Supplementary material

Contents

1-Visual interpretation 3
2-Band Combinations 5
3-Using improved DEM to extract streams network in Ras Ghareb city 6
4-Flood Inundation Mapping 10
5-Monitor Rainfall 13
6-Advantages of helicopter images and geolocated photos and disadvantage of Sentinel-2 15
7-Videos links 16

1-**Visual interpretation**

Based on visual interpretation we can note that all streets in zone B were changed to destroyed streets and ephemeral water bodies were stabilized in the lower area in the city and beside main roads (Hurgada-Al Ismaileya road- Zahfarana Ras Ghareb road). Green polygon shows most part in the zone A affected. Black polygons manifests location of water bodies (see fig.1 and 2)

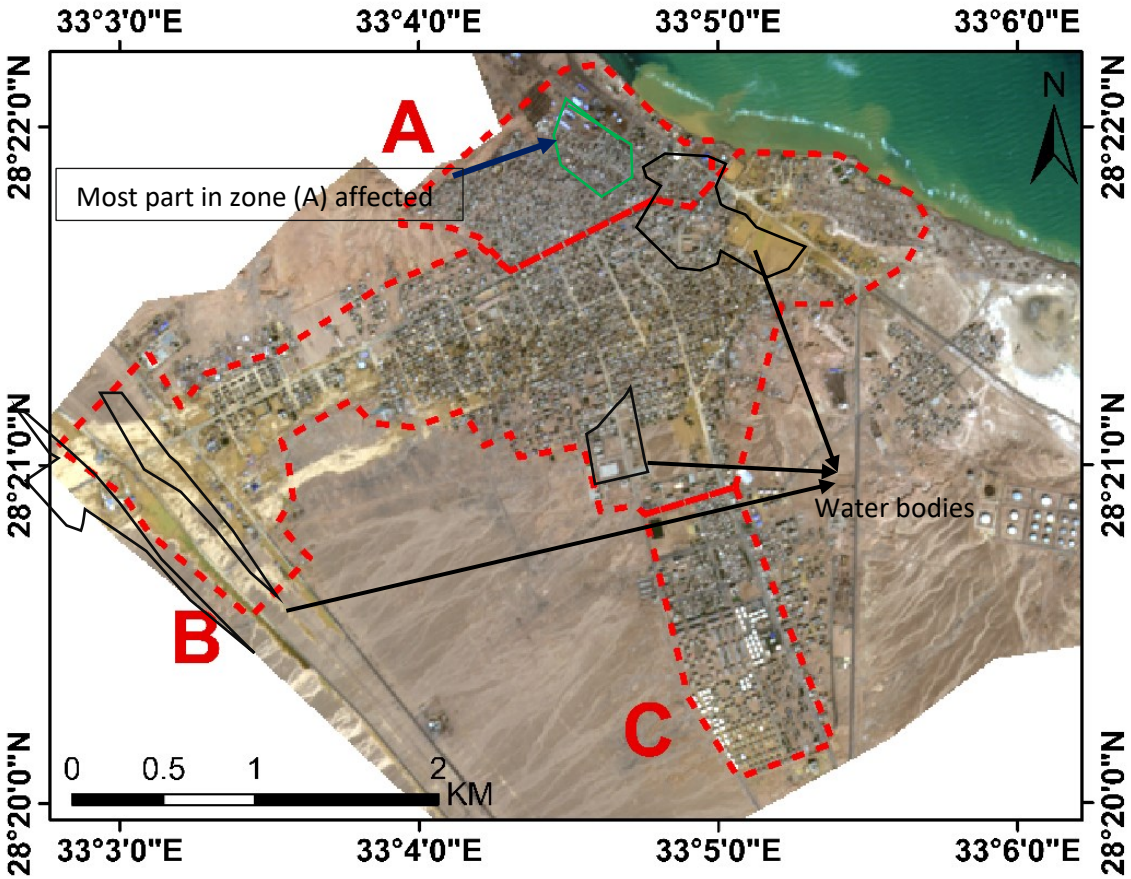


Fig.1 shows visual interpretation of image after flash flood for the Ras Ghareb City

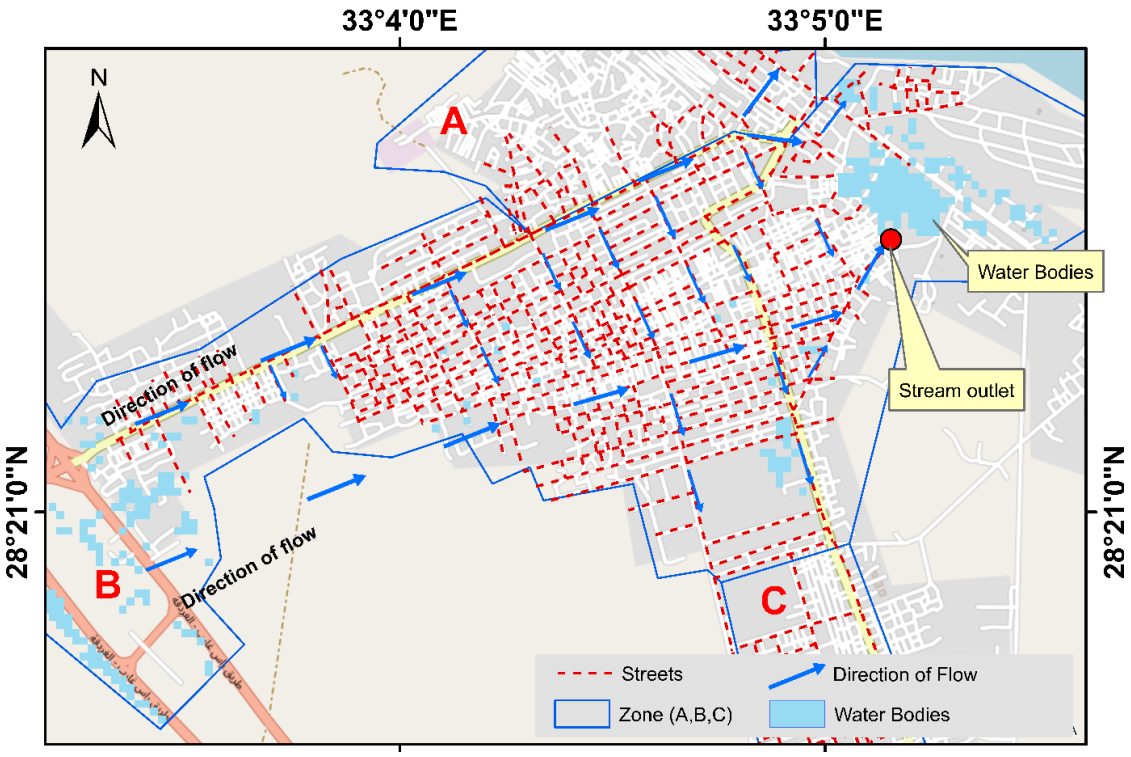


Fig.2 shows direction of flow in the city

2-Band Combinations

image (a) shows study area pre flash flood no water bodies while image (b) shows study area post the flood the water bodies were appeared. Based on band Combinations for Sentinel 2 we have used bands (8 -11- 4) (RGB) to show the location of ephemeral water bodies which appear in blue color. (see fig.3)

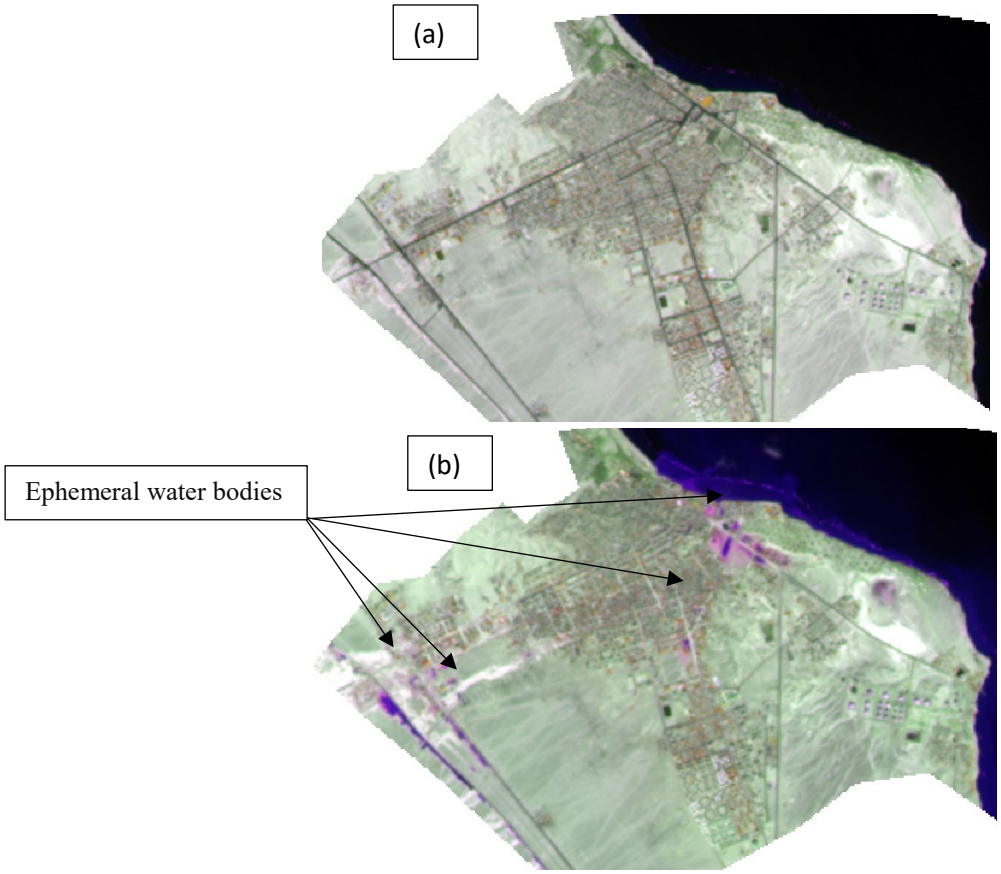


Fig.3 shows images interpretation of a and b based on band Combinations

3-Using improved DEM to extract streams network in Ras Ghareb city

This is the additional study to identify the direction of water flow in the study area by using ALOS PRISM DEM 12.5m as shown in **figure 3**. These following steps are used to extract stream network in the urban area:
a) Using inverse distance weighted (IDW) interpolation technique to produce DEM with1 spatial resolution (**see fig.4**)
b) DEM spatial resolution 1m was merged with the building layer (x,y) and assumed the height of the building (15m) above DEM level which is considered suitable for built-up in the study area
c) Digitizing all streets of the city
d) To improve DEM, the Topo-to-Raster technique is used because Topo-to-Raster is an interpolation method specifically designed for the formation of hydrologically correct digital elevation models (DEM's). Topo to raster can take various data such as points elevation, contour lines, streams layer, Sink, Boundary, Lake, Cliff, Exclusion and Coast. As a result we used the streets as the streams network because of the street is natural pass which water take during the flood in urban area. Surfer software version 15 is used to extract streams network. **Figure 5** show streams network extracted using improved DEM. **Fig.6-a and 6-b** show the water bodies settled at the outlet of the stream network also the destroyed area extracted from change detection is coincident with the results of streams network extracted from improved DEM 1m

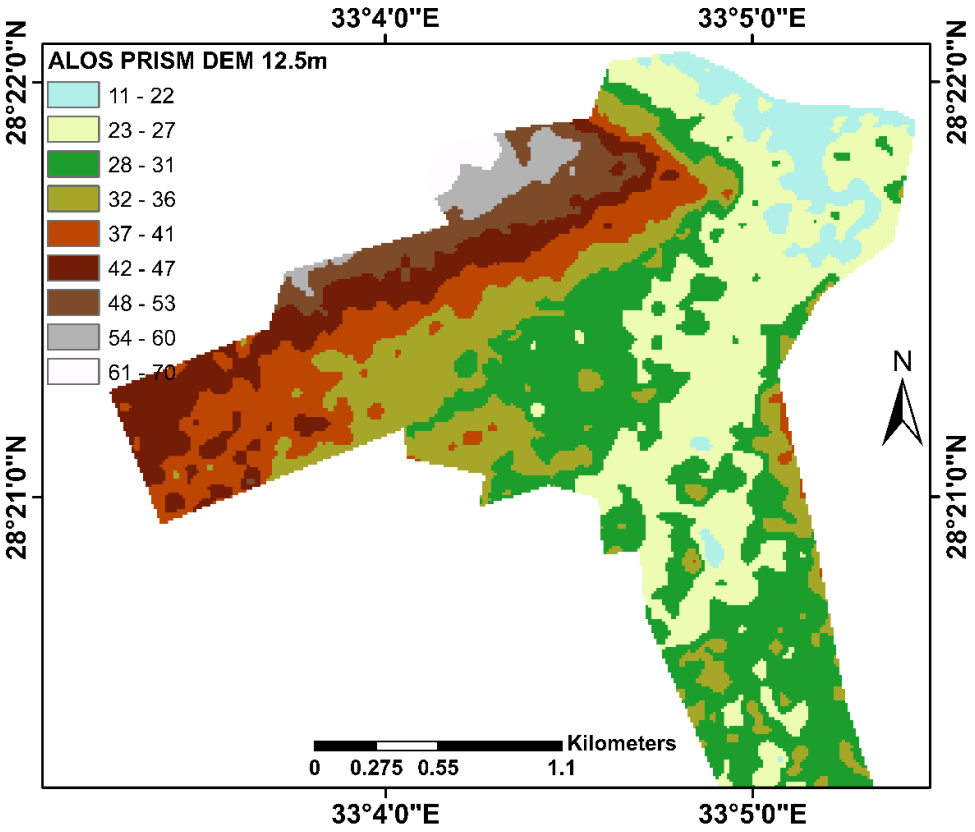


Fig.3 ALOS PRISM DEM 12.5m

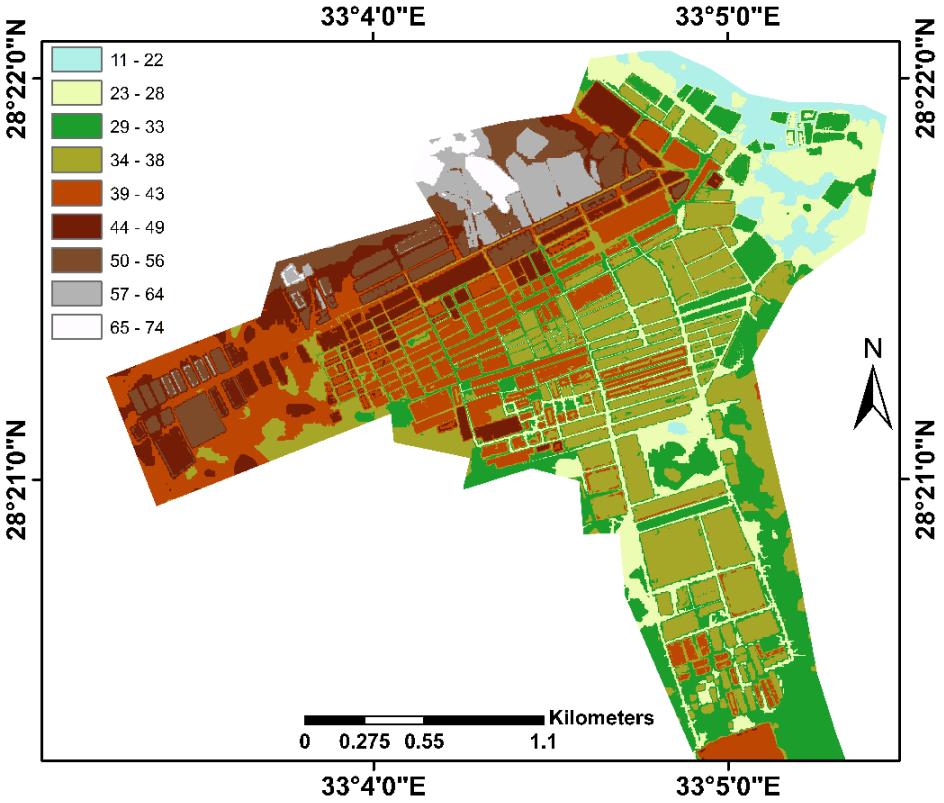


Fig.4 Improved DEM Spatial resolution 1m

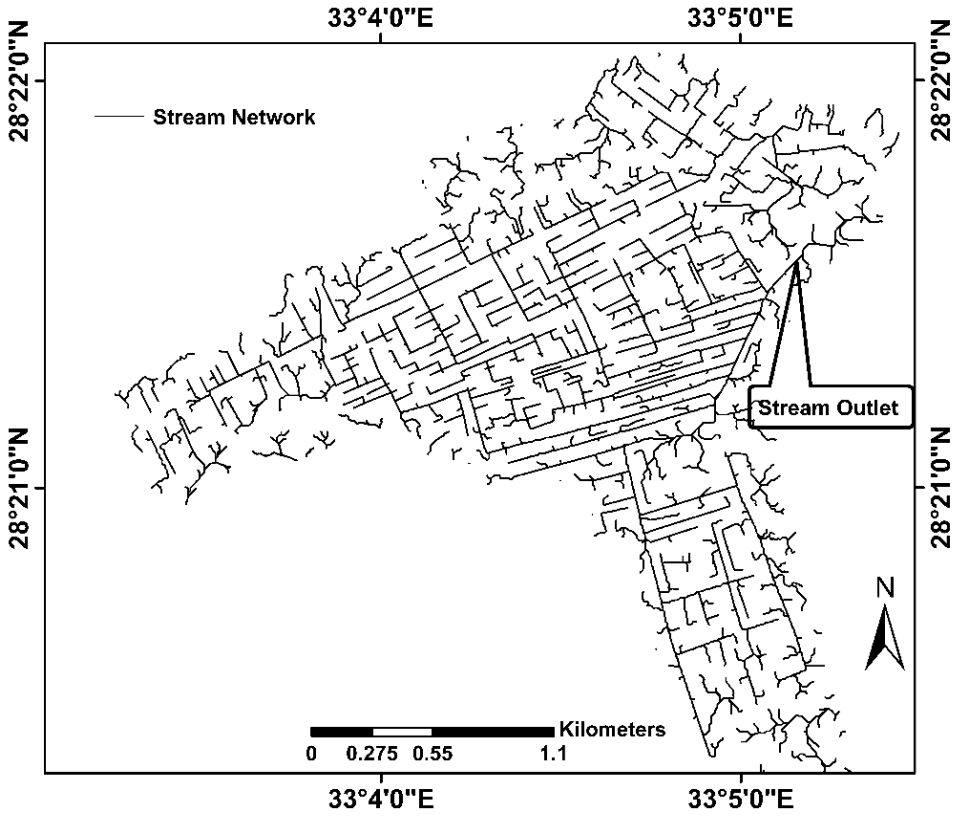


Fig.5 Streams network extracted using improved DEM

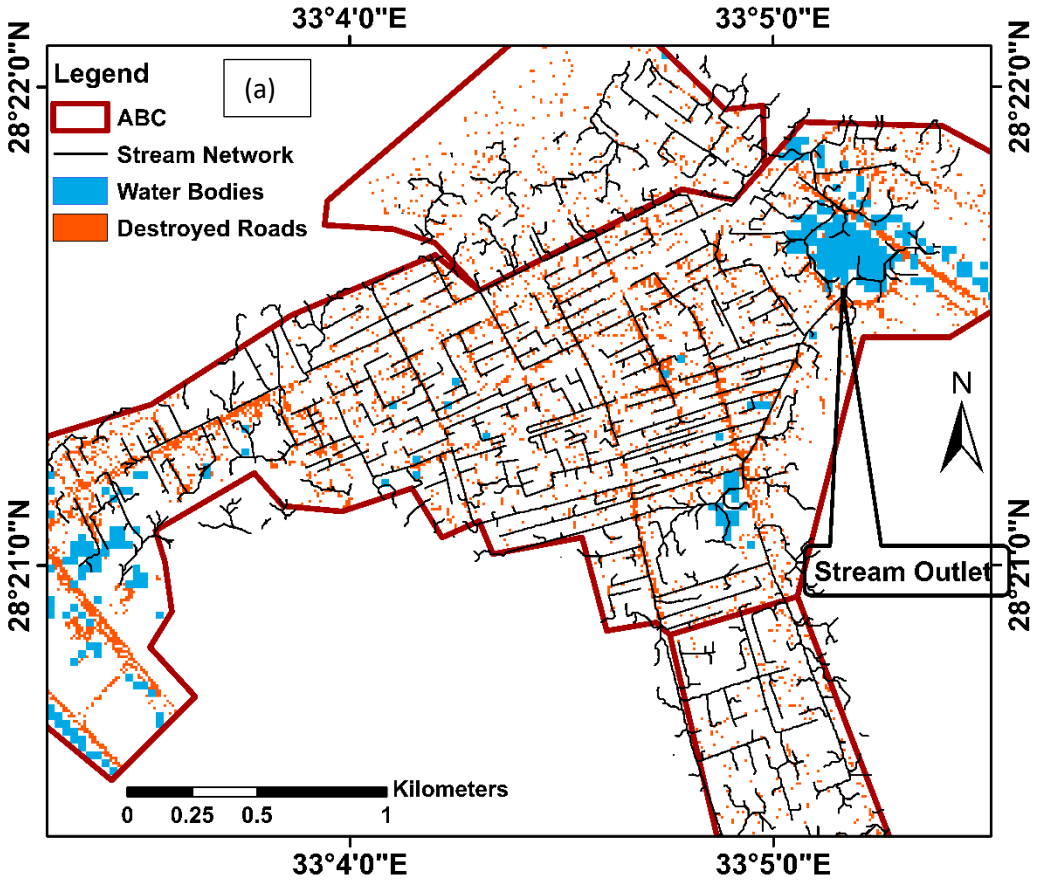
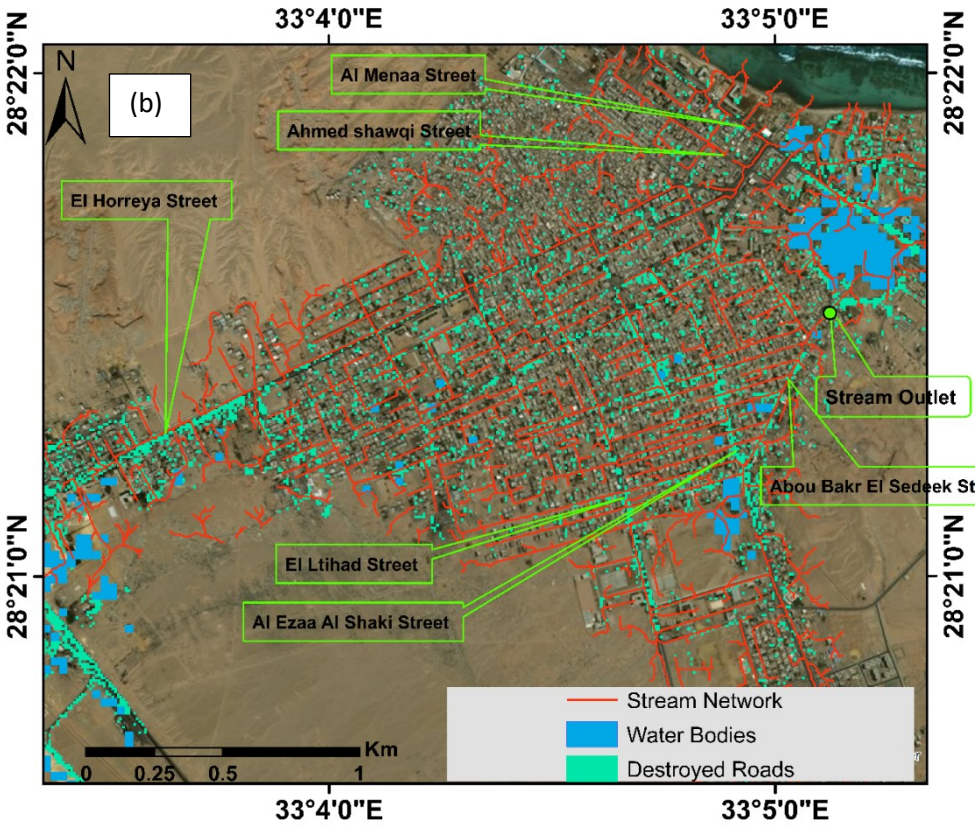


Fig.6 the water bodies settled at the outlet of the stream network also the destroyed area extracted from change detection is coincident with the results of streams network extracted from improved DEM 1m


33°4'0"E
33°5'0"E
28°22'0"N
28°21'0"N
N
(b)
Al Menaa Street
Ahmed shawqi Street
El Horreya Street
Stream Outlet
Abou Bakr El Sedeek St
El Ltihad Street
Al Ezaa Al Shaki Street
Stream Network
Water Bodies
Destroyed Roads
Km
0
0.25
0.5
1

4-Flood Inundation Mapping

Flood Inundation Mapping was prepared based on Volunteers inquiry about the depth of water also some of the images show the level of water, this map can be used to determine the height of damage in the face of building as shown in **figure-7**. Figures 8 show images captured by Volunteers

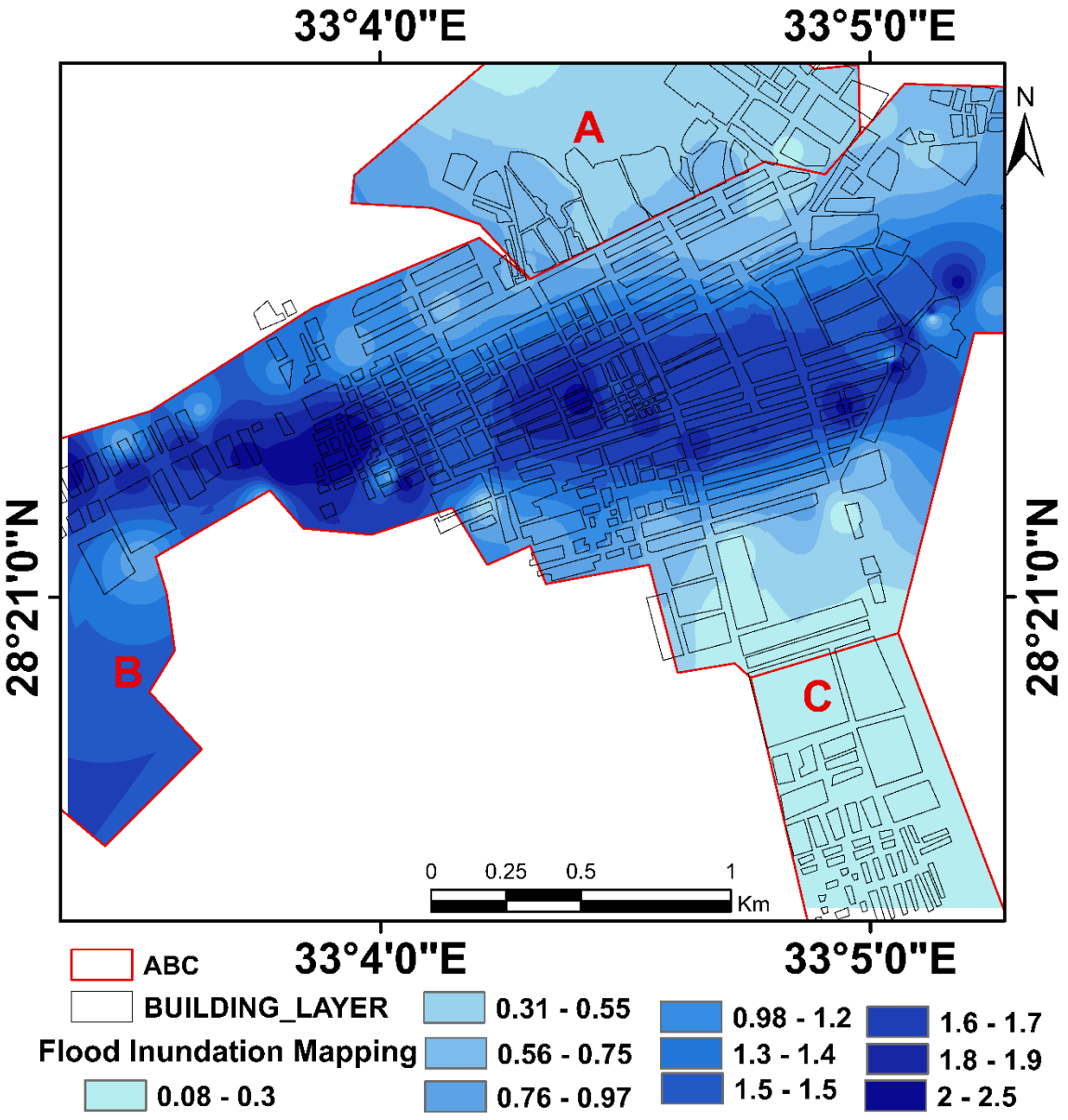


Fig.7 Flood Inundation Mapping

Hurgada-Al Ismaileya road

Zahfarana Ras Ghareb road

Fig 8 images captured by Volunteers

5-Monitor Rainfall

We can monitor rainfall which helps decision maker emptying residents from very high and high zones hazard determined based on AHP method by using JAXA GLOBAL RAINFALL WATCH that demonstrates hourly global rainfall maps in near real time using the combined MW-IR algorithm with satellite-based weather monitoring systems, (online) available at: "http://sharaku.eorc.jaxa.jp/GSMaP/index.htm". The monitoring of rainfall during 27 October 2016 (**Fig. 9**) shows that: 1) on 27 October, there was no rainfall in the study area before (6: 00 UTC), 2) slight rainfall (1 to 10 mm/h) was recorded during an hour (7: 00 -8:00 UTC) afterwards, rainfall was continuous for eight hours, 3)torrential rainfall (25 to 30 mm/h) was recorded for 8 hours (10:00 -18:00 UTC).finally rainfall stopped at hour 21:00.

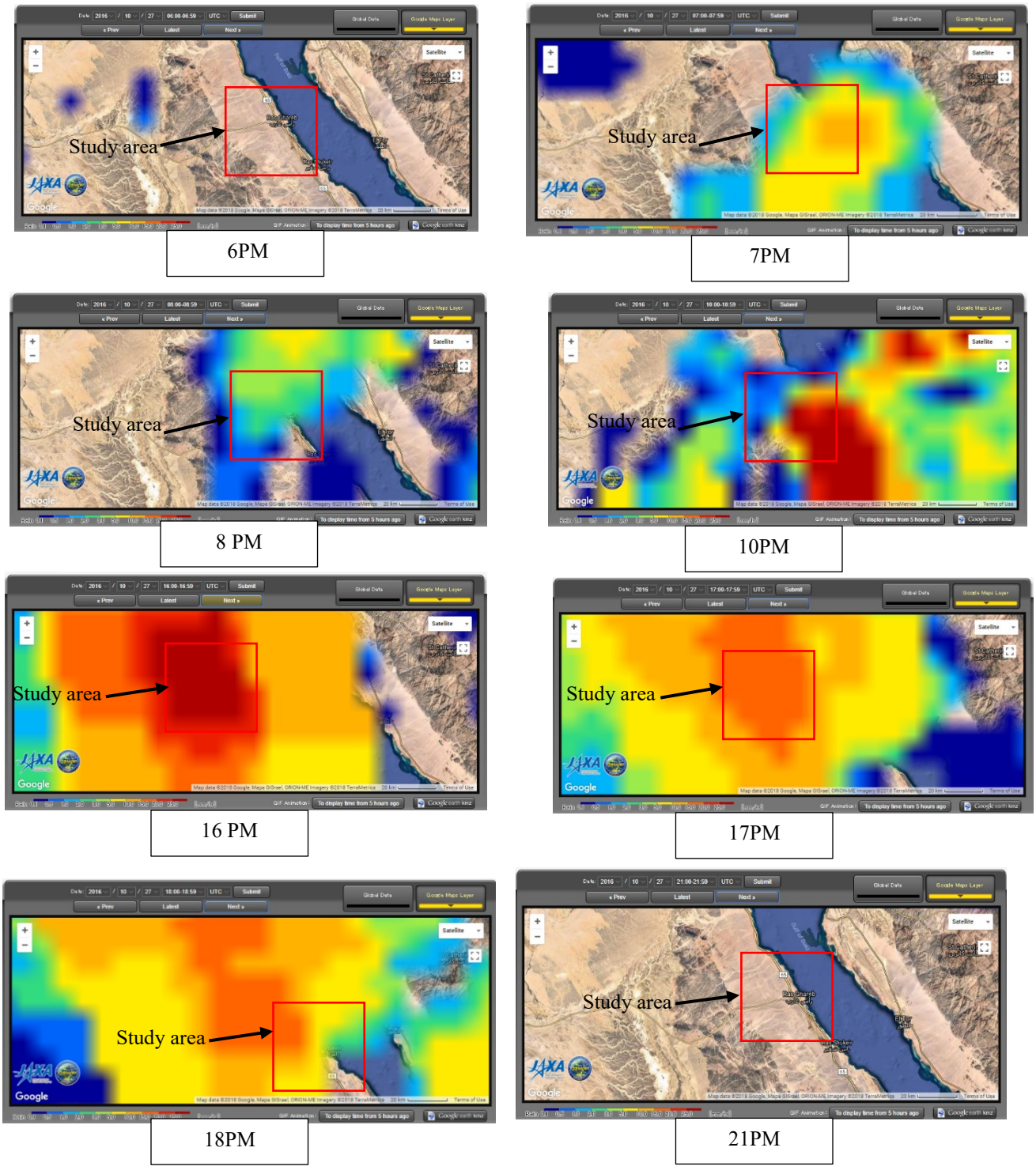
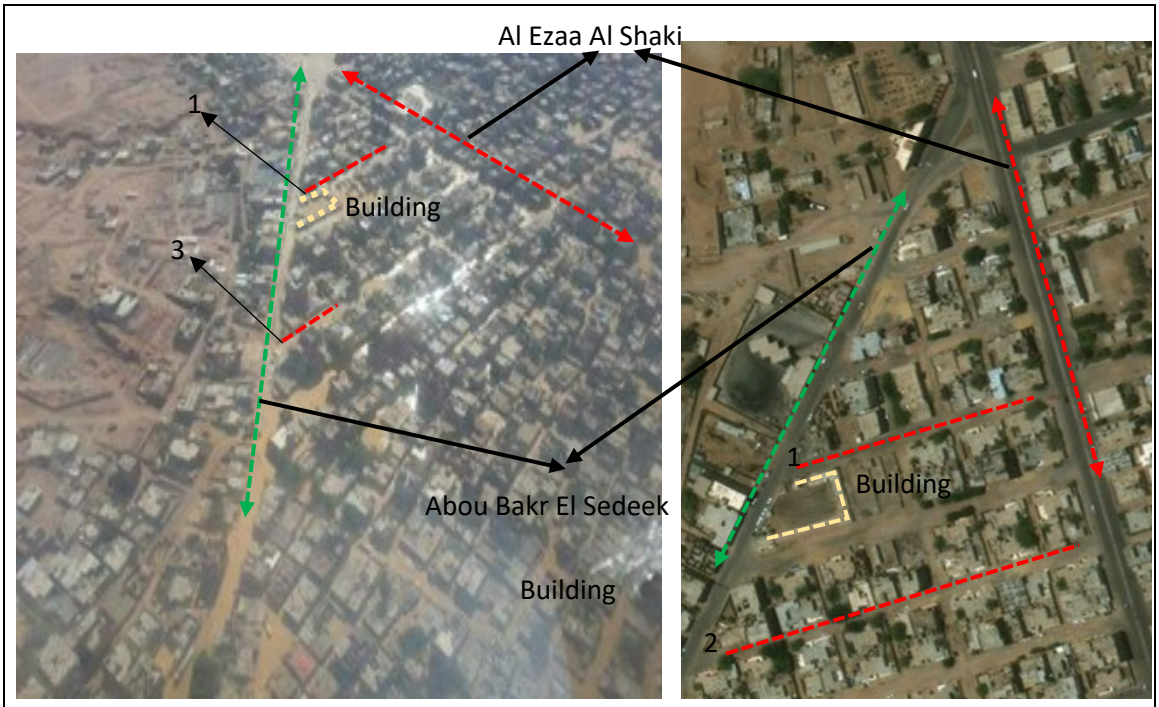
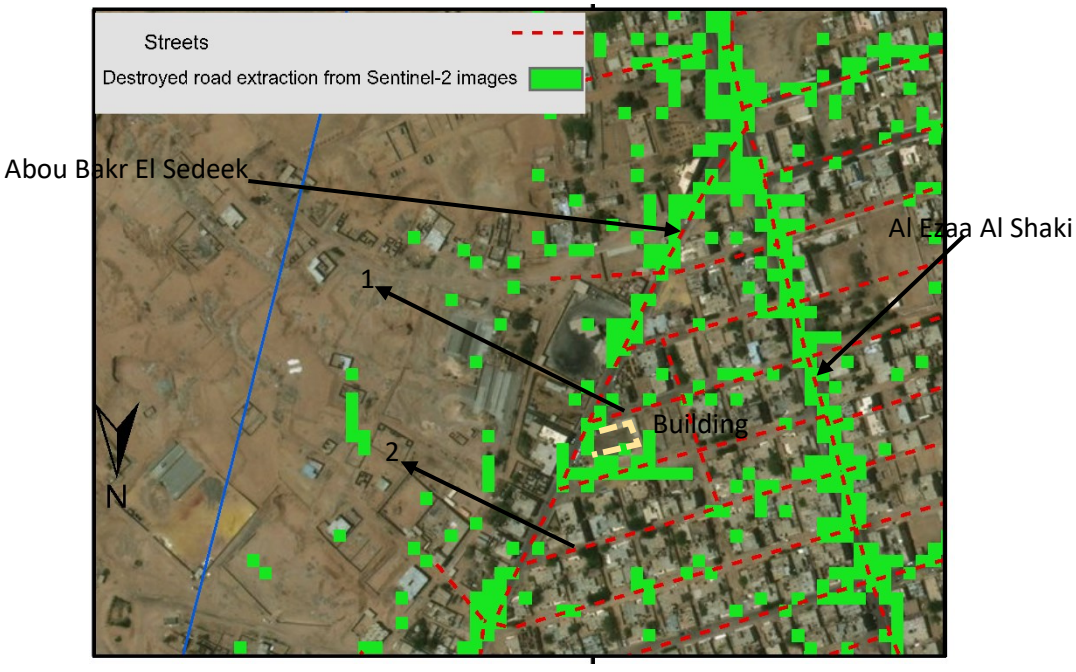


Fig.9 Rainfall from 6pm to 21pm 27 November based on JAXA GLOBAL RAINFALL WATCH.

6-Advantages of helicopter images and geolocated photos and disadvantage of Sentinel-2 images (see fig-10)





It is noted that Sentinel-1 images are unable to determine the destroyed streets whose width is less than 10-meter (street 1 and 2). Here appears the importance of pictures captured by volunteers and helicopter images which contributed to manifest submerged streets which less than the 10- meter width.

7-Videos links

Aerial photo captured by helicopter: https://www.youtube.com/watch?v=I_oSUx0wHQk

https://www.youtube.com/watch?v=2FETYnv52_o

Destroyed cars: https://www.youtube.com/watch?v=5zetWJ-qpG8

https://www.youtube.com/watch?v=hmU32B_rArI

https://www.youtube.com/watch?v=0wZJZZZVSpo

https://www.youtube.com/watch?v=XfWcEnwFJQI

Destroyed Streets: https://www.youtube.com/watch?v=ghAJ9XOmPNc

Main roads: https://www.youtube.com/watch?v=6uMI2xJEdEU

Clear the sandy layer from streets: https://www.youtube.com/watch?v=ywcdN5bGNJg