

# FLOOD RISK MODELLING

Presented by:

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## Purpose:

1. Identify at-risk infrastructure and population.
2. Develop stronger preparedness measures for future flood events.
3. Planning flood mitigation measures.
4. For the sustainable planning of land and urban areas.

## Motivation:

Intensity and damage created by some floods in India exposes the lack of capacity within institutions to respond to hydro- meteorological events in the country.

Eg. Kerala in July '19 and Bihar in August '19

## Objectives:

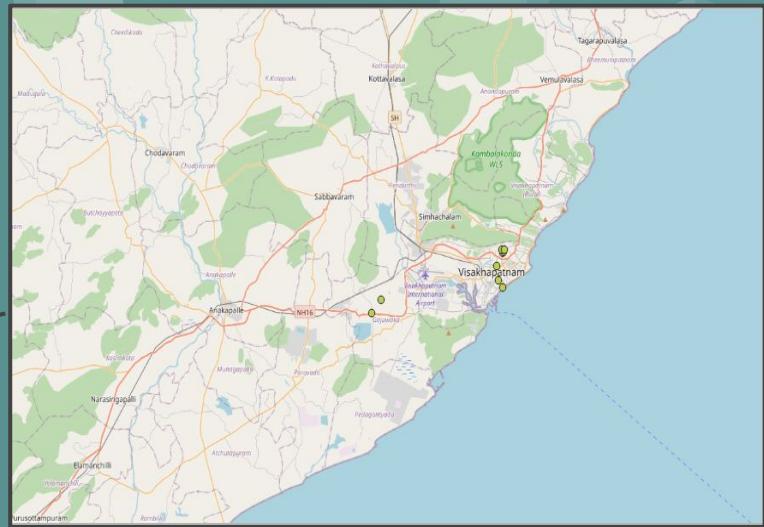
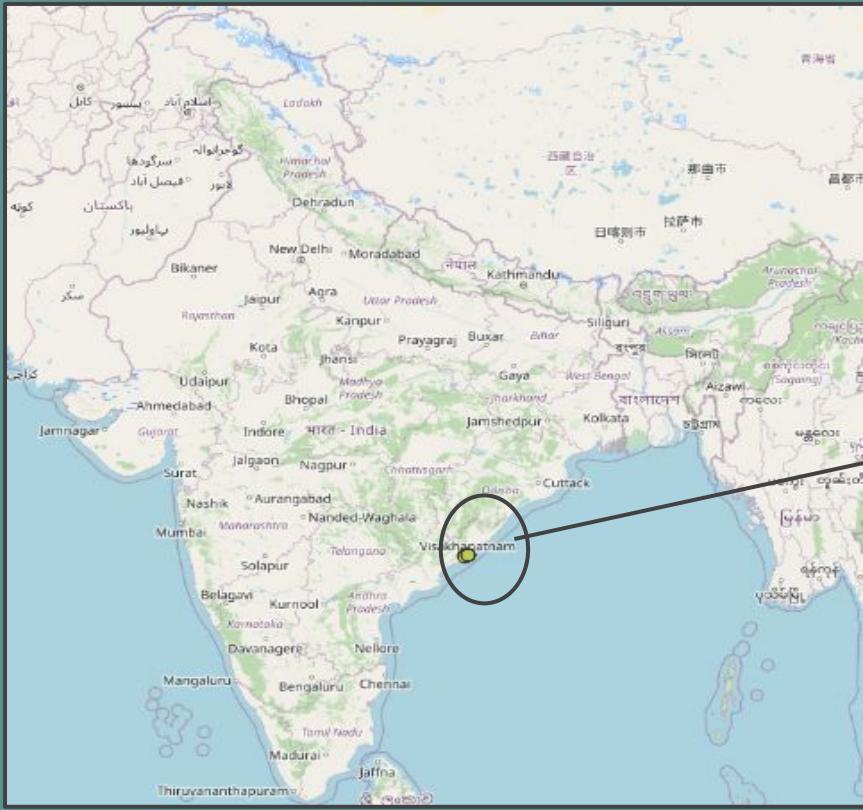
- A study of vulnerability and risk due to floods in particular to a geographical location, by doing Risk Assessment.
- To develop a prototype that provides the assessment of flood consequences.
- Vulnerability or Damage Analysis due to floods.

## Software Requirement: QGIS

Data Requirements: Satellite Images (.TIF) of a location, Shapefiles of Visakhapatnam, OpenStreetMaps of the area (between 17°35'00" N to 17°50'00" N latitude and 83°10'00" E to 83°22'00" E longitude)

Source website: EarthExplorer, urs.earthdata.nasa.gov, extract.bbbike.org, etc

**INPUT “Visakhapatnam” district (Andhra Pradesh State), as the area for risk analysis. We considered latest data available.**



Area of Interest : Visakhapatnam District

## Analysis

- Mostly covered with the settlements, sparsely distributed vegetation and higher altitude terrain.
- Higher altitude region - Simhachalam hilly range
- Massive Human Population and highest vulnerability to the floods - Locations along the coastal zone, like Thimmapuram, DwarakaNagar

# Flood Risk Assessment Framework

$$\text{Risk} = (\text{Probability}) \times (\text{Consequence})$$

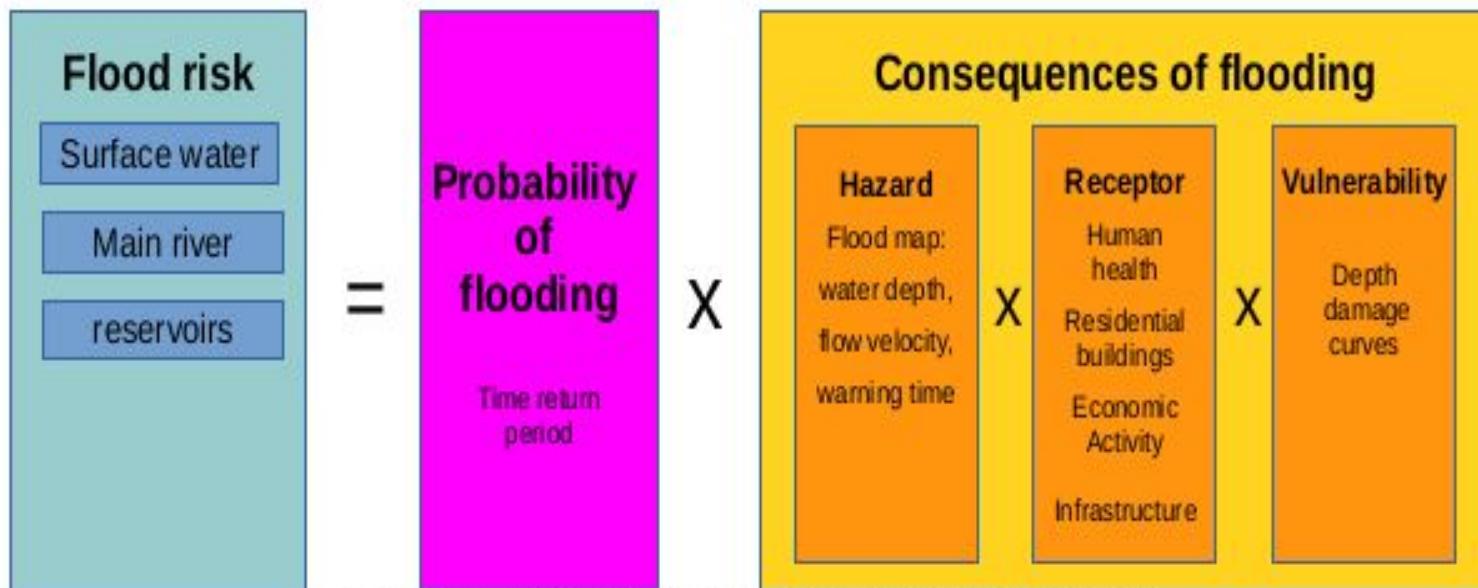


Figure 1 :Framework for flood risk assessment

## Historical Events of Flooding

Date of Occurrence	Location
10-09-1904	Visakhapatnam
27-10-1906	Visakhapatnam
23-06-1915	Visakhapatnam
06-10-1955	Visakhapatnam
30-12-1965	Visakhapatnam
02-10-1983	Visakhapatnam
09-10-1985	Visakhapatnam

## Flood Discharge Magnitude-Frequency Relationships

Low magnitude events happen pretty frequently, while high magnitude events are rare.

Floods can be characterized by magnitude(how large they are). A common measure of magnitude with floods is discharge(how much water in the stream bed is flowing past a certain point in a given period of time).

For example, discharge could be given in cumecs or cubic meters per second or cubic feet per second.

## Calculation of Time Return Period

We Rank each year or event by its discharge.

Then we calculate the Time return Period with respect to the next flood that is as big or bigger.

Enter the return period (ie..100 year flood)	Percent chance of occurrence
100 year flood	9.6 %
Enter the number of years (ie..over the next 10 years)	There is a 9.6 % chance that a 100 year flood will occur over the next 10 year(s)
10 year(s)	
Convert	Clear Values

## Discharge measured from a reservoir near Vizag for every water year

<b>Years</b>	<b>June</b>	<b>July</b>	<b>August</b>	<b>September</b>	<b>October</b>	<b>November</b>	<b>December</b>	<b>January</b>	<b>February</b>	<b>March</b>	<b>April</b>	<b>May</b>	<b>Total</b>
1982-1983	305	3398	194319	84777	55399	44593	14988	10253	7120	4870	11758	19314	451094
1983-1985	5903	5429	548709	491445	335849	23514	4001	5248	2696	5207	13841	15342	1457184
1984-1985	4466	2625	141241	21360	32984	19554	17236	7705	14599	25530	22090	22643	332033
1985-1986	7923	3875	56466	21903	29076	1321	1154	954	0	1212	11043	20360	155287
1986-1987	9559	204	83139	9656	3551	12463	297	2051	3170	10906	140	117	135253
1987-1988	861	11193	4416	601	5167	42226	603	0	0	21227	15574	23997	125874
1988-1989	8652	57423	280606	640533	172314	10351	3124	2895	2185	23169	33521	11096	1245869
1989-1990	9626	128248	96657	192502	176774	10727	16145	9208	13156	14485	19316	60312	747150
1990-1991	22370	16897	427912	166710	171196	36625	25071	28975	46549	54618	37928	11689	1046531
1991-1992	32324	169097	602487	145967	28310	42587	29731	16341	31666	37834	43008	25833	1205185
1992-1993	8109	0	14288	100409	23525	22871	20808	20718	29665	28585	32399	22785	324162
1993-1994	6587	9601	15323	49314	301641	35322	34758	41710	56000	62139	29792	15049	657236
1994-1995	4056	317403	212314	406561	120023	107154	48268	35963	37357	31852	1409	6944	1329304
1995-1996	3116	2106	14182	15251	100163	6170	16733	572	0	0	7504	11005	176802
1996-1997	8777	5395	56611	69025	344654	32440	26966	14799	14595	31860	27366	8143	640631
1997-1998	5340	1762	239569	191914	26287	16860	8018	5677	3484	9090	15136	10011	534148
1998-1999	12090	10142	43034	250205	778946	45234	5935	10991	10187	17349	36585	6199	1226897
1999-2000	11929	30277	144971	56449	26985	6429	7157	1464	3226	11776	23248	9631	333542
2000-2001	18542	22796	140423	6953	4252	4158	3680	102	1613	5873	7901	5011	221304
2001-2002	5575	204	1026	6378	37644	916	0	846	0	2545	7216	2932	65282
2002-2003	1717	0	0	0	564	0	0	0	0	0	0	0	2281
2003-2004	234	0	2553	470	853	0	2183	0	0	0	0	0	6293
2004-2005	0	0	5413	1489	10055	0	0	0	0	0	0	53	17010
2005-2006	0	4385	437415	563250	176119	32749	1339	0	0	2529	4768	2415	1224968
2006-2007	1760	783	768761	132851	39993	21054	383	0	0	0	1689	946	968220
2007-2008	6699	80021	293331	422661	73601	4980	0	0	5222	11439	8552	594	907100
2008-2009	792	1929	118510	154439	5060	9371	7384	73	0	0	1496	525	299579
2009-2010	0	0	1347	1002	495529	3359	0	0	0	0	0	0	506974
2010-2011	1041	31874	31249	195895	88558	55170	18856	0	579	0	6483	924	430629
2011-2012	282	4549	27221	181627	688	0	157	2220	47	0	0	0	216791
2012-2013	0	4351	22203	183789	138155	294562	0	0	22383	0	0	0	665443

## Probability of Flooding

Probability of Flooding is the Inverse of the flood Return Period, which is calculated as

[https://www.weather.gov/epz/wxcalc\\_floodperiod.](https://www.weather.gov/epz/wxcalc_floodperiod)

We calculate it using the formulas,

<http://www.eeescience.utoledo.edu/faculty/stierman/Notes/odds.htm>

$$T = \frac{(N+1)}{M}$$

$$T = \frac{N + 1 - 2A}{M - A}$$

Here, M is the rank of the event, A is the statistical factor, N is the interested number of years

## Formulas to estimate Probability of Flooding

Probability  $J_K$  that a flood of average probability of occurrence  $p$  will be exceeded exactly  $k$  times during an  $N$ -year period is given by

$$J_K = \frac{N!}{k!(N-k)!} (1-p)^{N-k} p^k$$

probability that an event will be exceeded one or more times in  $N$  years is

$$J_{1 \text{ or more}} = 1 - (1-p)^N$$

500-year flood. Calculate the probability that it will experience a flood before in the next 30 years. Then,

$$1 - (1 - .002)30 = 0.058 \text{ (that is, } 5.8\%, \text{ about one chance in 20).}$$

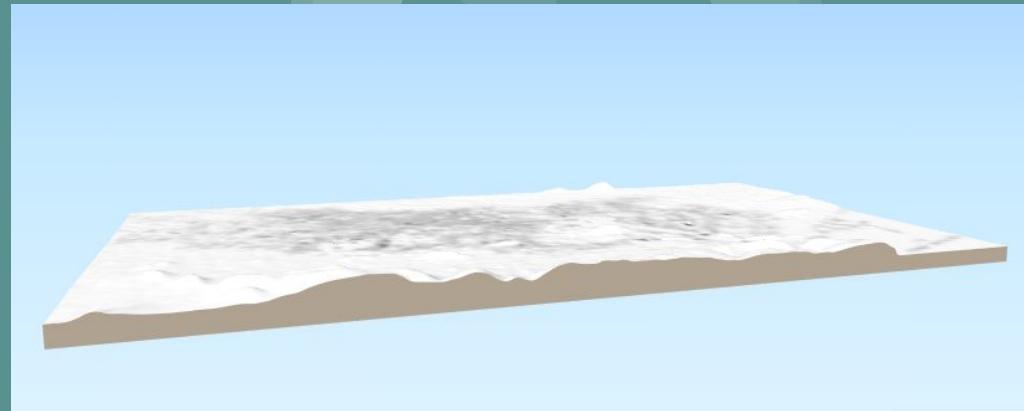
## Hazard Assessment:

- The analysis of the intensity of the flood and the degree of danger it brings with it.
- It is estimated using Depth Elevation Model, which gives elevation values, which is used to calculate depth of the flood water.

Elevation from OSM using  
SRTM Downloader

Depth Elevation Model

Value	Color	Label
102.6		102.6
223.2		223.2
343.8		343.8
464.4		464.4
585		585



From these we estimate the level of the water table.

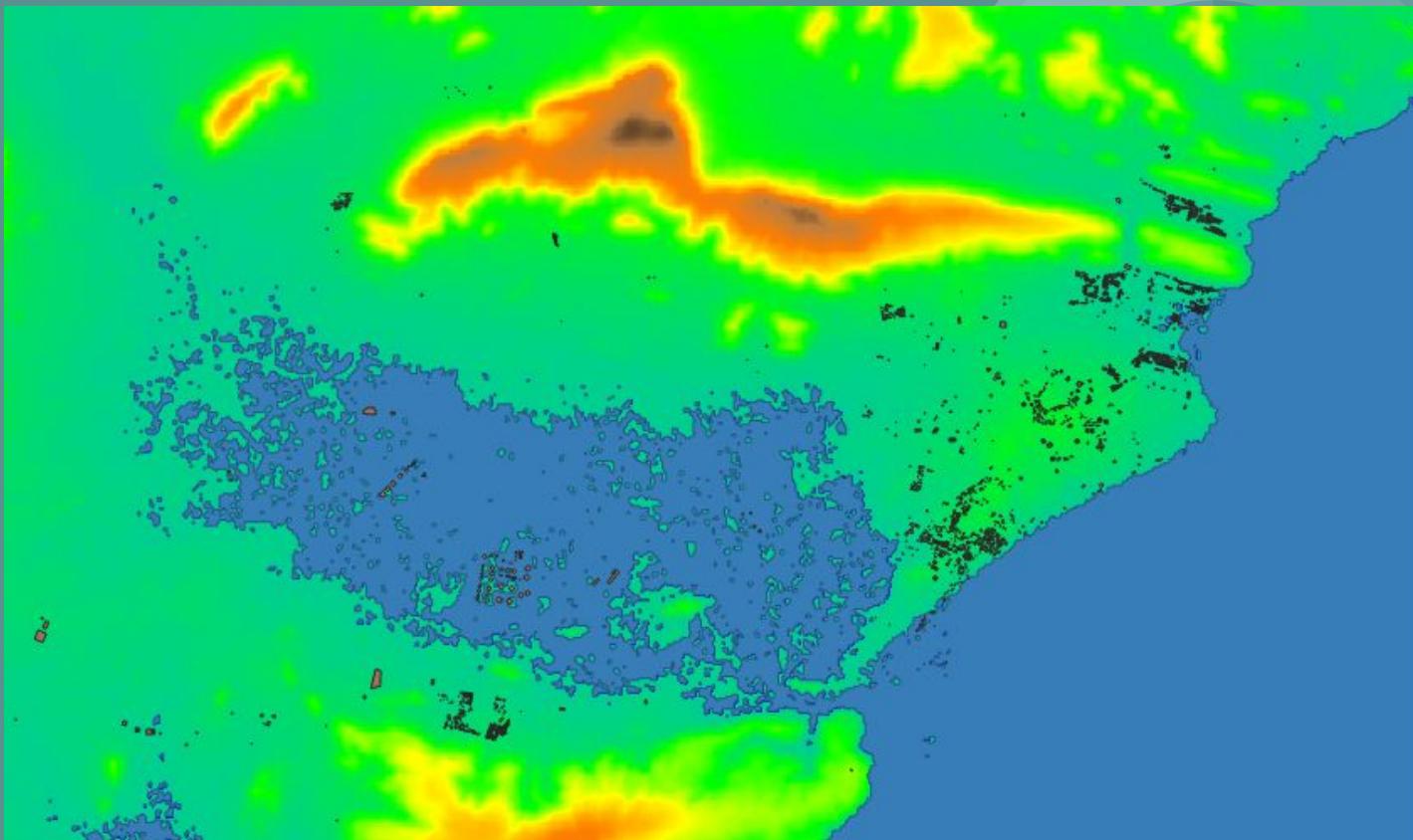
In raster calculator:

- $\text{out\_raster1} = \text{DEM} * \text{binary\_mask}$ , where binary mask means 1 if area is flooded and 0 if non-flooded.

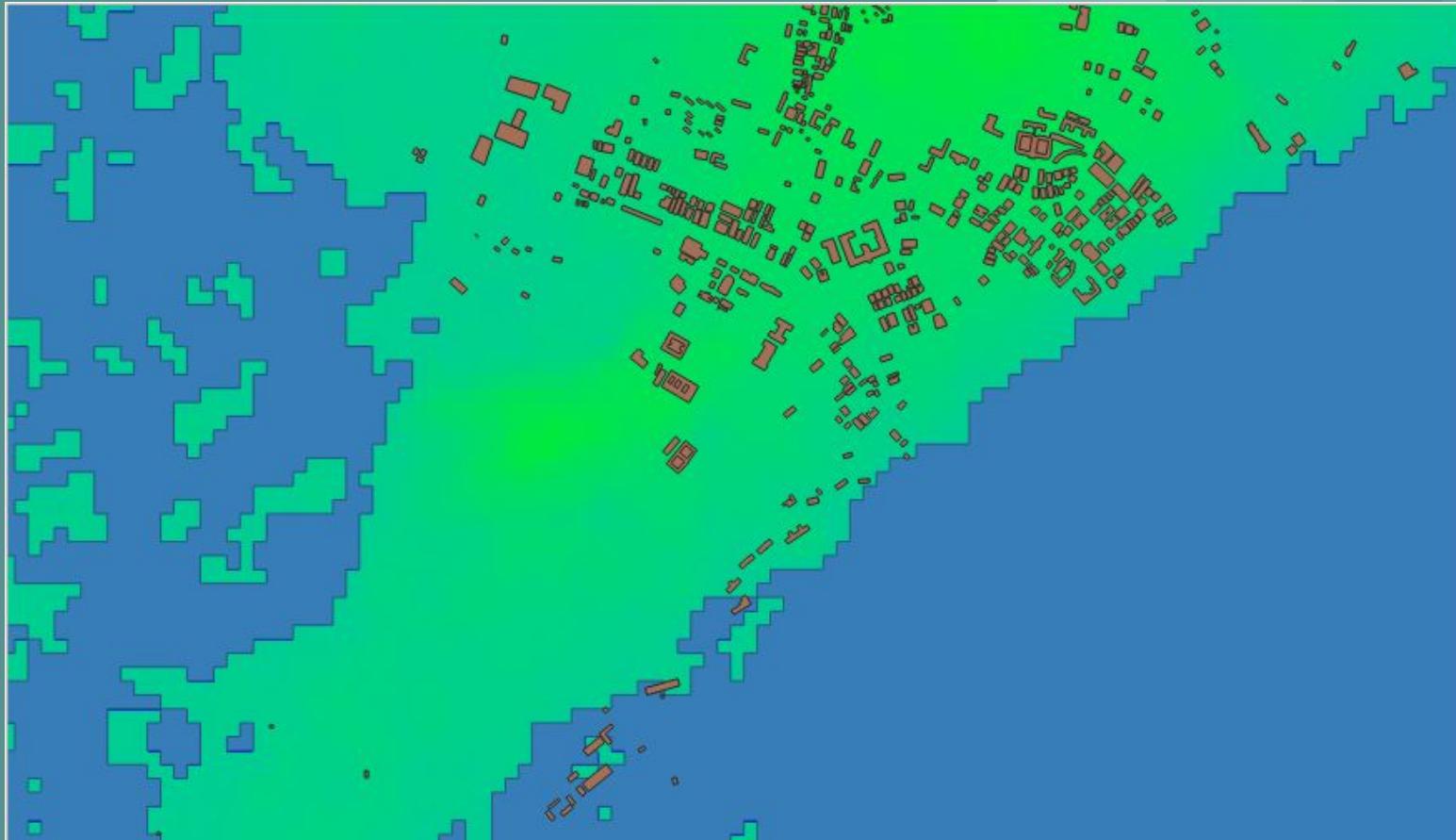
# Land Use Map



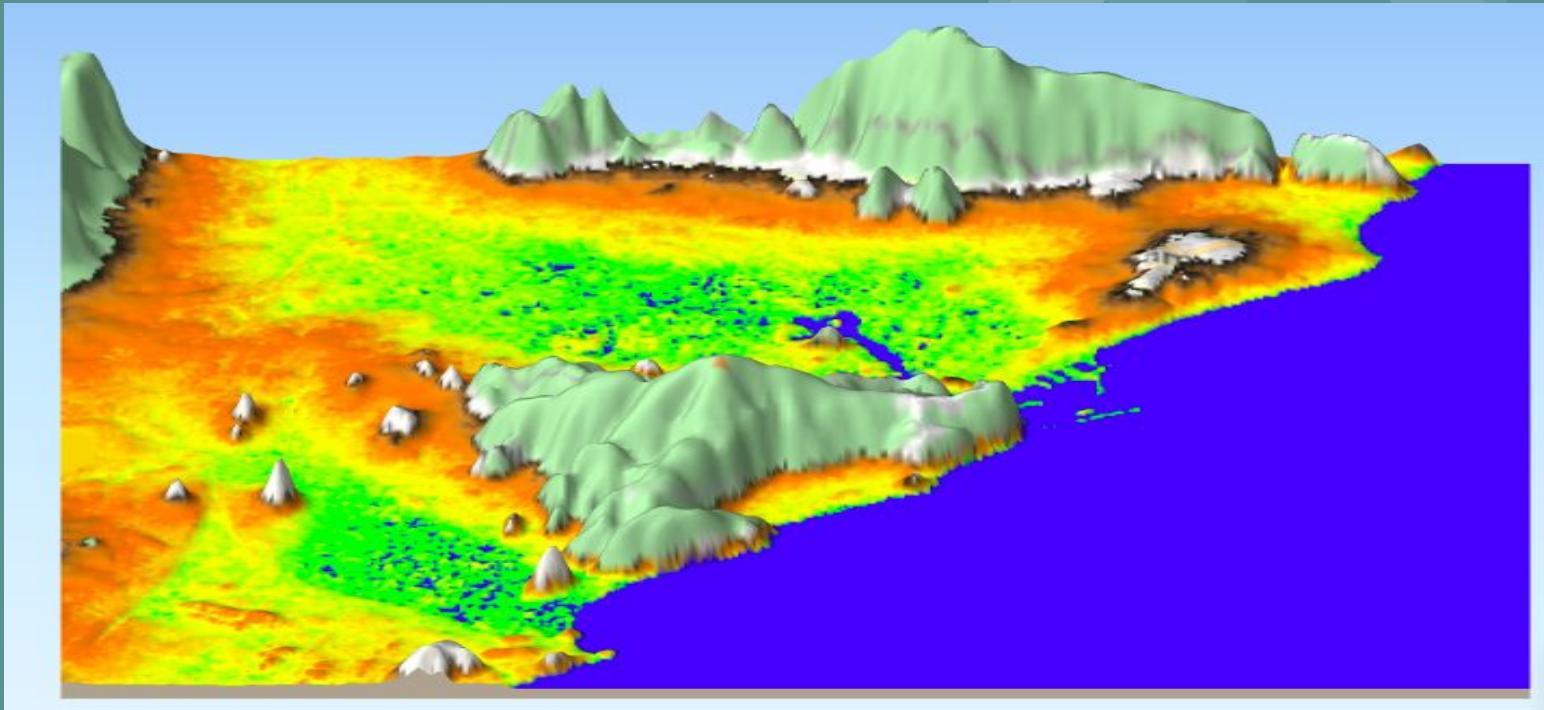
## Induction Map



# Buildings and the landscape with probable flood prone area



## Flood Inundation Visualisation



## Exposure / Receptor

To get the areas exposed:

1. The areas which are flooded on occurrence floods are found.
2. Then, we check for the intersection of those areas which causes damage, when affected by flood. These are the local flood prone zones.
3. We then find the intersection of flooded zones and shapefiles of the areas like buildings, roads, land use.
4. These are the Infrastructures/Receptors that could get affected by the flood.

The screenshot shows the QGIS application interface with the following details:

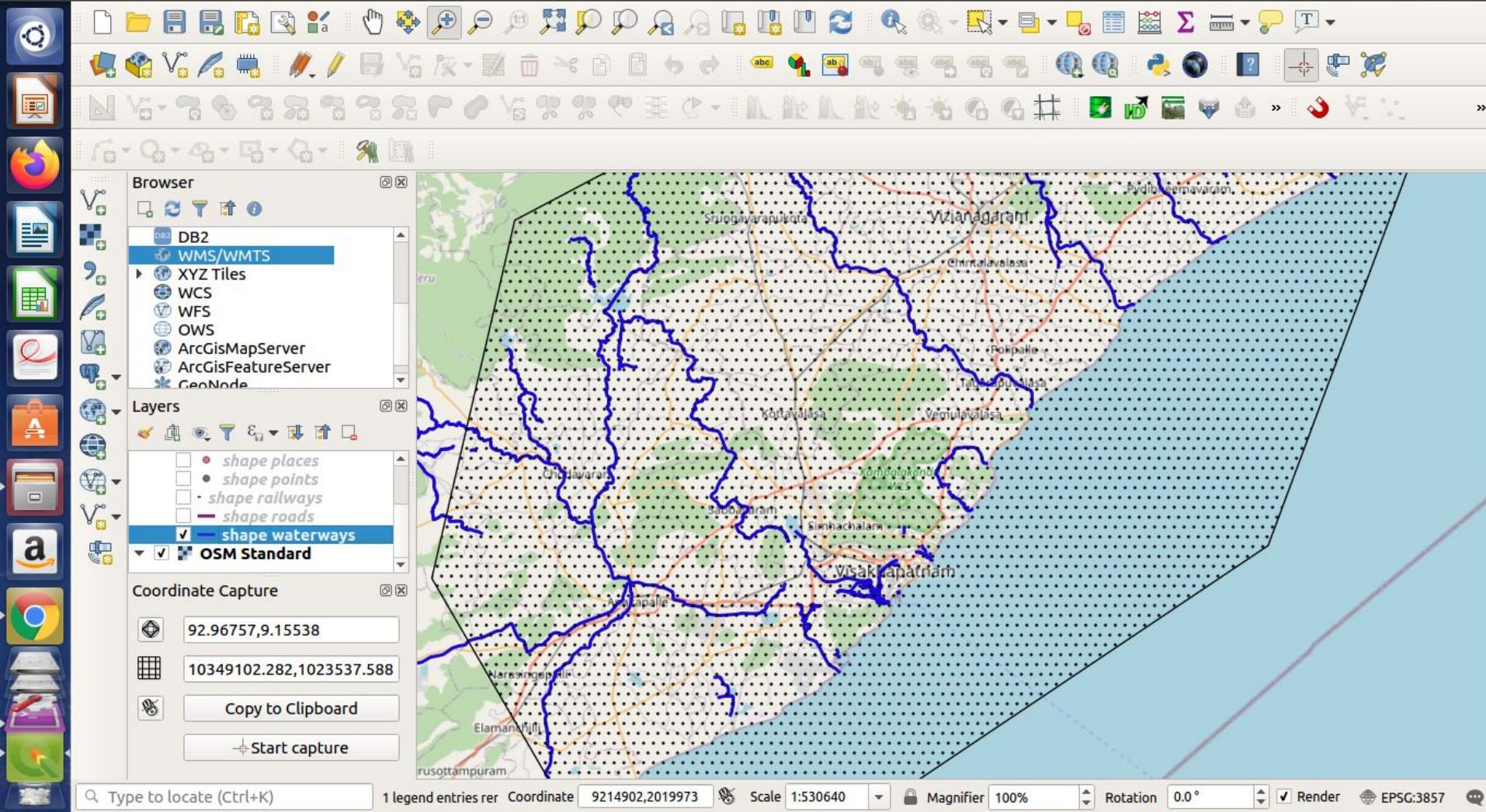
- Toolbar:** Top bar with various icons for file operations, selection, measurement, and editing.
- Browser Panel:** On the left, under "WMS/WMTS", "visakha" is selected. Other options include DB2, XYZ Tiles, WCS, WFS, OWS, ArcGisMapServer, ArcGisFeatureServer, and GeoNode.
- Layers Panel:** Shows the "shape" layer, which contains "visakha" and "shape buildings". Other layers listed are "shape landuse", "shape natural", "shape places", and "shape points".
- Coordinate Capture Panel:** Displays coordinates: 92.96757, 9.15538 and 10349102.282, 1023537.588. Buttons for "Copy to Clipboard" and "Start capture" are present.
- Map View:** The main area displays a map of the Visakhapatnam region. A large black polygon covers most of the map. Overlaid on this are several orange and red boundary lines, some labeled with place names like "Stugavaramukota", "Yelangadram", "Chinnavallasa", "Pokkale", "Tatraduvulasa", "Venuvalasa", "Dipalakonda", "Visakhapatnam", "Simhachalam", "Sabbavaram", "Anapalle", "Haresgepal", "Elamandulli", and "rusottampuram".
- Bottom Bar:** Includes a search bar ("Type to locate (Ctrl+K)"), coordinate information (9217149, 1990209), scale (1:530640), magnifier, rotation (0.0°), render checkbox, and EPSG:3857 projection indicator.

The screenshot shows the QGIS application interface with the following details:

- Toolbar:** A comprehensive toolbar at the top with icons for file operations, selection, measurement, and editing.
- Browser Panel:** On the left, it lists available data sources:
  - DB2
  - WMS/WMTS (selected)
  - XYZ Tiles
  - WCS
  - WFS
  - OWS
  - ArcGisMapServer
  - ArcGisFeatureServer
  - GeoNode
- Layers Panel:** Shows the current layers in the project:
  - shape (selected)
  - visakha
  - shape buildings (selected)
  - shape landuse
  - shape natural
  - shape places
  - shape points
- Coordinate Capture:** A panel on the left showing coordinates and capture options:
  - Point: 92.96757, 9.15538
  - Line: 10349102.282, 1023537.588
  - Area: 9220518, 2006355
  - Copy to Clipboard
  - Start capture
- Map View:** The main area displays a map of Visakhapatnam, India, with several layers visible:
  - Buildings (red polygons)
  - Natural features (orange lines)
  - Places (yellow lines)
  - Landuse (green areas)
  - Points (small red dots)Labels on the map include: Srivilliputhur, Vizianagaram, Chintapalli, Polpalle, Tadikonda, Venugopalapeta, Kondapalli, Kottur, Chintalapalli, Sambivaram, Visakhapatnam, Anantapur, Narasimhapet, Elamangal, and Rusottampuram.
- Bottom Bar:** Includes a search bar ("Type to locate (Ctrl+K)"), coordinate display (9220518, 2006355), scale (1:530640), magnifier, rotation (0.0°), render checkbox, and EPSG code (EPSG:3857).

The screenshot shows the QGIS application interface with the following details:

- Toolbar:** A large top bar containing numerous icons for file operations, editing, selection, measurement, and analysis.
- Browser:** A panel on the left under the heading "Browser" showing connection options like DB2, WMS/WMTS, XYZ Tiles, WCS, WFS, OWS, ArcGisMapServer, ArcGisFeatureServer, and GeoNode.
- Layers:** A panel showing the current layers:
  - shape (selected)
  - visakha
  - shape buildings (selected)
  - shape landuse
  - shape natural
  - shape places
  - shape anuante
- Coordinate Capture:** A panel at the bottom-left showing coordinates: 92.96757, 9.15538 and 10349102.282, 1023537.588, along with "Copy to Clipboard" and "Start capture" buttons.
- Map View:** The main area displays a map of the Visakhapatnam region in Andhra Pradesh, India. The map features several orange-shaded areas representing different land use or natural resources categories. A red dashed line highlights a specific route or boundary. Numerous place names are labeled across the map, including Aravakurthy, Vizianagaram, Chintalavallabha, Polkipalle, Tadapuduvula, Venkulpalle, Nallamalla, Chodavaram, Tabbavaram, Simhachalam, Visakhapatnam, Kondapalli, Hanumakonda, and Sottampalam.
- Bottom Bar:** A footer bar with the following controls: "Type to locate (Ctrl+K)", "Coordinate" (9212375, 2005232), "Scale" (1:530640), "Magnifier" (100%), "Rotation" (0.0 °), "Render" (checked), and "EPSG:3857".



The screenshot shows the QGIS application interface with a map of Bangalore, India, displayed in the main window. The map features a grid of buildings and roads, with several specific locations labeled: Mysore Road, VIT, Jaya Chaitanya University, Maddilapalem, All India Institute of Speech and Hearing, Reliance, Ghina Valley, and NUDA Park. A red crosshair is positioned over the area around VIT. The QGIS toolbar at the top contains numerous icons for various functions like selection, measurement, and symbology. On the left, the 'Browser' panel lists connections to DB2, WMS/WMTS (with XYZ Tiles selected), WCS, WFS, OWS, ArcGisMapServer, ArcGisFeatureServer, and GeoNode. The 'Layers' panel shows a legend for 'shape places', 'shape points', 'shape railways', 'shape roads', and 'shape waterways' (which is currently selected). Below the layers is the 'OSM Standard' layer. The 'Coordinate Capture' panel at the bottom-left shows coordinates 92.96757, 9.15538 and 10349102.282, 1023537.588, with buttons for 'Copy to Clipboard' and 'Start capture'. The status bar at the bottom provides information about the legend entries (1), coordinate (9278154, 2006809), scale (1:16582), magnifier (100%), rotation (0.0°), render status, and EPSG code (EPSG:3857).

Browser

- DB2
- WMS/WMTS
  - XYZ Tiles
  - WCS
  - WFS
  - OWS
  - ArcGisMapServer
  - ArcGisFeatureServer
  - GeoNode

Layers

- shape places
- shape points
- shape railways
- shape roads
- shape waterways

OSM Standard

Coordinate Capture

92.96757, 9.15538

10349102.282, 1023537.588

Copy to Clipboard

Start capture

Type to locate (Ctrl+K)

1 legend entries per Coordinate 9278154,2006809

Scale 1:16582

Magnifier 100%

Rotation 0.0°

Render

EPSG:3857

The screenshot shows the QGIS application interface with a map of South India. The map displays a dense network of purple lines representing railway tracks. A legend in the bottom left corner identifies these layers under the heading "shape roads". Other layers visible include "shape places", "shape points", "shape railways", "shape waterways", and "OSM Standard". The "shape roads" layer is currently selected. The map also features green shaded regions and place names like "Chennai", "Madras", "Vellore", "Coimbatore", "Kanchipuram", "Erode", "Hariharanallur", "Elamkulam", and "Tirupuram".

**Browser**

- DB2
- WMS/WMTS
  - XYZ Tiles
  - WCS
  - WFS
  - OWS
  - ArcGisMapServer
  - ArcGisFeatureServer
  - GeoNode

**Layers**

- shape places
- shape points
- shape railways
- shape roads**
- shape waterways

**Coordinate Capture**

- 92.96757,9.15538
- 10349102.282,1023537.588

**Tools**

- Copy to Clipboard
- Start capture

Type to locate (Ctrl+K)

1 legend entries per Coordinate 9214341,1998914

Scale 1:530640

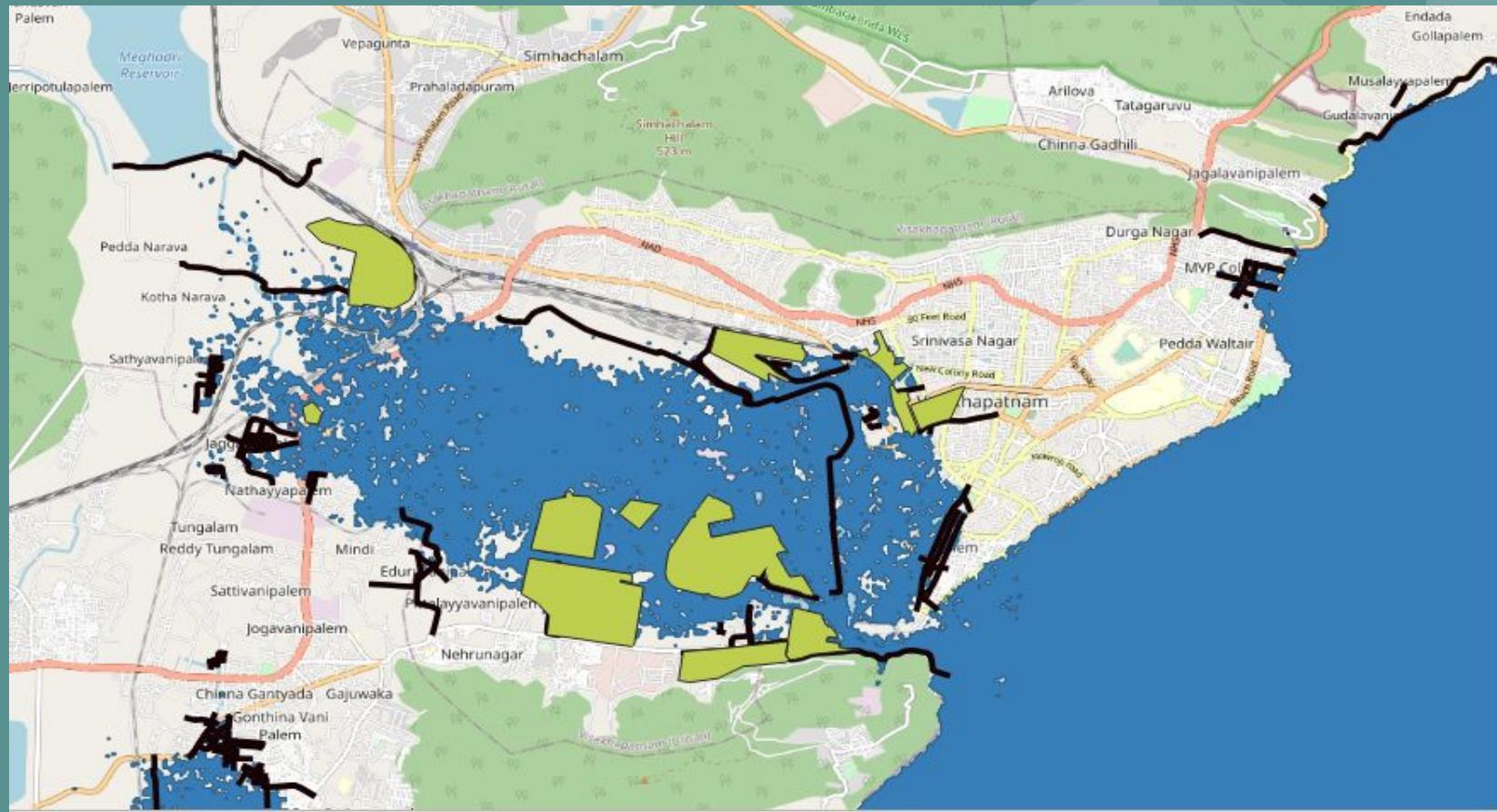
Magnifier 100%

Rotation 0.0°

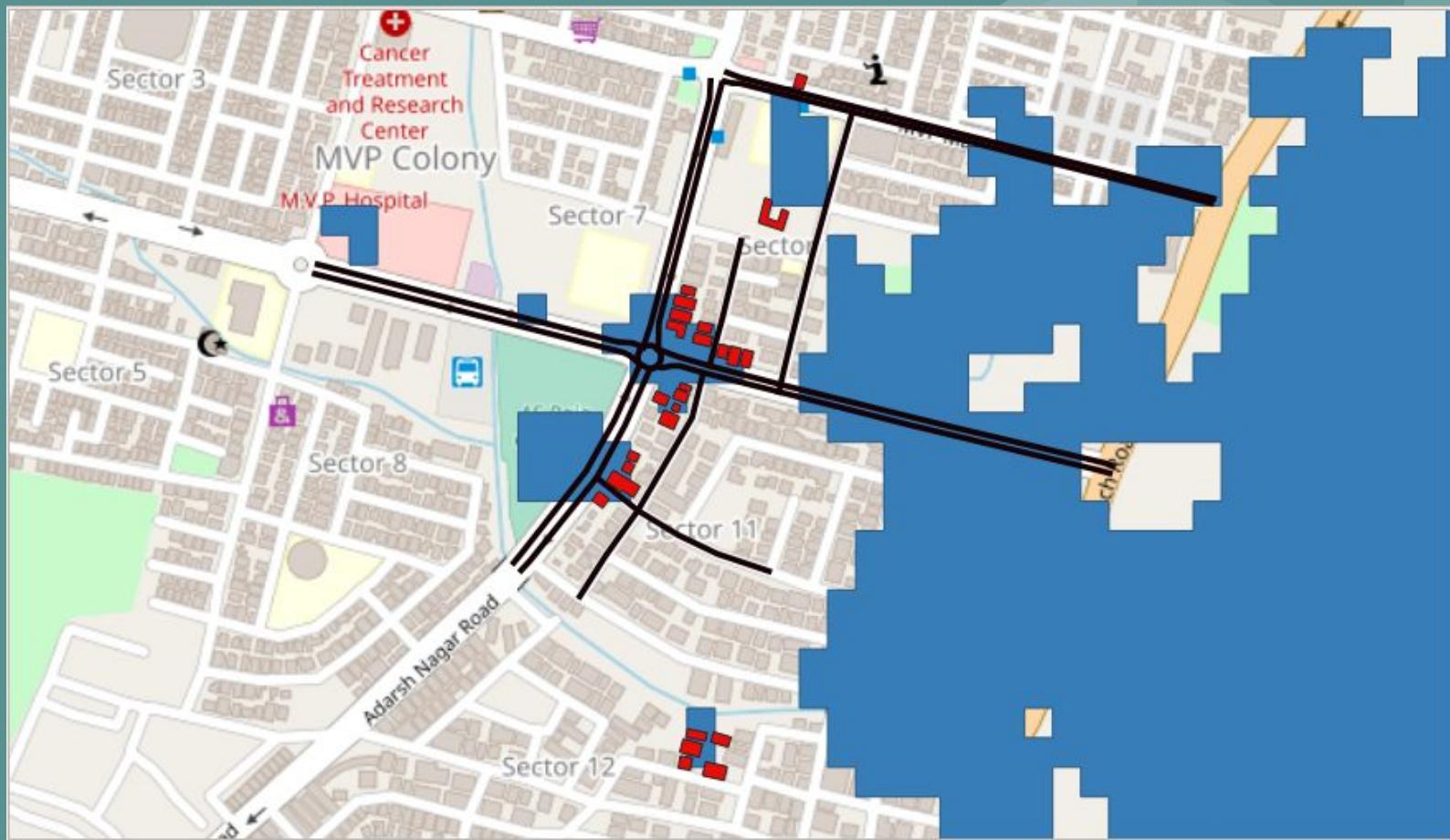
Render

EPSG:3857

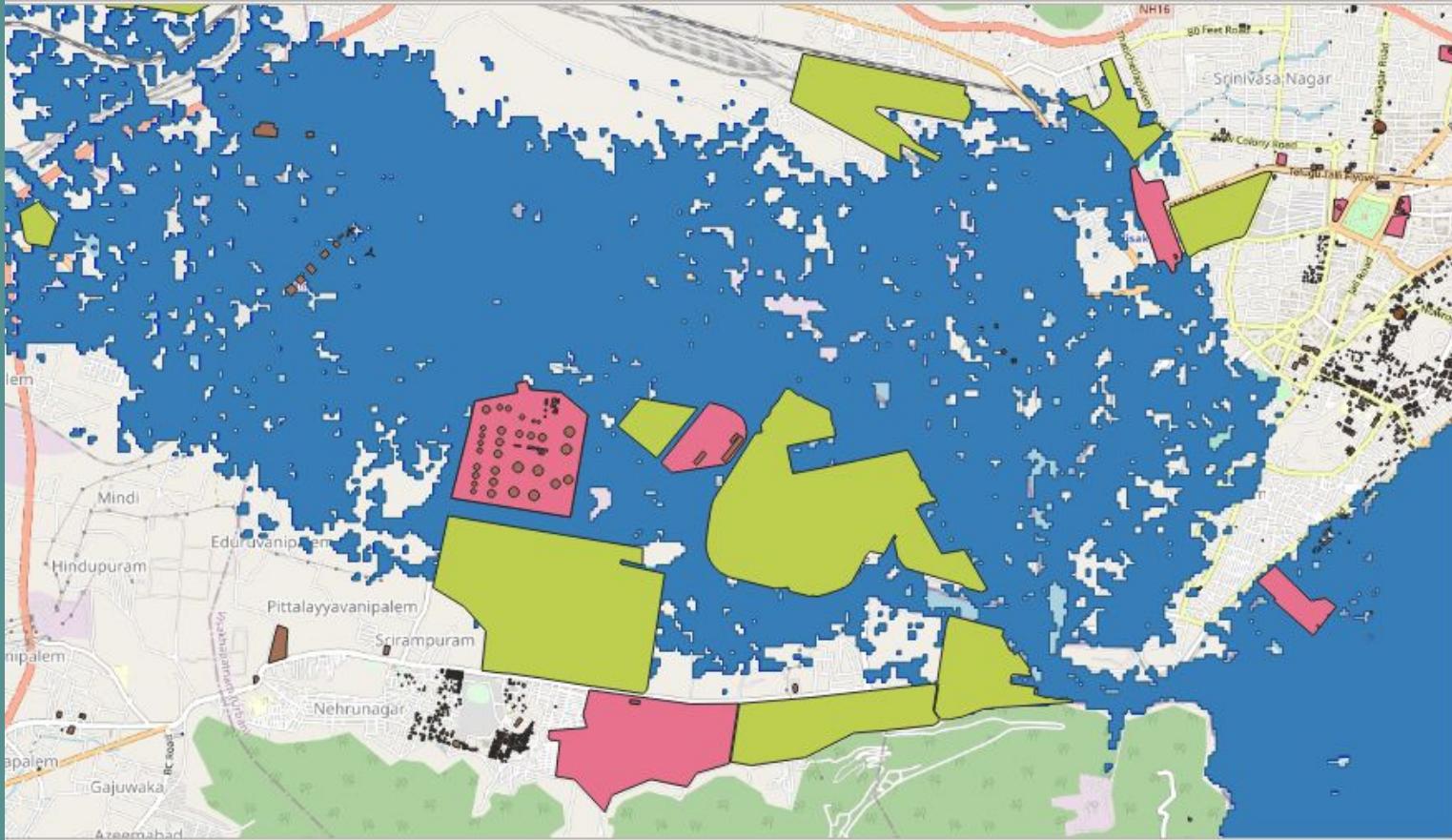
# Land use that is exposed to floods



# Exposed buildings (in red) and roads (in black)



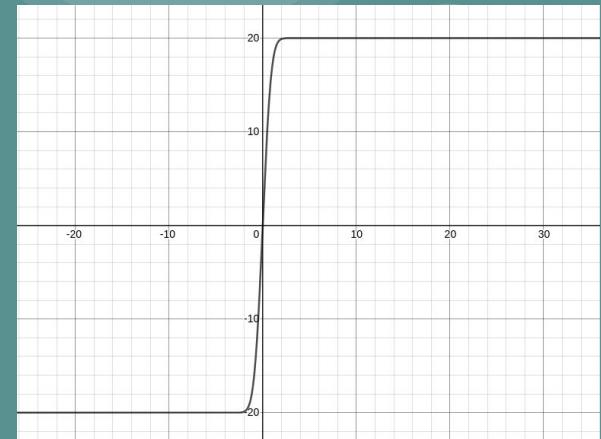
# Exposed land cover



## Vulnerability Assessment:

- As we have seen the areas which are exposed to floods, we find there vulnerability is estimated from depth-damage curves.
- Damage is calculated in terms of area and depth.
- We find area using field calculator in qgis.
- Depth is got from DEM models.

Demand-Depth Curve



Project Edit View Layer Settings Plugins

File Layer Vector Raster Tools

Layers

- points
- places
- railways
- land\_intersect
- plis**
- landuse
- waterways
- natural
- build\_intersect
- buildings
- road\_intersect
- roads
- poly\_wat**
- fld10**
- nonflooding
- flooding
- N17E083.hgt
  - 18
  - 102.6
  - 223.2
  - 343.8
  - 464.4
  - 585
- OSM Standard

Field

Coordinate 9262290,2005530 Scale 1:52221 Magnifier 100% Rotation 0.0° Render EPSG:3857

### Field calculator

Input layer plis

Output file [Save to temporary file]

Create a new field  Update existing field

Output field name fid

Output field type Float

Output field width 10 Precision 3

Expression Function Editor

\$area

Search... Show Help

function bounds\_height

Returns the height of the bounding box of a geometry. Calculations are in the Spatial Reference System of this geometry.

Syntax

bounds\_height(*geom*)

Arguments

*geom* a geometry

Examples

- bounds\_height(\$geometry) → height of bounding box of \$geometry

Output preview: 663159.6391359732

0%

Cancel OK



## Risk Assessment

Risk is equal to the product of all these factors. That is,

Risk = Probability of flooding \* Depth values(Hazard) \* Exposure \* Vulnerability