FLOOD RISK MODELLING

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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:

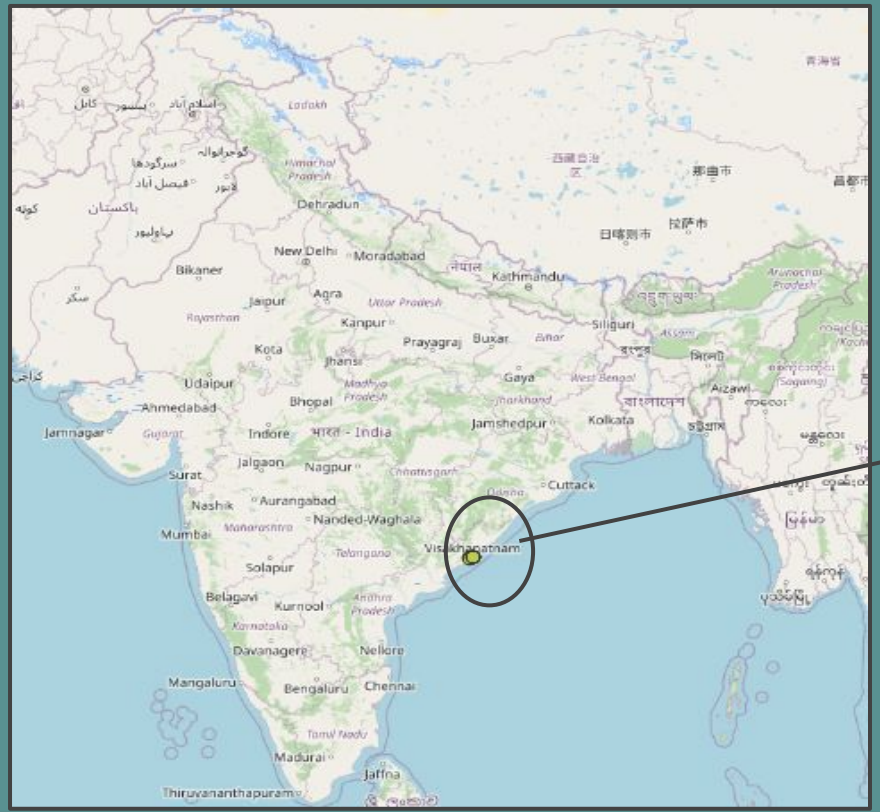
- A study of vulnerability and risk due to floods in particular to a geographical location, by doing Risk Assessment.
- To develop a prototype that provides the assessment of flood consequences.
- Vulnerability or Damage Analysis due to floods.

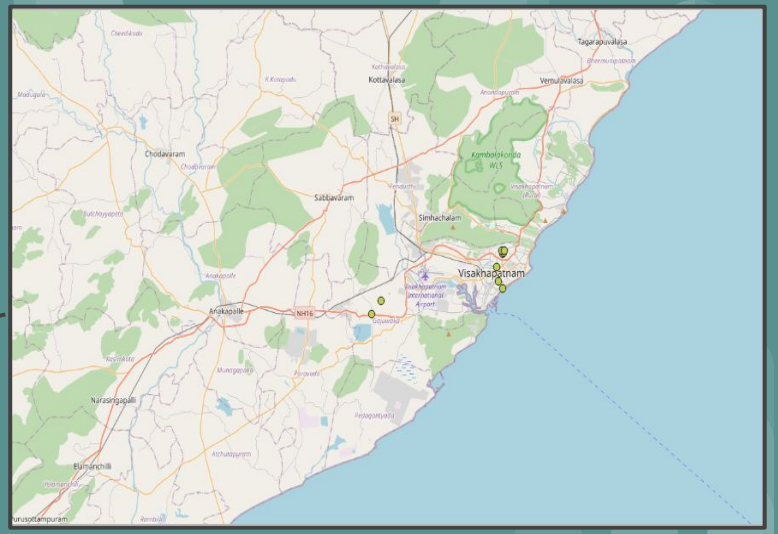
Software Requirement: QGIS

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

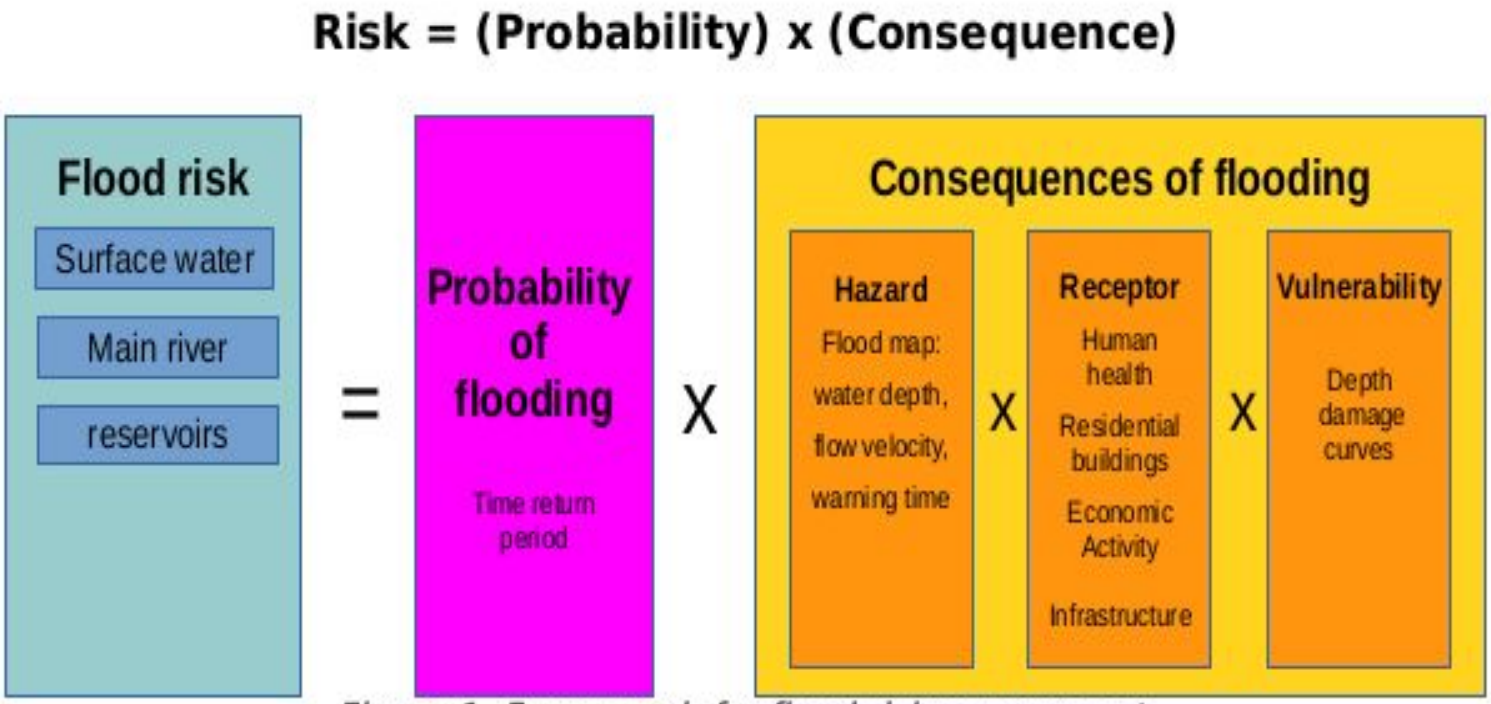


Figure 1 :Framework for flood risk assessment

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.

The 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

Years	June	July	August	September	October	November	December	January	February	March	April	May	Total
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	5737	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.

We calculate it using the formulas, http://www.eeescience.utoledo.edu/faculty/stierman/Notes/odds.htm

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

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 JK 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

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

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 (that is, 5.8%, about one chance in 20).

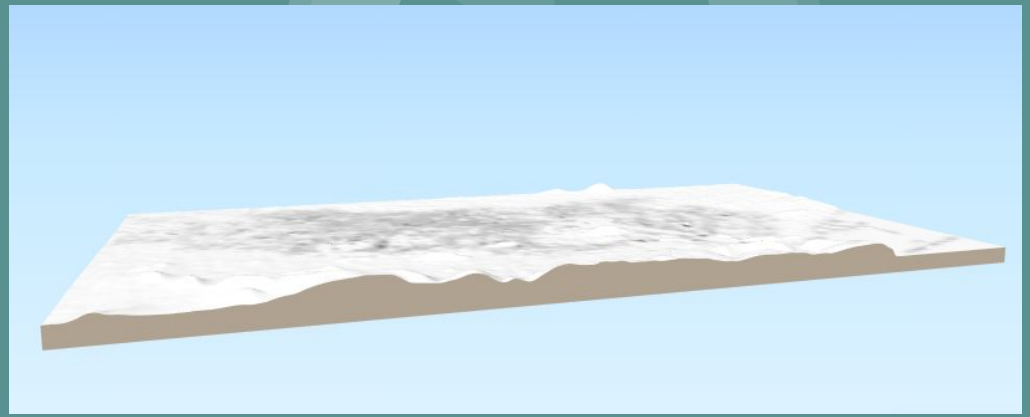
Hazard Assessment:

- 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

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

Depth Elevation Model

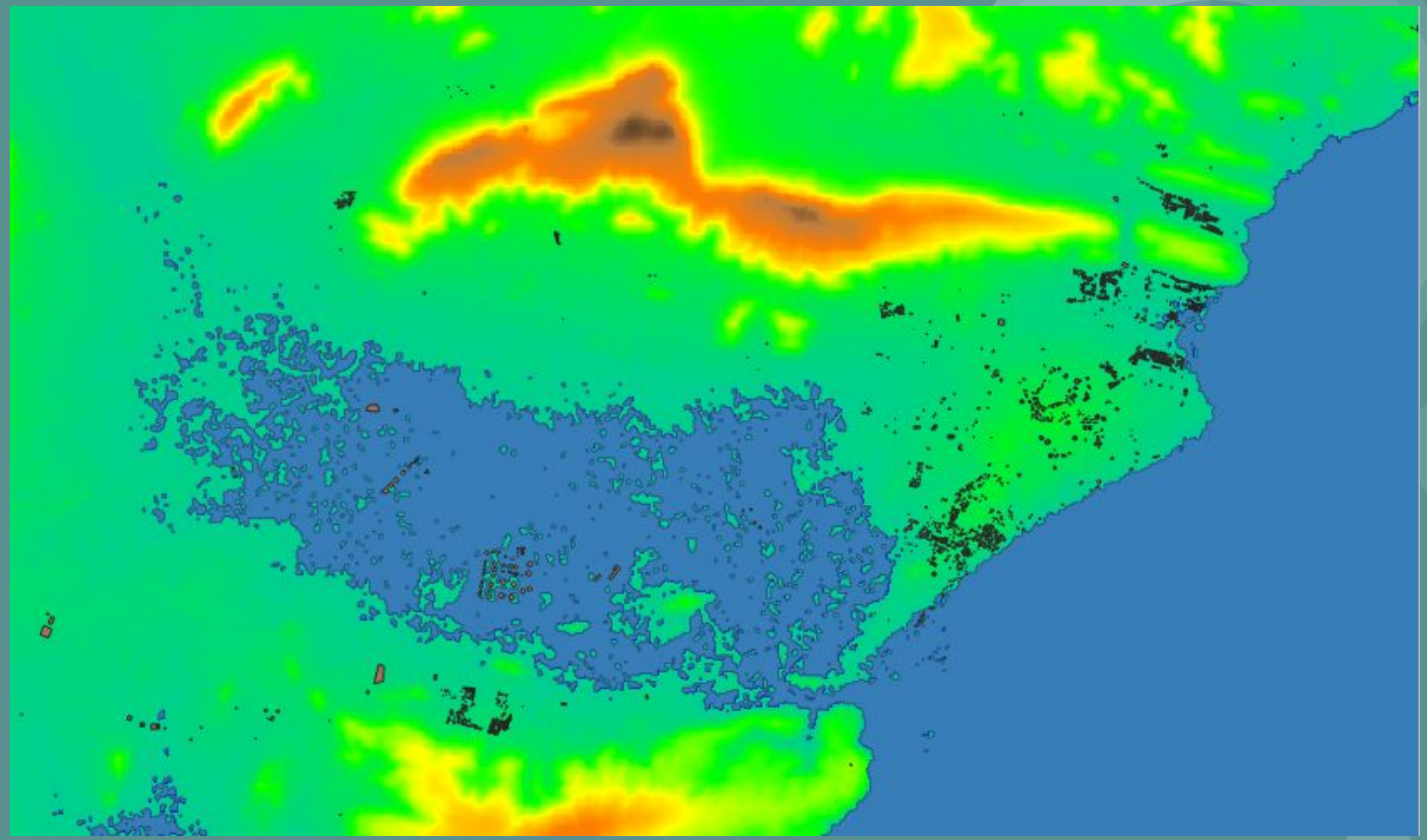


From these we estimate the level of the water table.
In raster calculator:

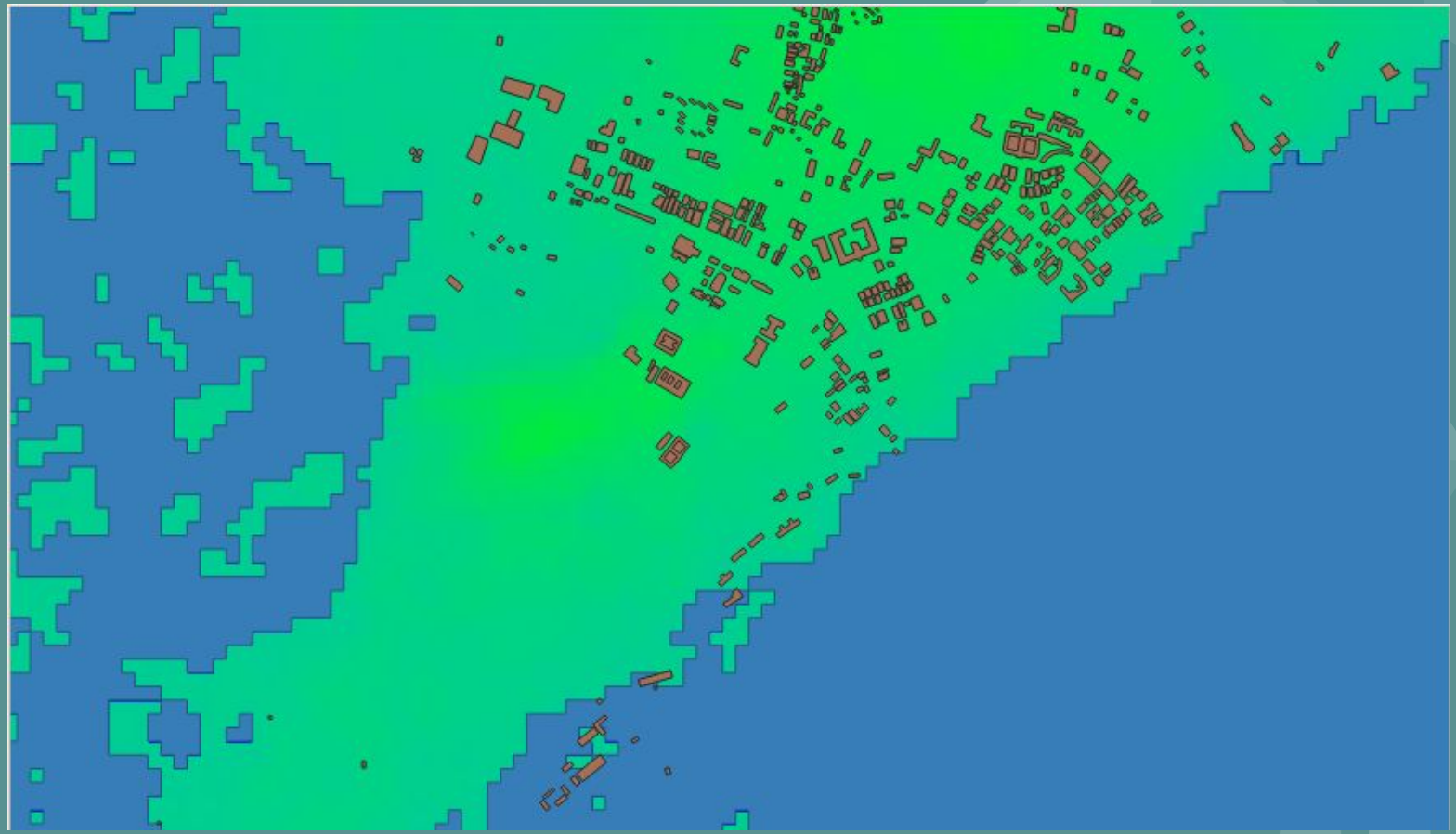
- out_raster1 = DEM * binary_mask, where binary mask means 1 if area is flooded and 0 if non-flooded.

Land Use Map

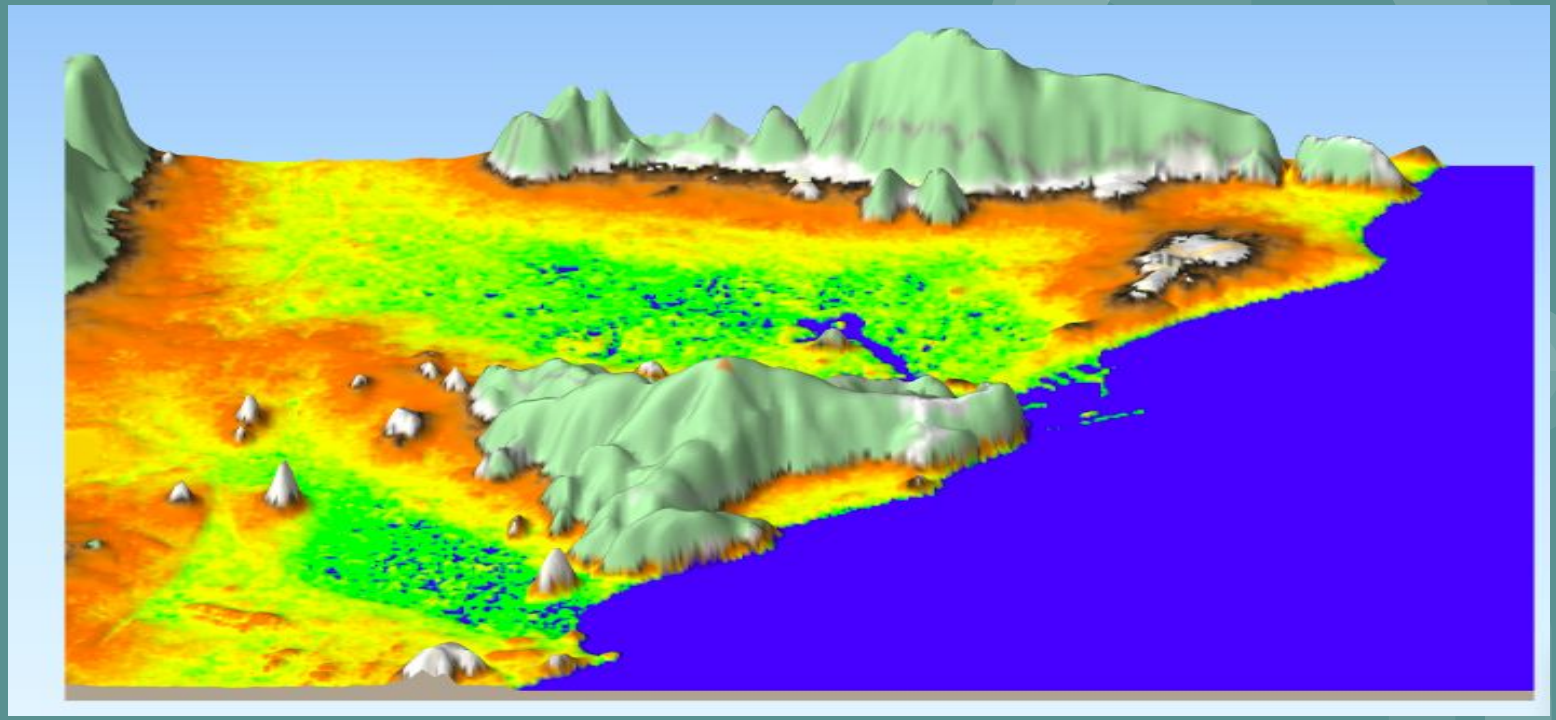
Induction Map



Buildings and the landscape with probable flood prone area



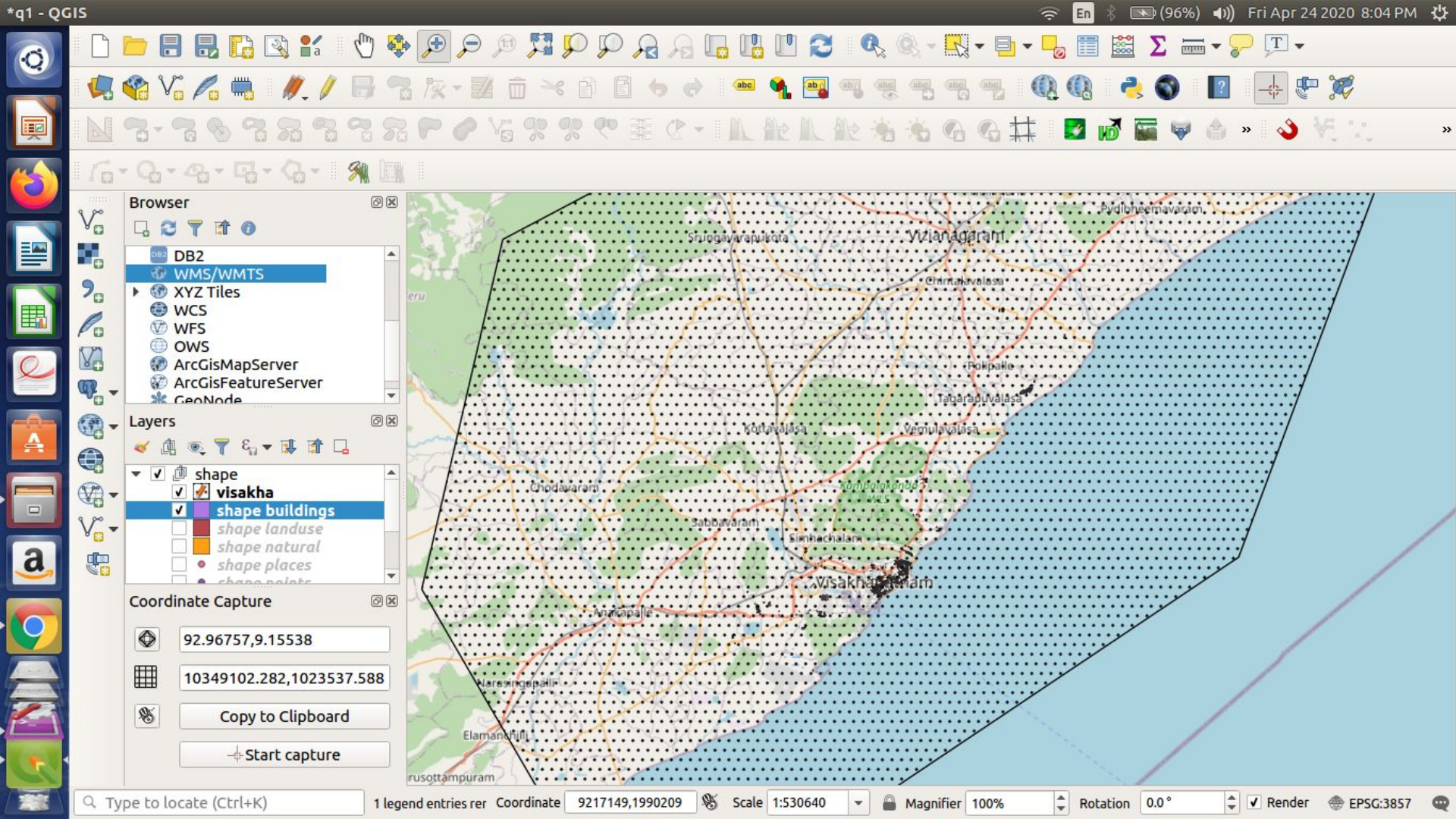
Flood Inundation Visualisation



Exposure / Receptor

To get the areas exposed:

1. The areas which are flooded on occurance 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.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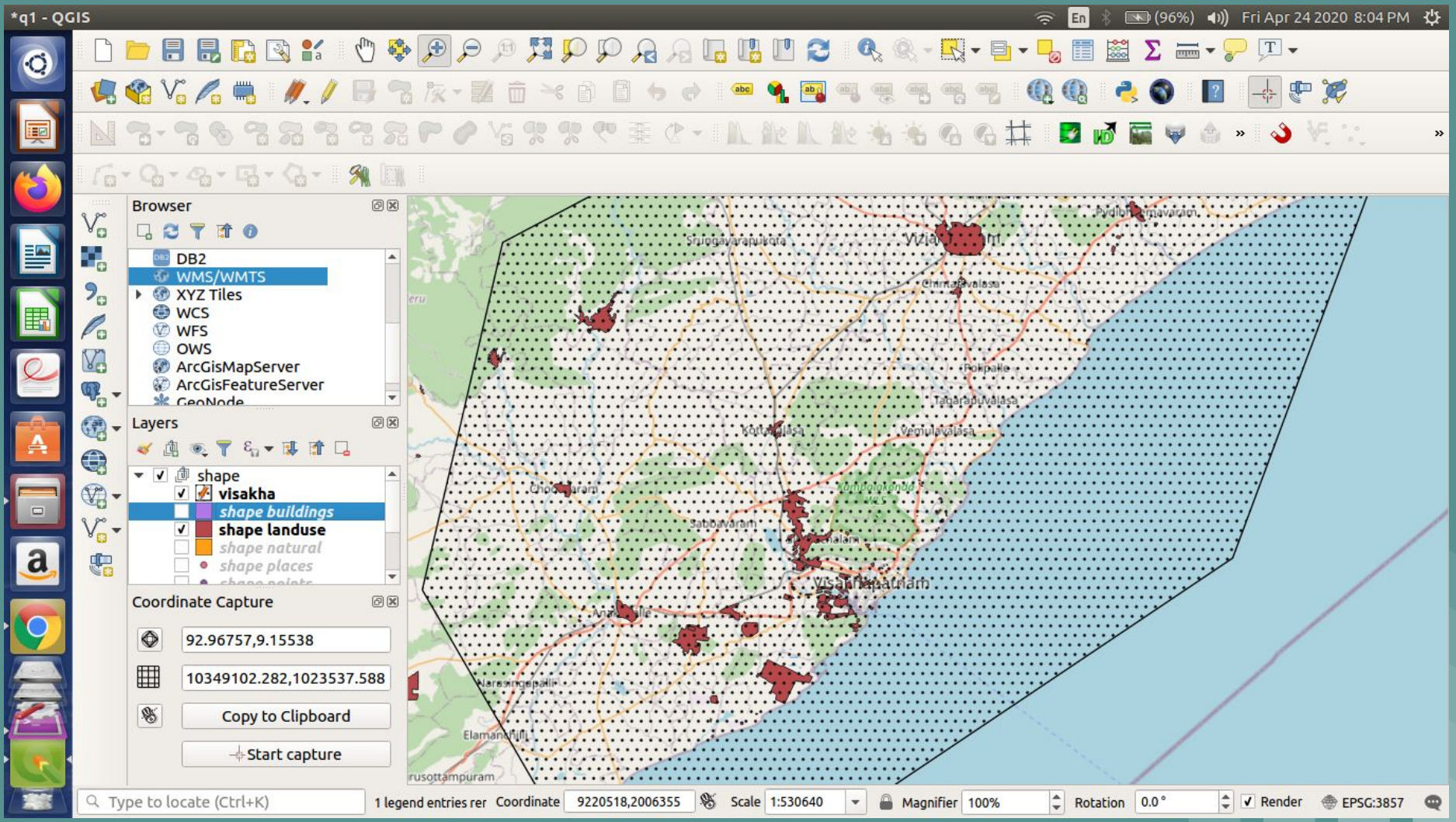
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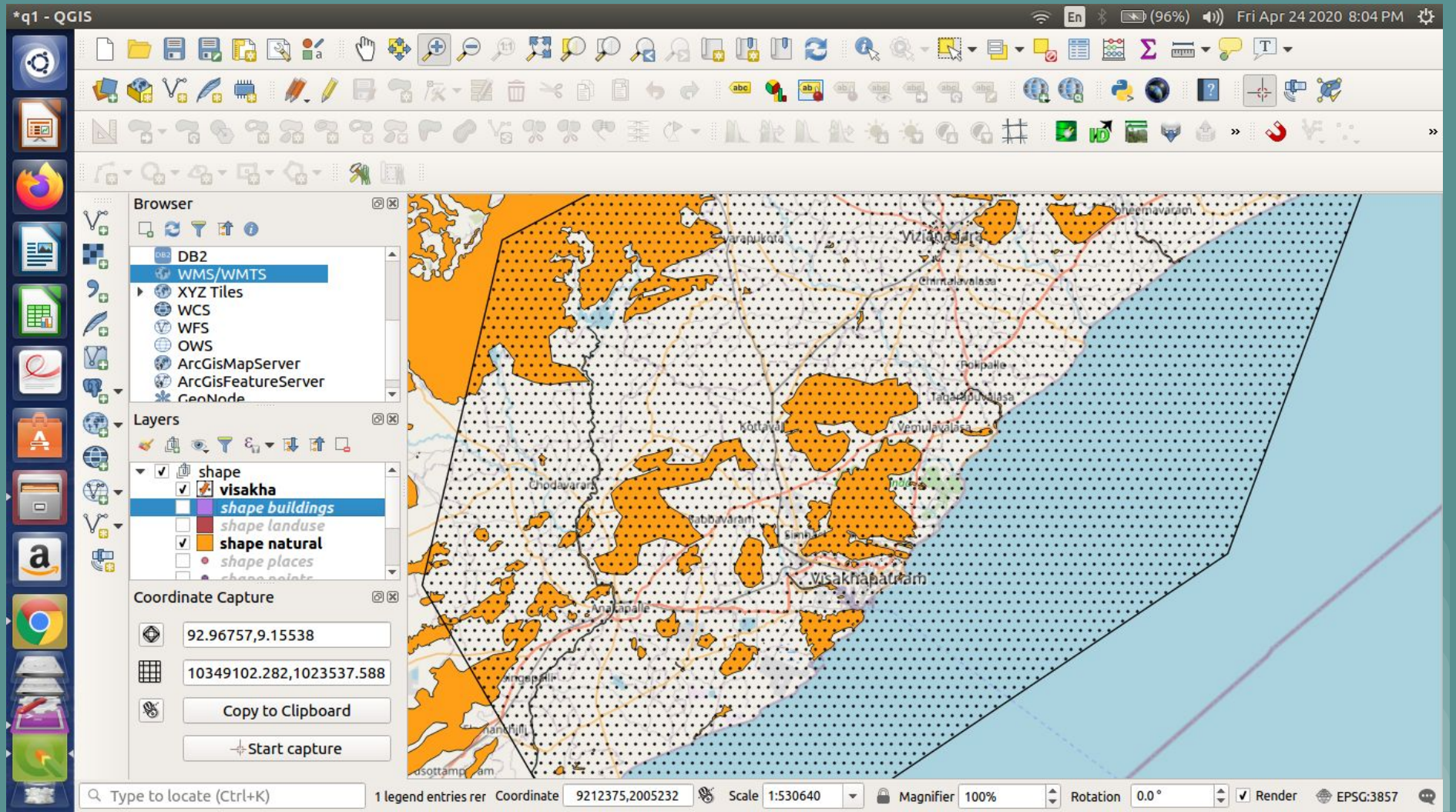
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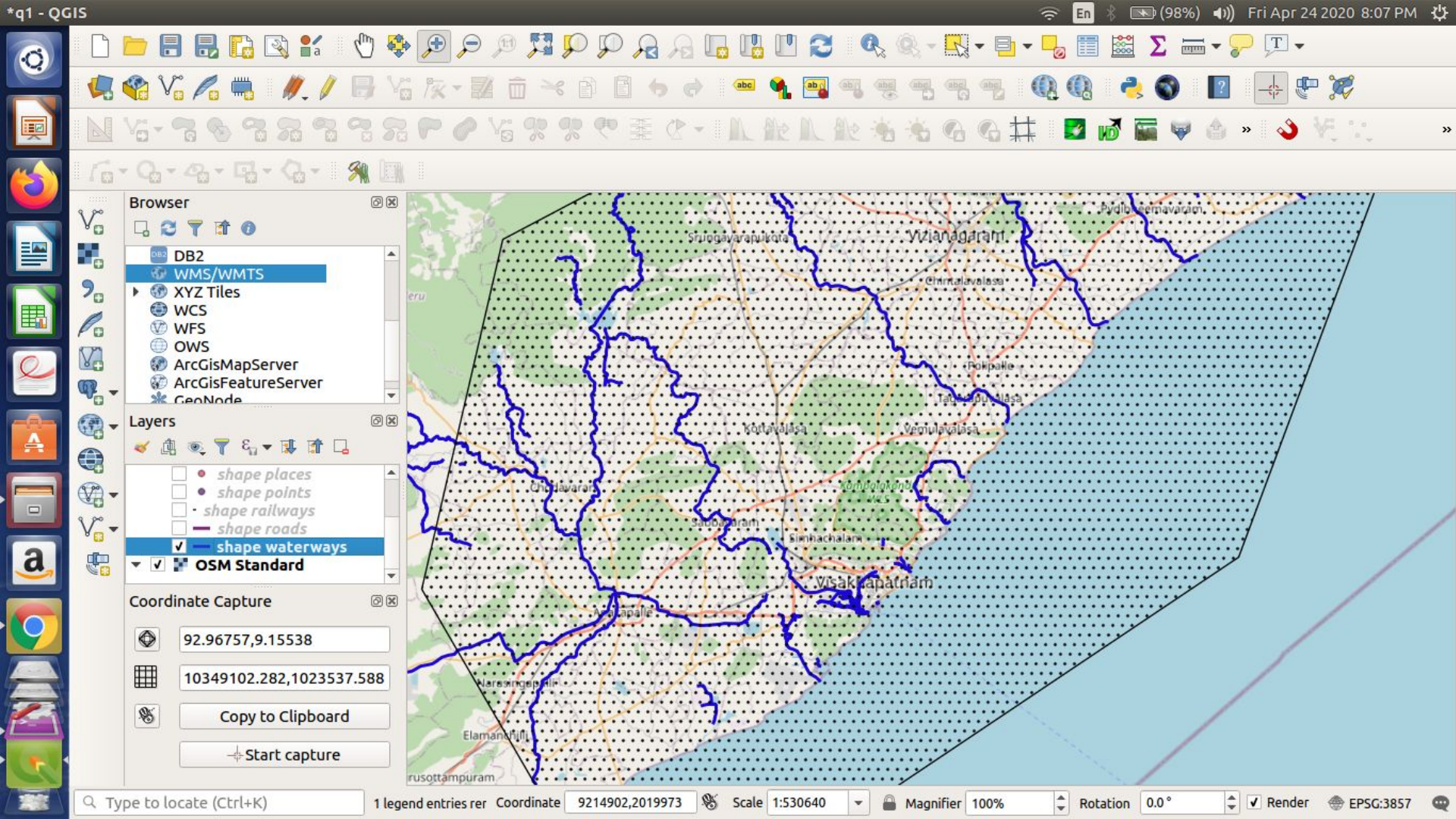
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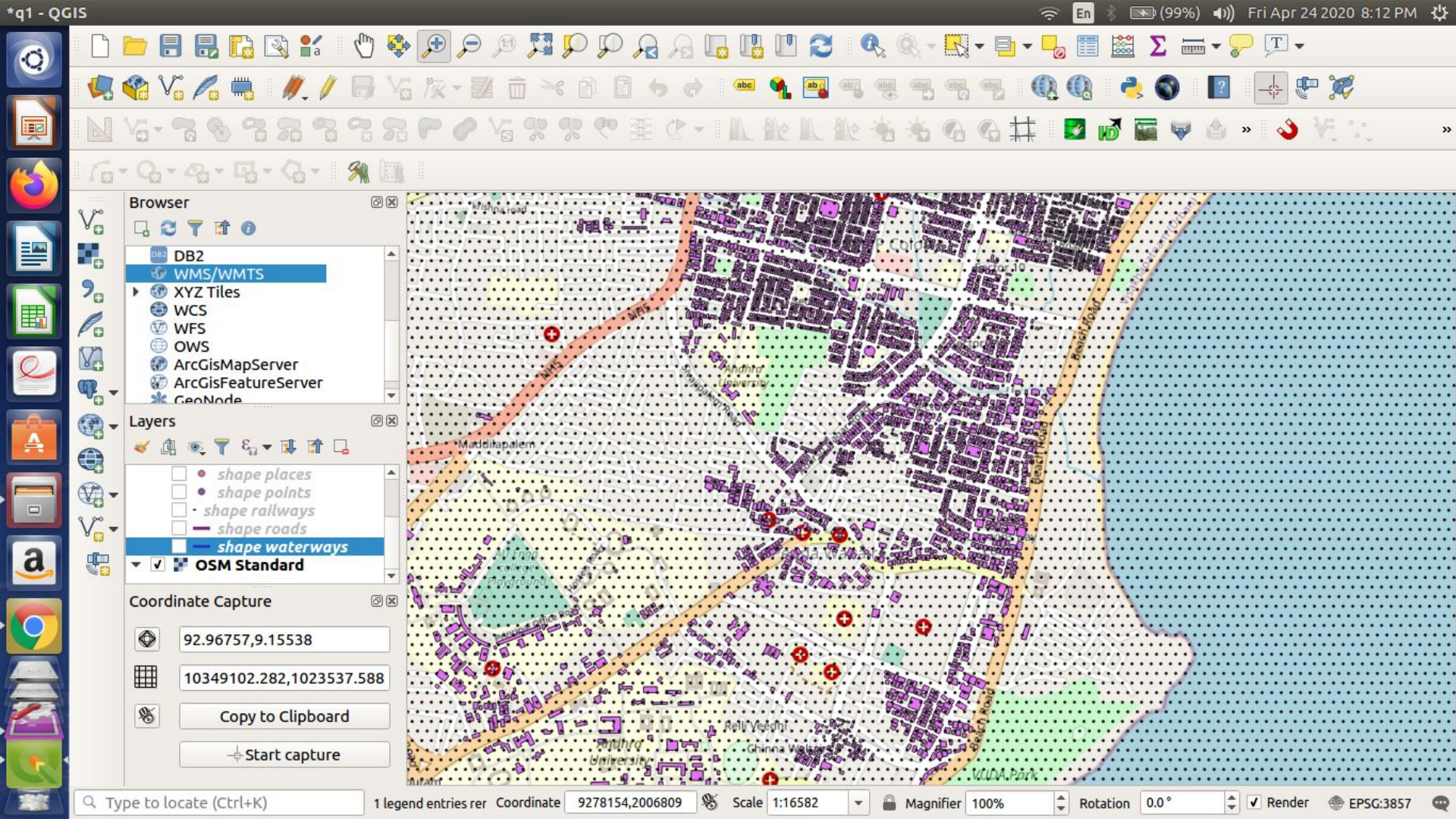
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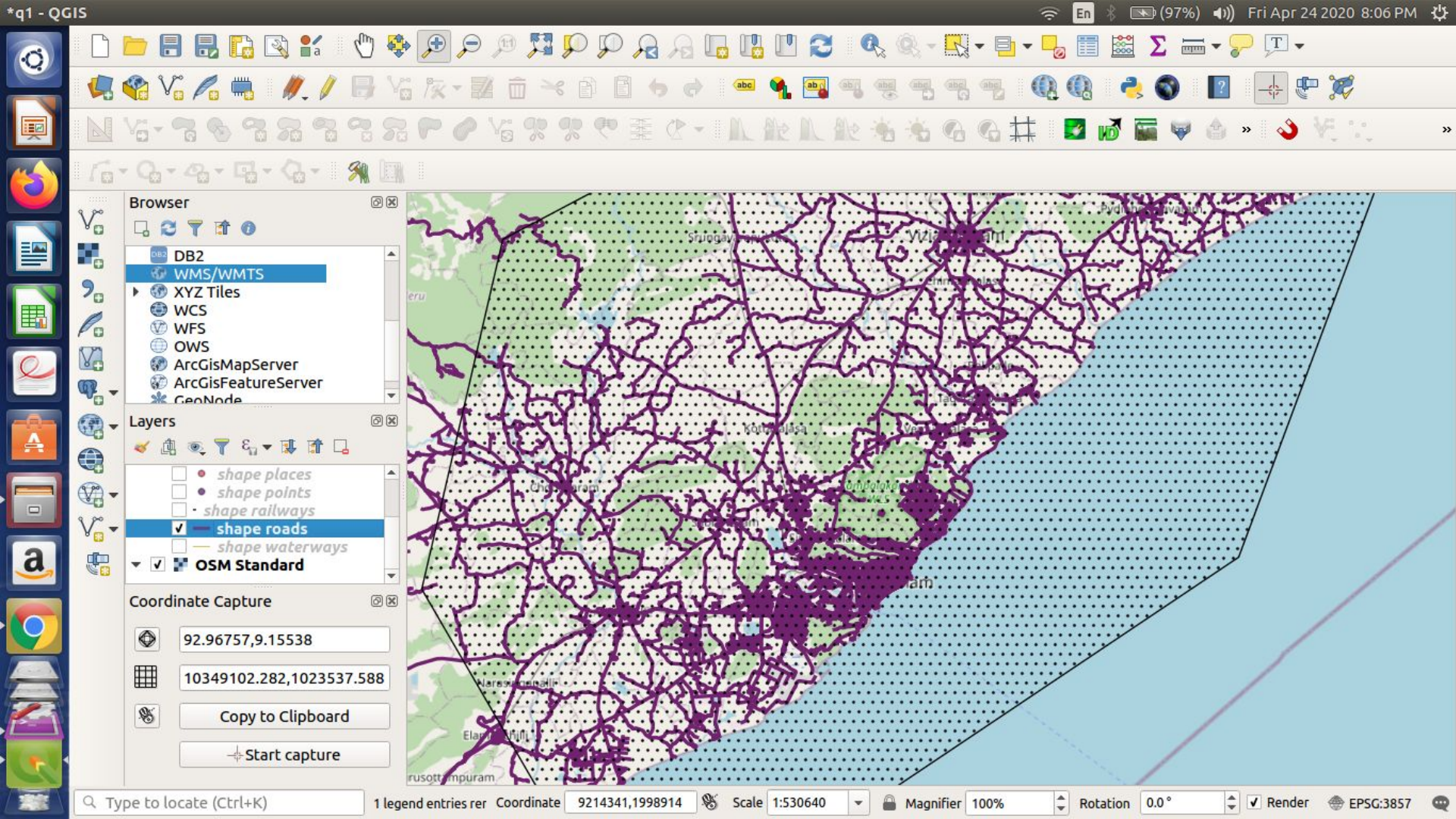
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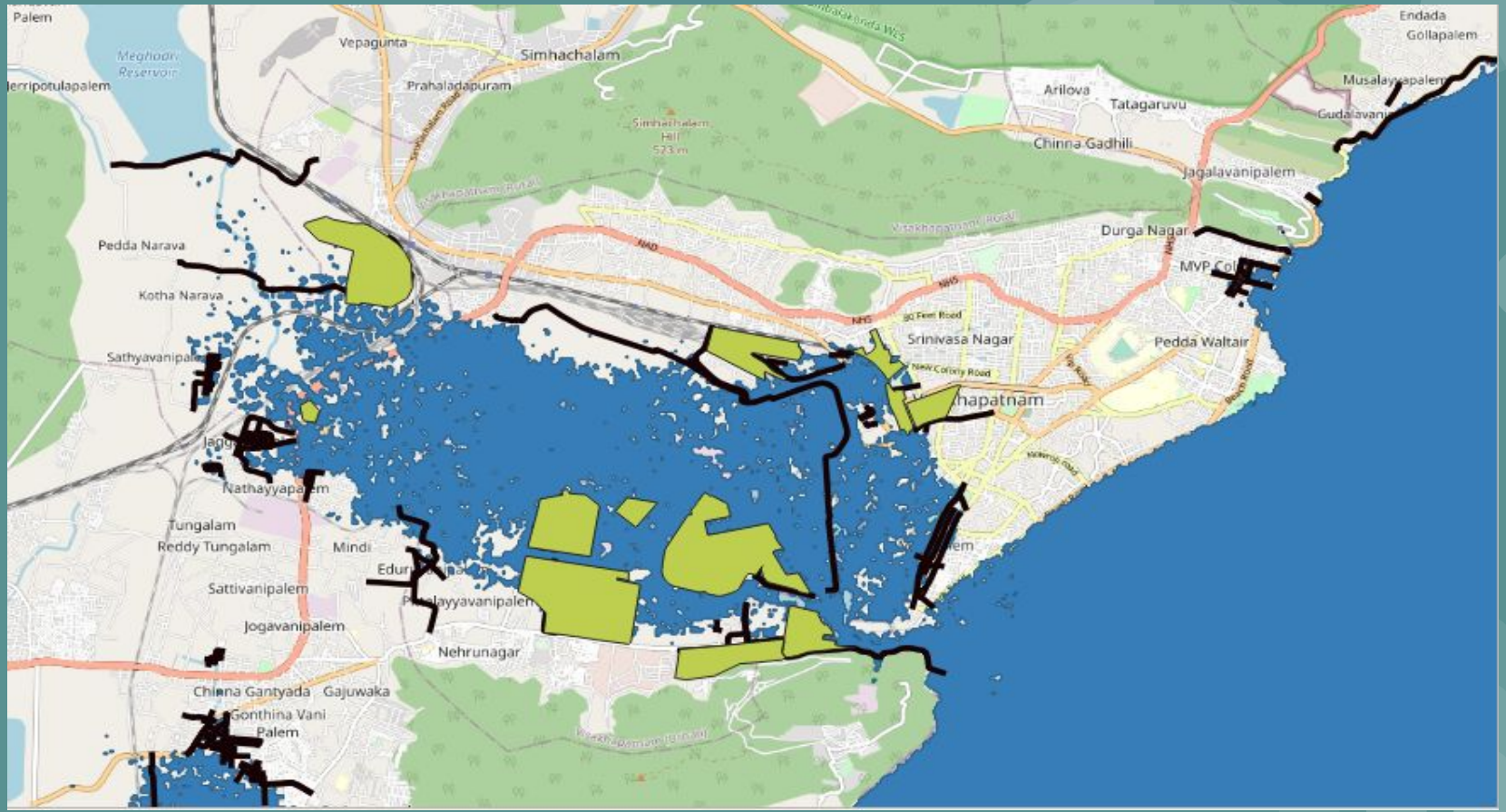
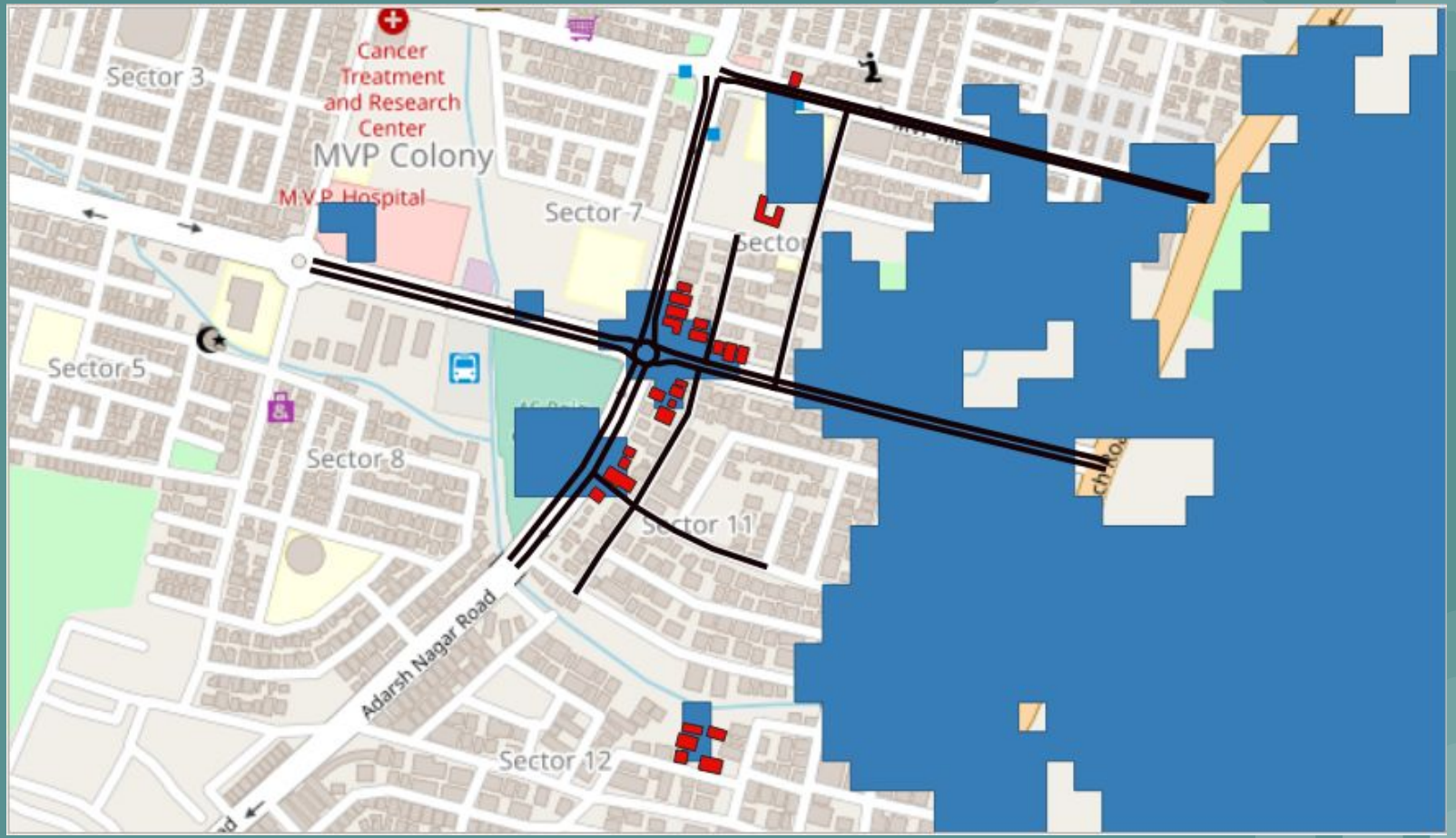
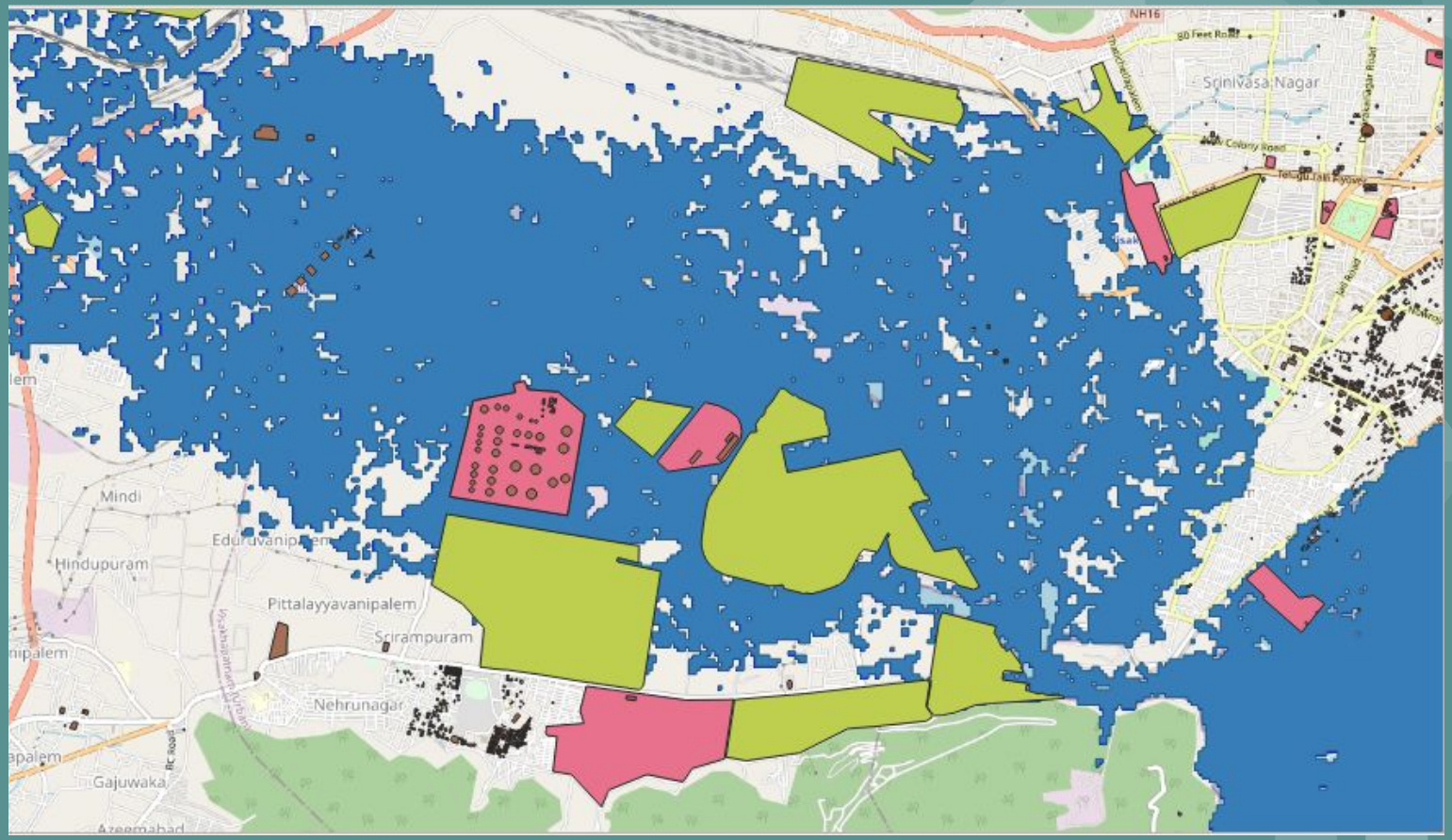
Land use that is exposed to floods



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



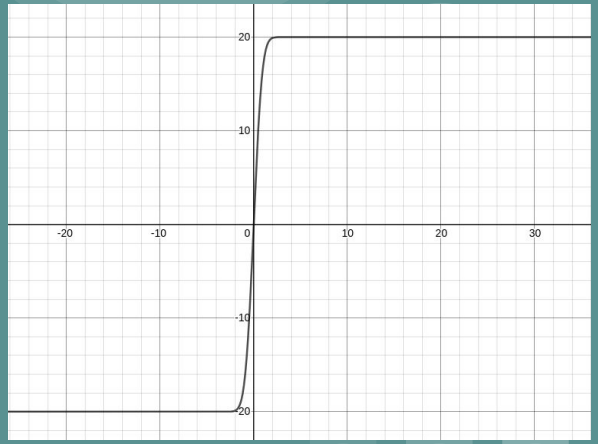
Exposed land cover

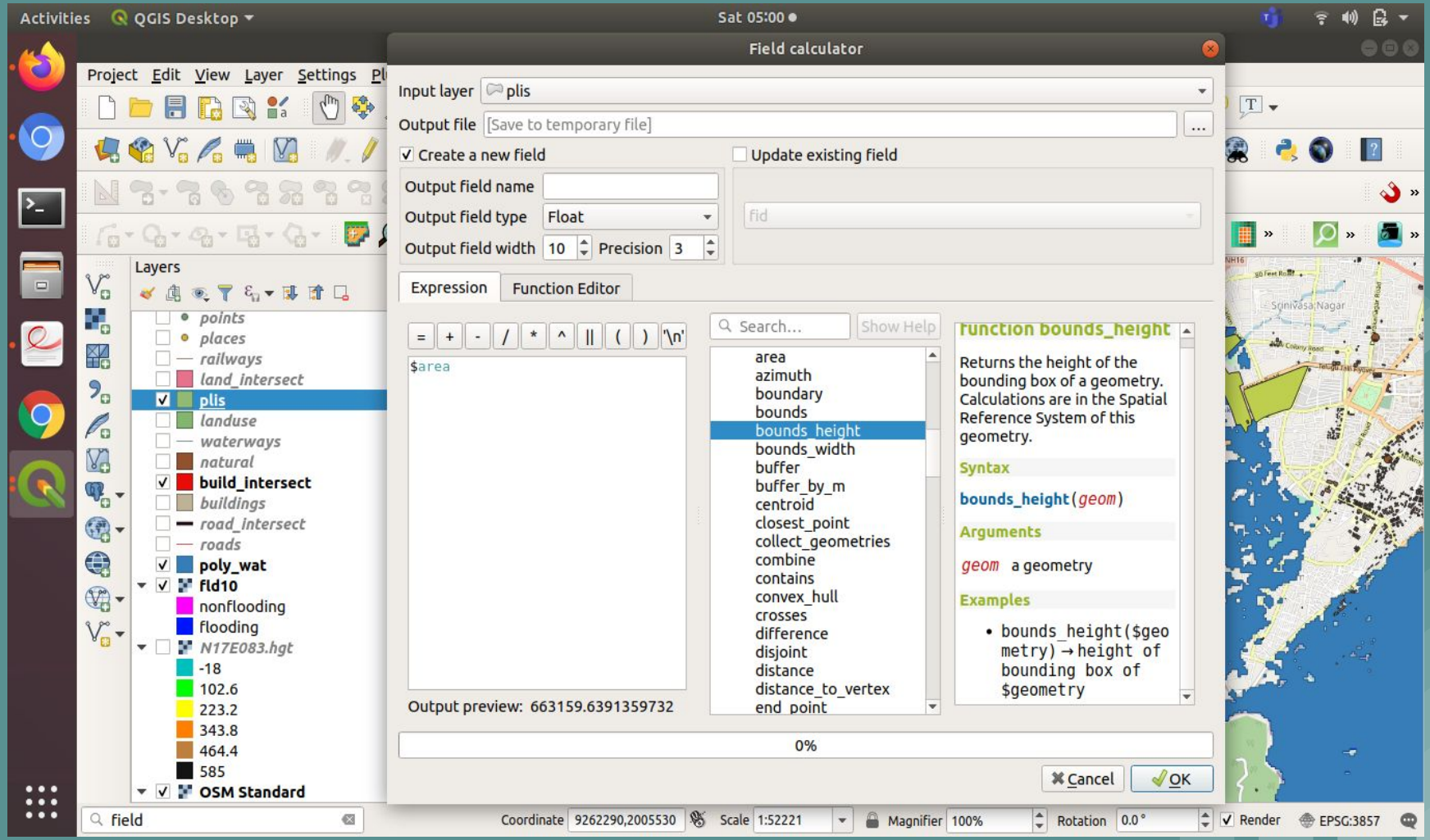


Vulnerability Assessment:

- 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

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convex_hull
crosses
difference
disjoint
distance
distance_to_vertex
end_point
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
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Risk Assessment

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

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