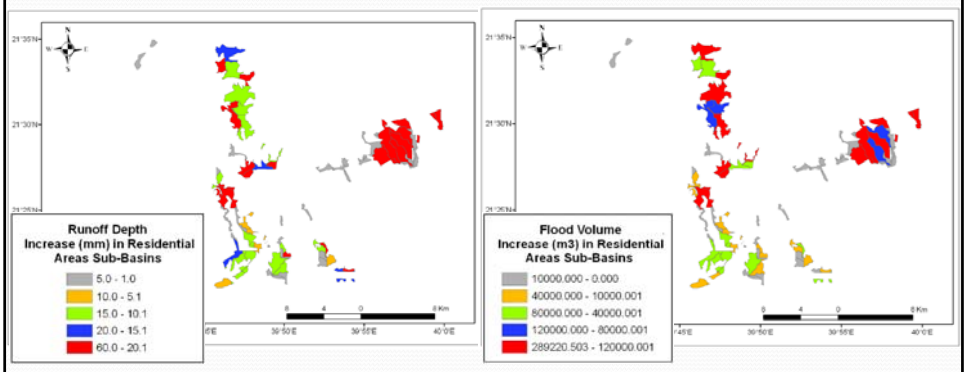


Results



Results

Item	1990	2010
Number of sub-basins contain residential areas	25	64
Total area of residential areas (km^2)	80.021	157.564
Minimum flood volumes (m^3)	79,623	45,487
Maximum flood volumes (m^3)	1,809,701	2,928,694
Total flood volumes (m^3)	11,849,980	41,282,085



Conclusions

1. Urban growth in Makkah city = **97%** from 1990 to 2010 (with 5% annual rate).
2. Urban sprawl mainly exist in **low- and moderate-elevation** regions.
3. Urban development has been intensive mostly **along main two highways.**
4. Establishment of new residential areas was in regions that already **posse high flood impacts**
5. Building up new suburban areas on sediment soil significantly decreases the permeability of the soil and, thus, ***leads to a crucial increase in hazardous water surface runoff.***

Thank you