Variation in vulnerability to seawater intrusion with response to change in groundwater level in the coastal region of Sankaraparani river basin, India

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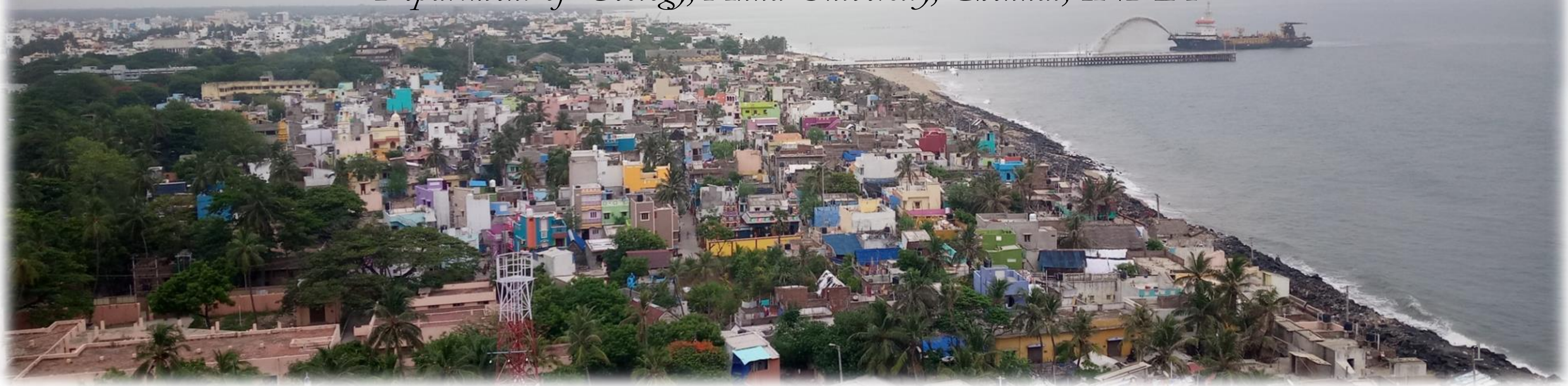
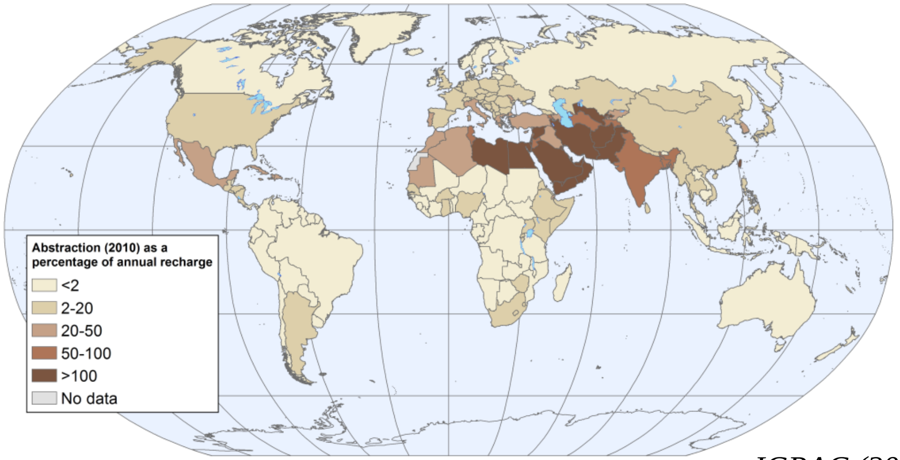
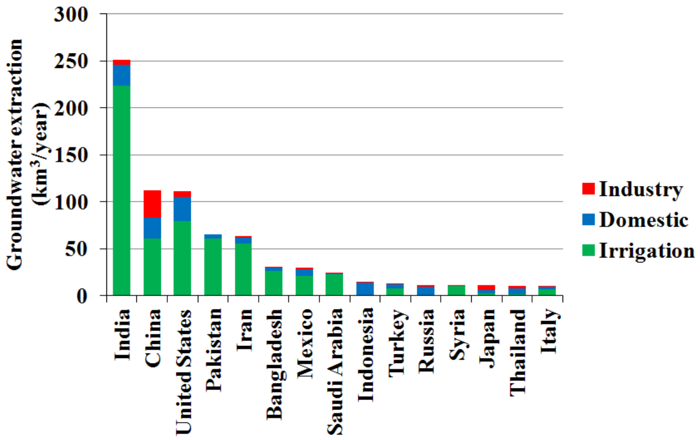


Introduction

- Over pumping of groundwater – major concern
- Around 982 km^3/year – irrigation (75%) – domestic (17%) – industries (8%)
- Groundwater over extraction causes
  - Decrease in groundwater resources – aquifer over exploitation
  - Coastal region – **Seawater Intrusion**



IGRAC (2014)



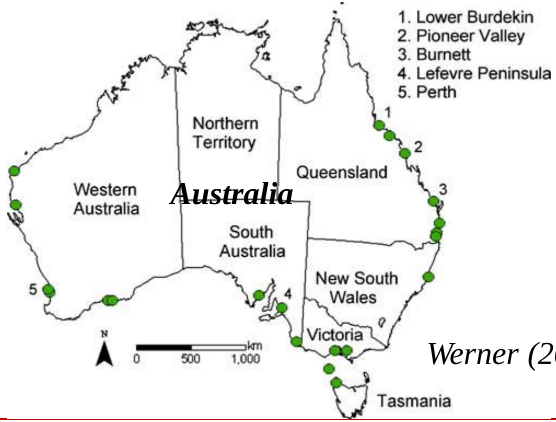
Margat and Gun (2013)

Seawater Intrusion – World Scenario

NASA (2016)

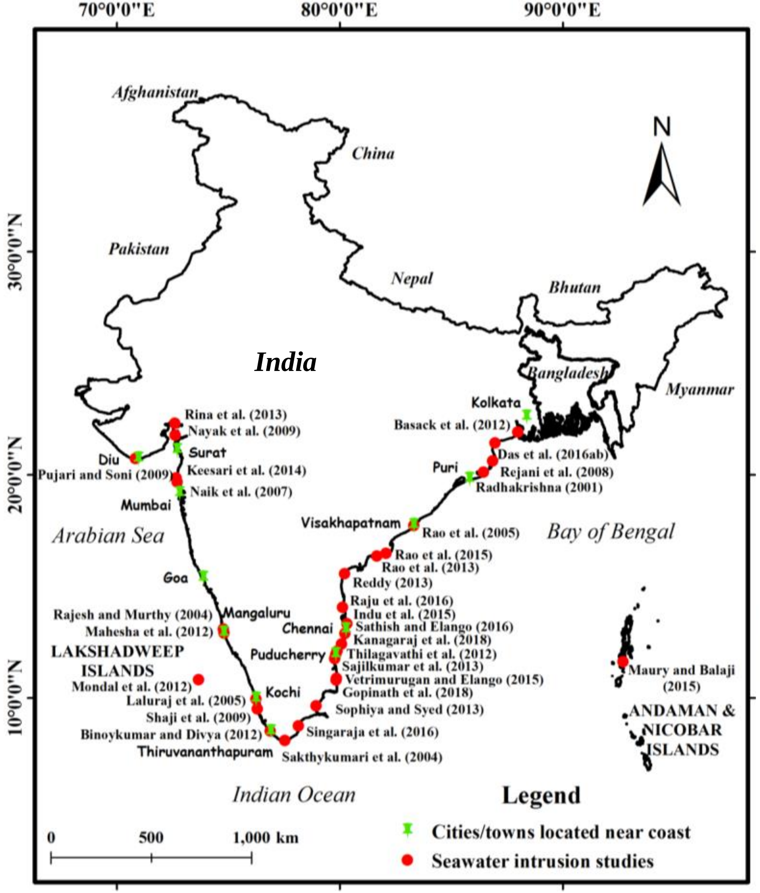
Shi and Jiao (2014)

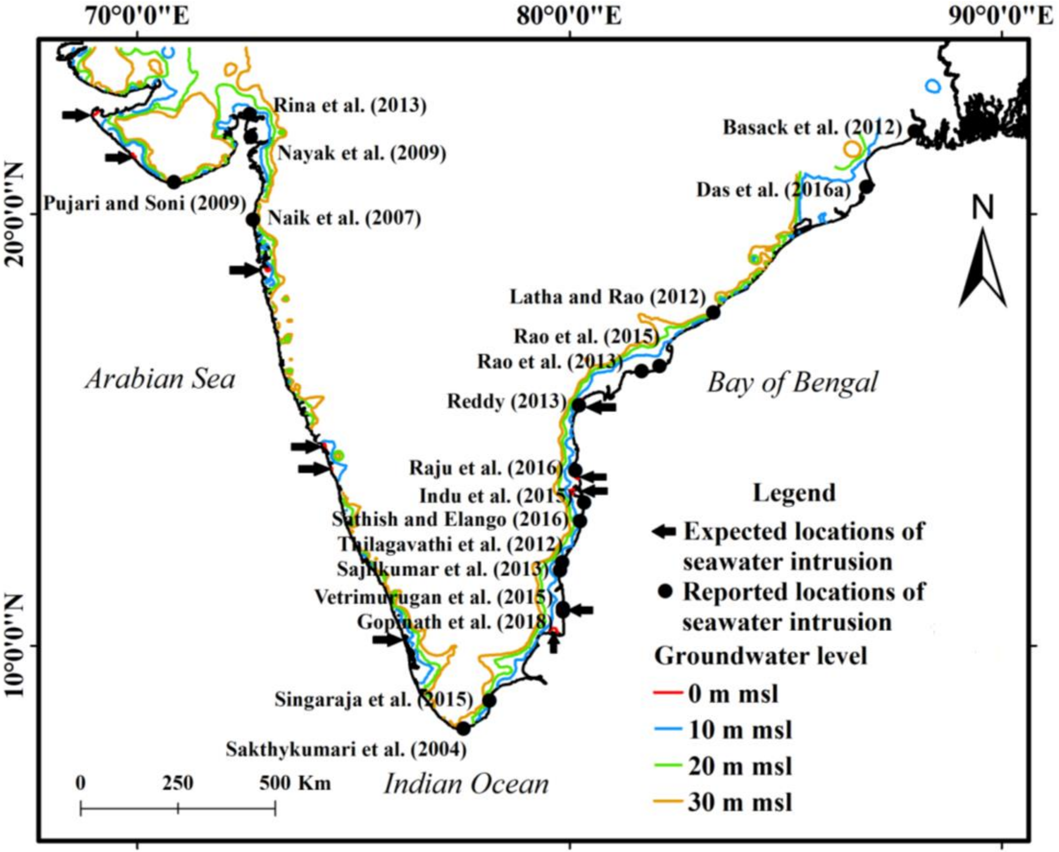
Agoubi (2021)



Werner (2010)

Seawater Intrusion – Indian Scenario

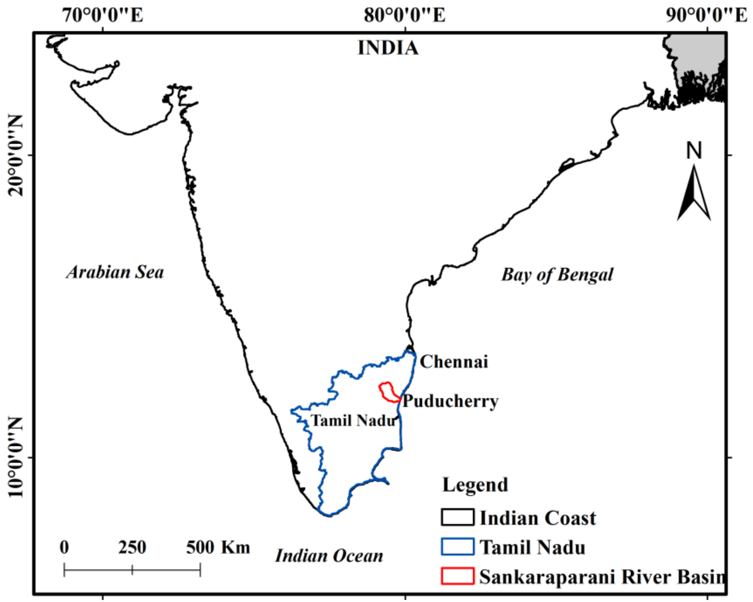




(Manivannan and Elango 2019)

Objective

- To understand the vulnerability of coastal aquifer to seawater intrusion in Sankaraparani river basin



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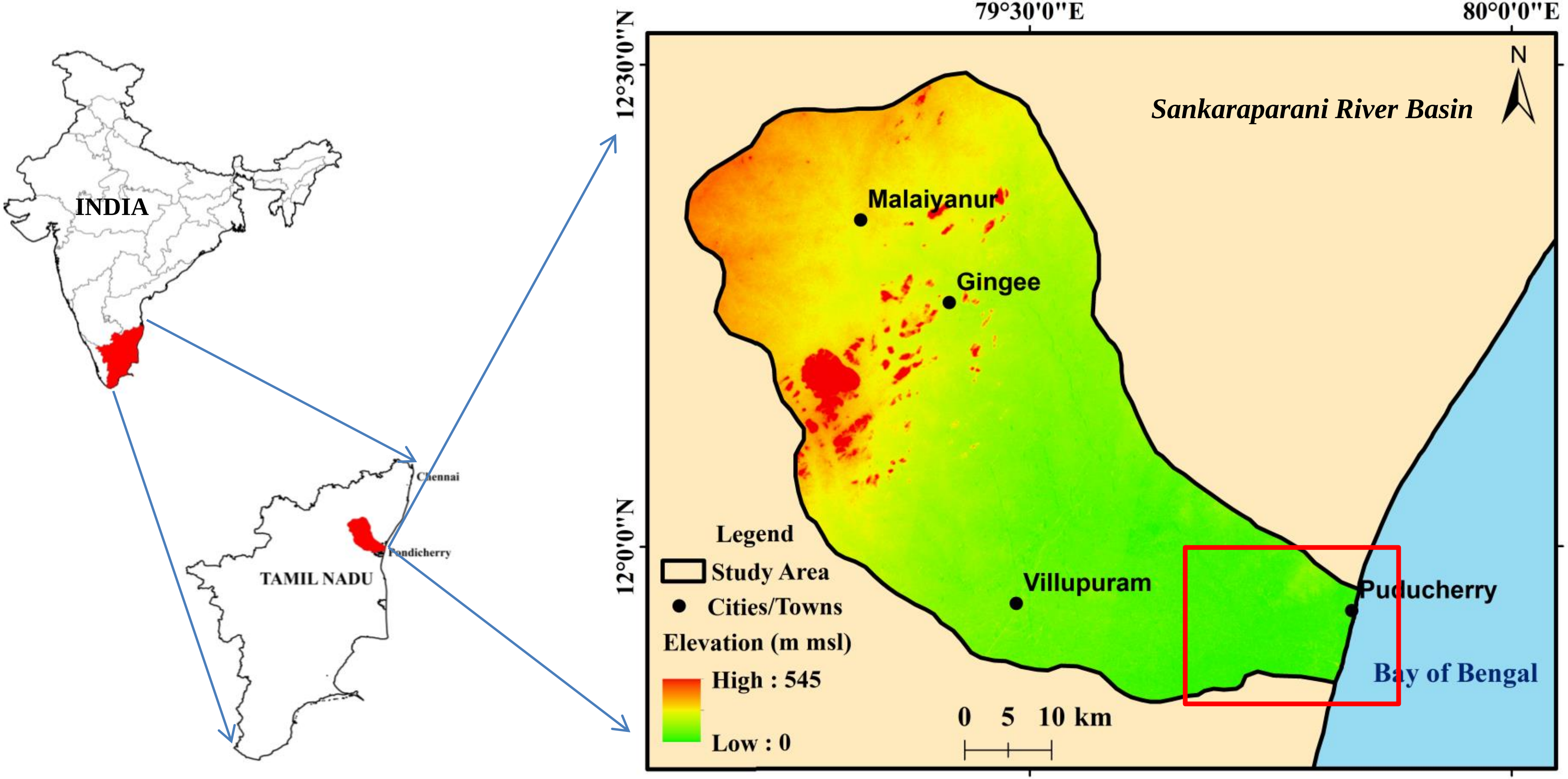
Study Area


INDIA
TAMIL NADU
Chennai
Pondicherry
79°30'0"E
80°0'0"E
12°30'0"N
12°0'0"N
N
Sankaraparani River Basin
Malaiyanur
Gingee
Villupuram
Puducherry
Bay of Bengal
Legend
Study Area
Cities/Towns
Elevation (m msl)
High : 545
Low : 0
0 5 10 km

Puducherry – Tourists Attraction

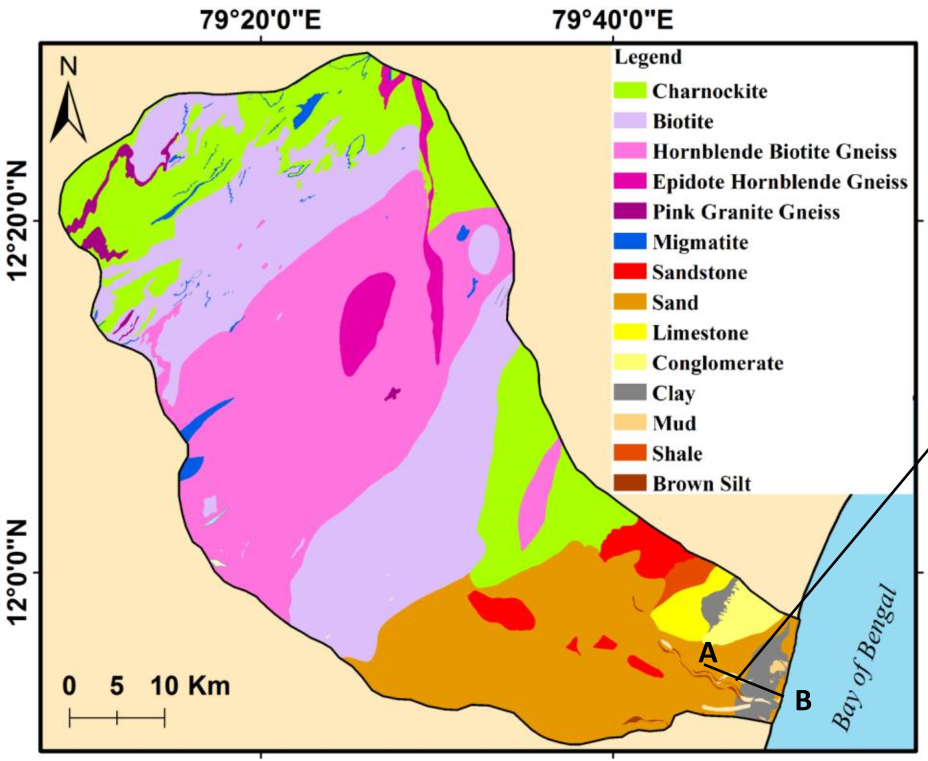
ANNA UNIVERSITY
PROGRESS THROUGH KNOWLEDGE

White Town – French Settlement

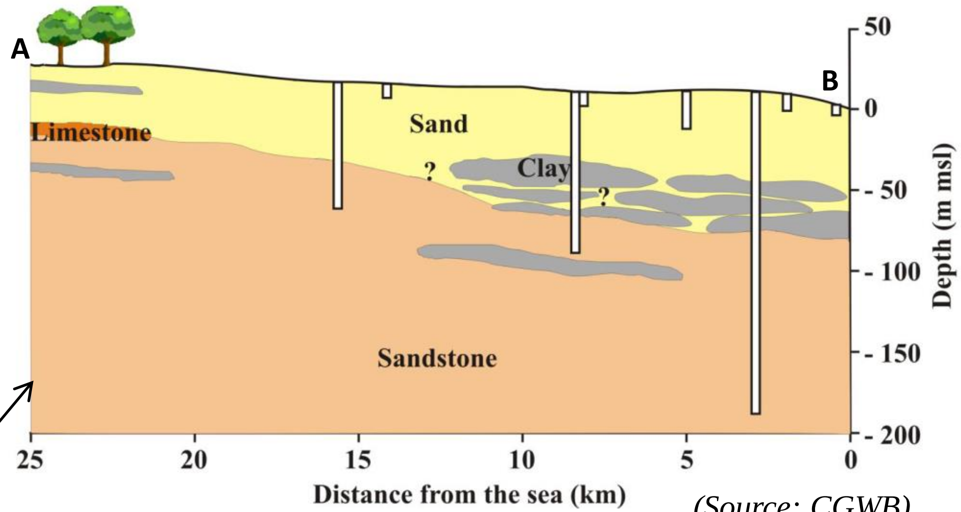
Oussudu Lake

Auroville

Geology and Hydrogeology



(Source: Bhukosh)



(Source: CGWB)

Aquifer	Groundwater Extraction (MCM/Year)	Transmissivity (m^2/day)
Upper	0.025	275 – 770
Lower	0.14 – 0.4	1000 – 2000

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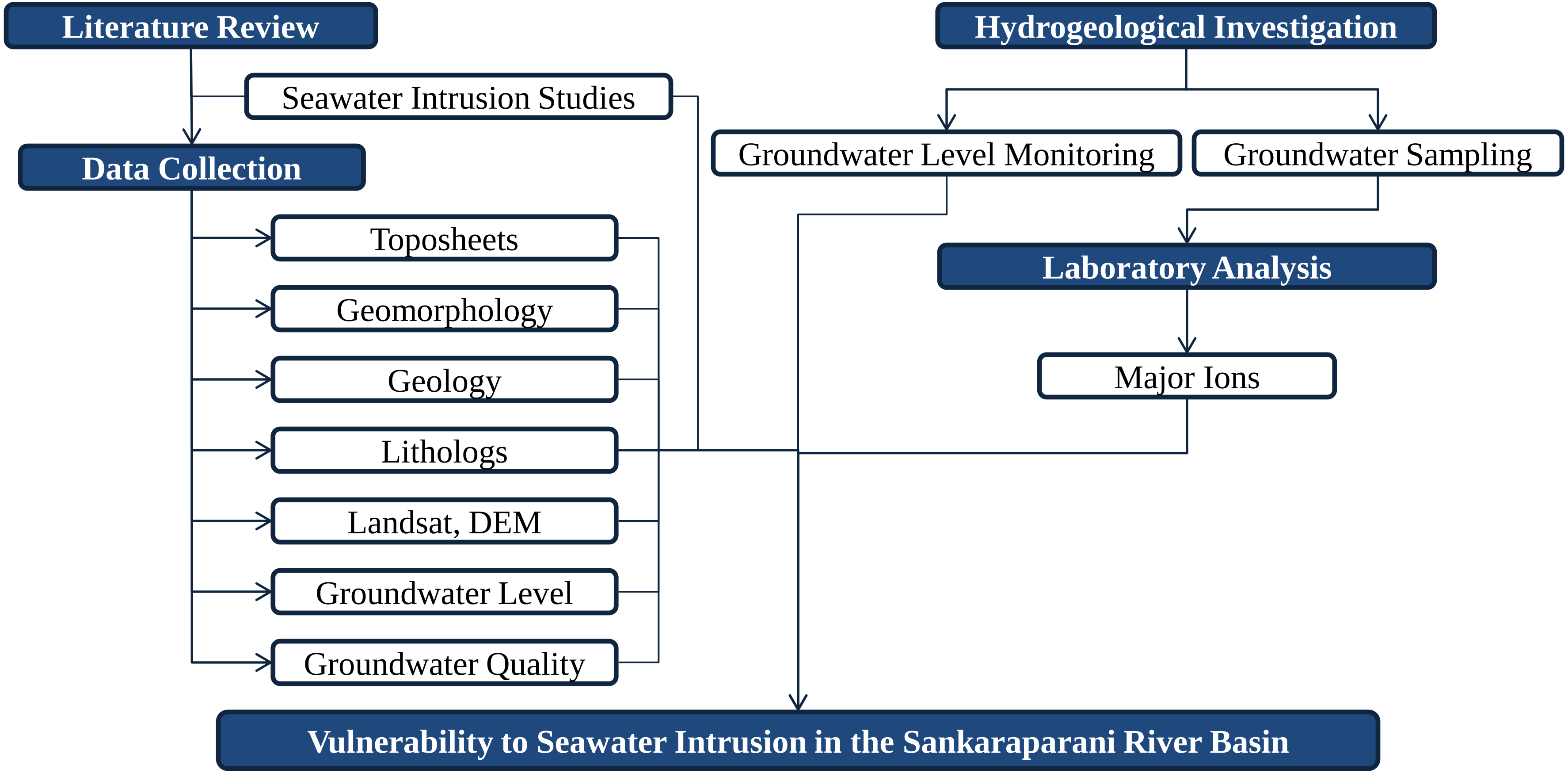
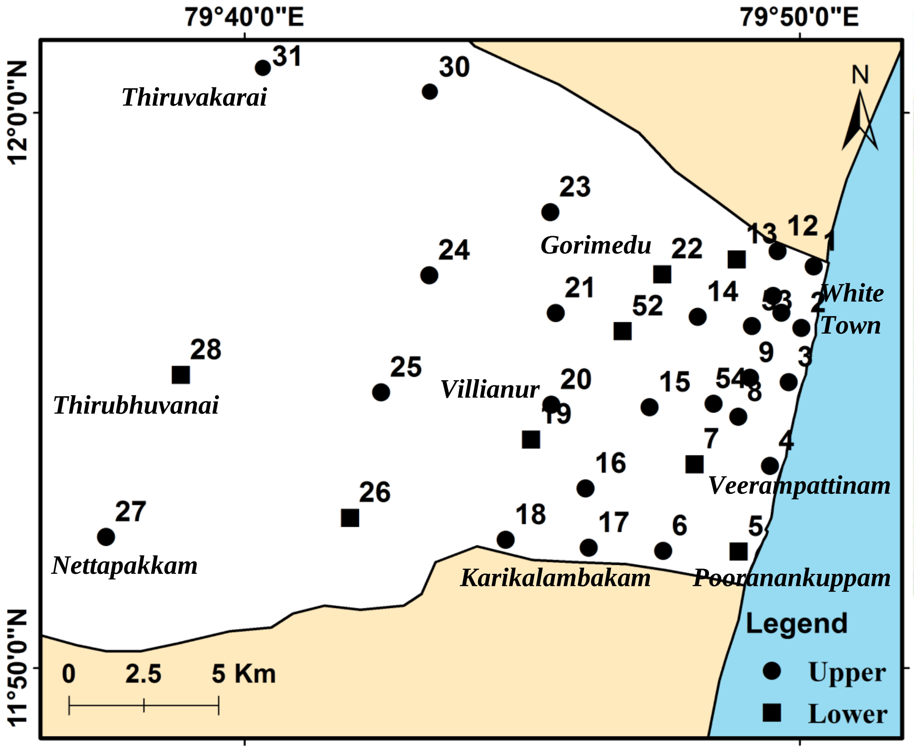


Collection of Groundwater Samples



Upper aquifer (Depth < 50m): 23 wells
Lower aquifer (Depth > 50m): 12 wells

Period of sampling	No. of samples
June 2017	35
June 2018	35
June 2019	35
Total	105

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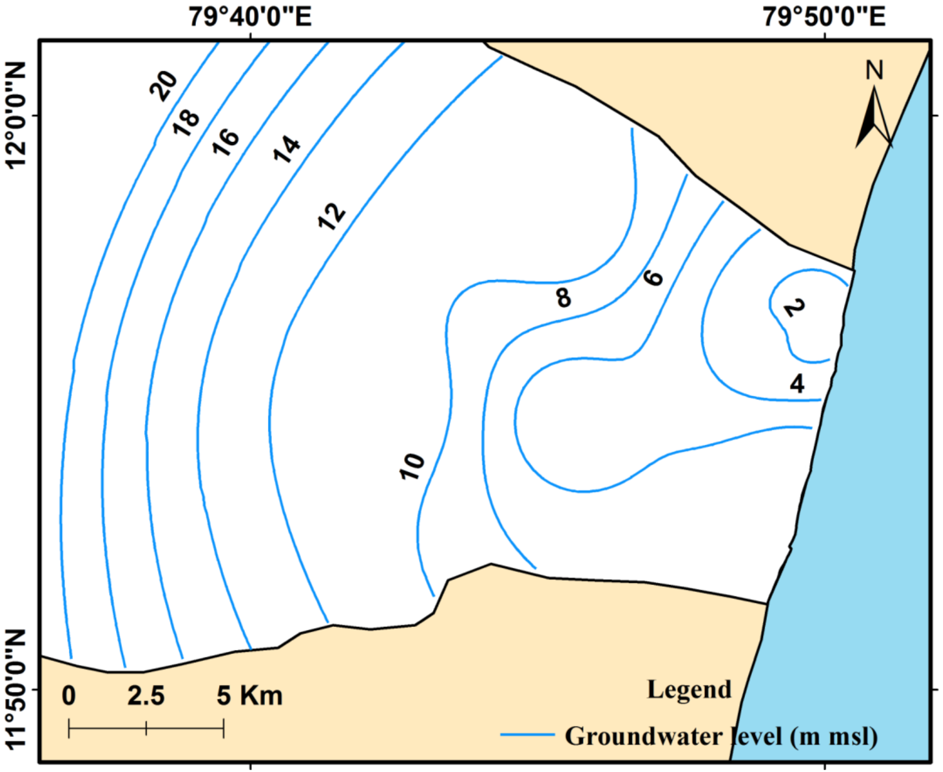
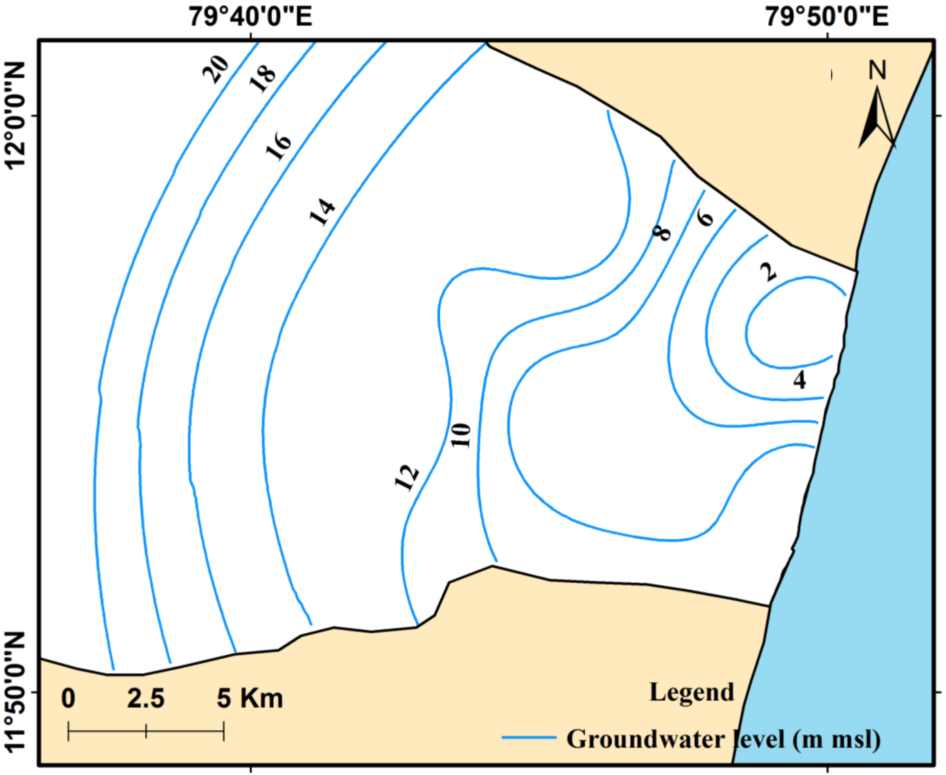
Variation in Groundwater Level

Pre-monsoon



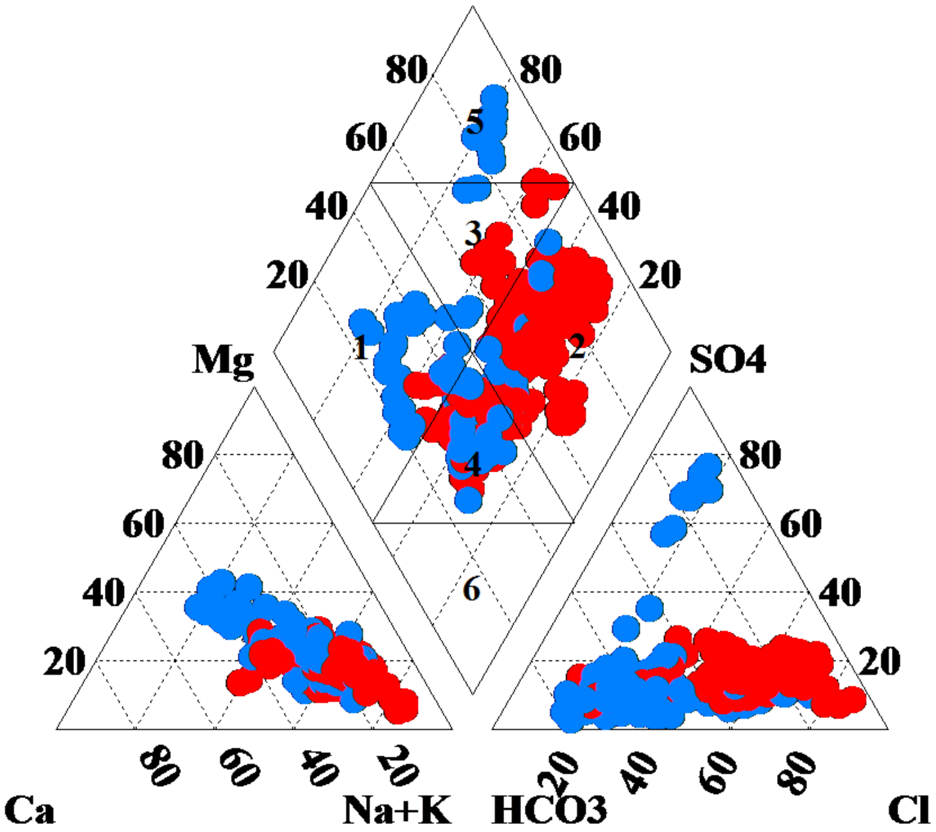
Post-monsoon



Geochemical Parameters in Groundwater

Parameters	Units	Min	Max
pH	-	6.0	8.1
Electrical Conductivity	(µS/cm)	324	7710
Calcium (Ca^{2+})	(mg/l)	15	463
Magnesium (Mg^{2+})	(mg/l)	11	185
Sodium (Na^{+})	(mg/l)	28	687
Potassium (K^{+})	(mg/l)	1	89
Chloride (Cl^{-})	(mg/l)	18	2034
Sulphate (SO_4^{2-})	(mg/l)	16	359
Bicarbonate (HCO_3^{-})	(mg/l)	122	775

Hydrogeochemical Variation in Coastal Aquifers



Legend

- Lower Aquifer
- Upper Aquifer

1 $Ca\text{-}HCO_3$
2 Na-Cl
3 Ca-Mg-Cl
4 $Ca\text{-}Na\text{-}HCO_3$
5 Ca-Cl
6 $Na\text{-}HCO_3$

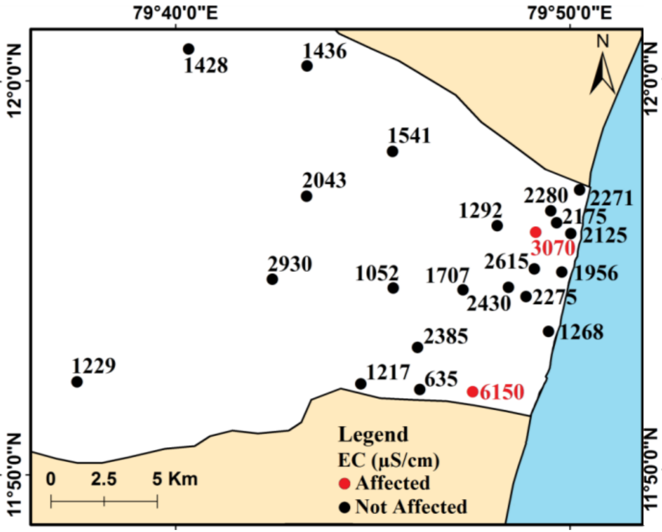
Upper Aquifer – Na-Cl, $Ca\text{-}Na\text{-}HCO_3$

Lower Aquifer – $Ca\text{-}HCO_3$, $Ca\text{-}Na\text{-}HCO_3$

(Piper 1953)

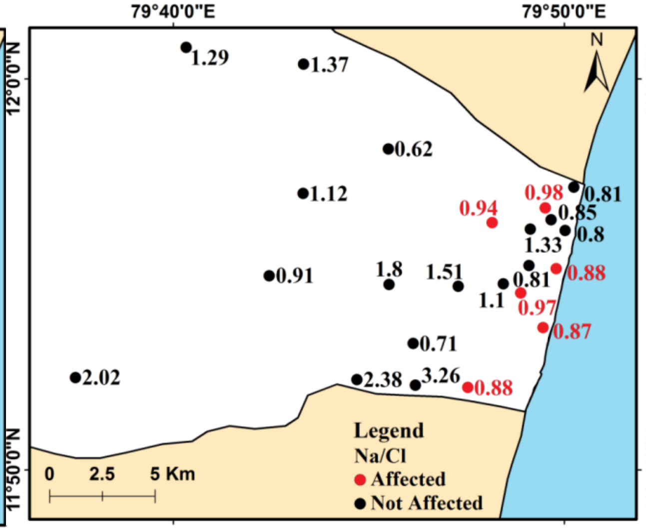
Variation in Geochemical Signatures

Upper Aquifer



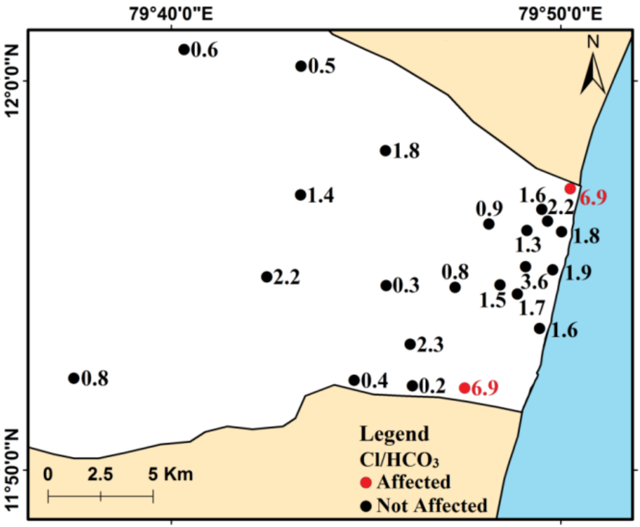
EC > 3000 µS/cm

(Karahanoglu 1997)



0.86 < Na/Cl < 1

(Vengosh and Rosenthal 1994)

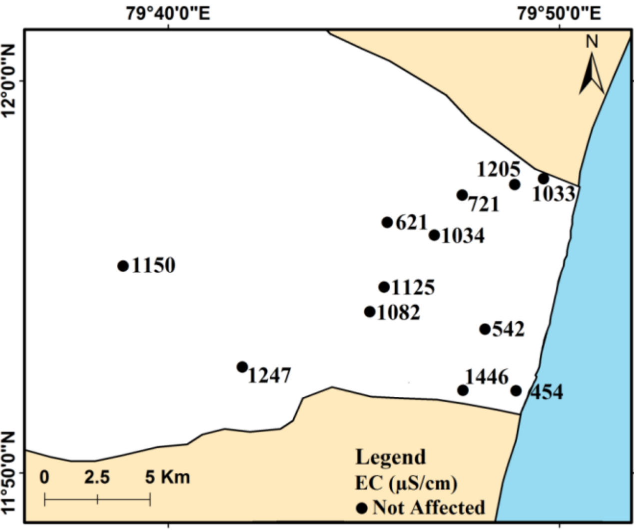


Cl/HCO_3 > 6.6

(Todd 1959)

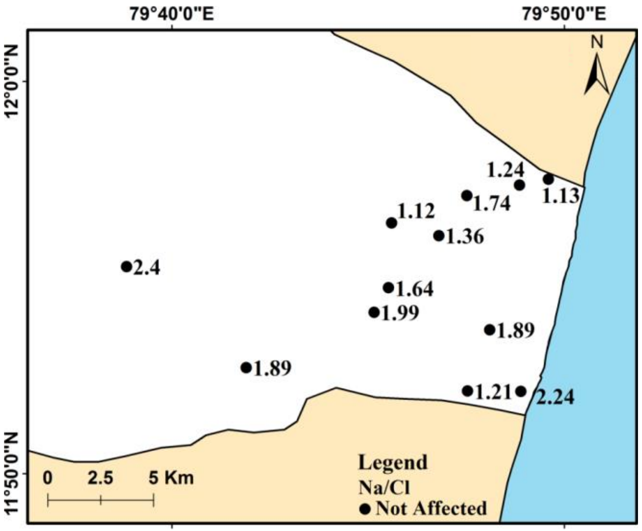
Variation in Geochemical Signatures

Lower Aquifer



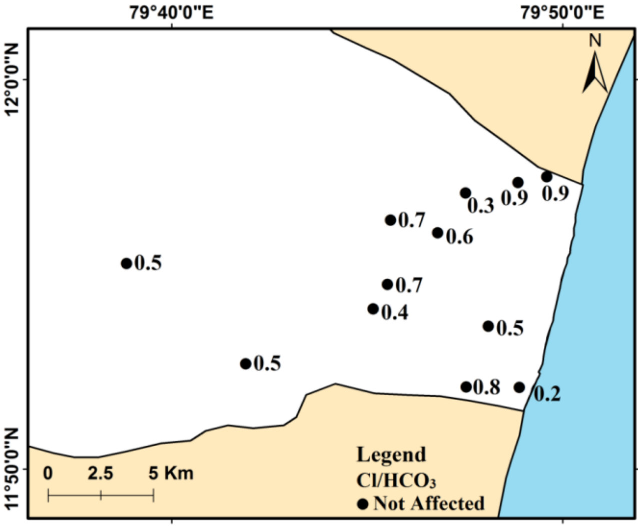
EC < 3000 µS/cm

(Karahanoglu 1997)



Na/Cl > 1

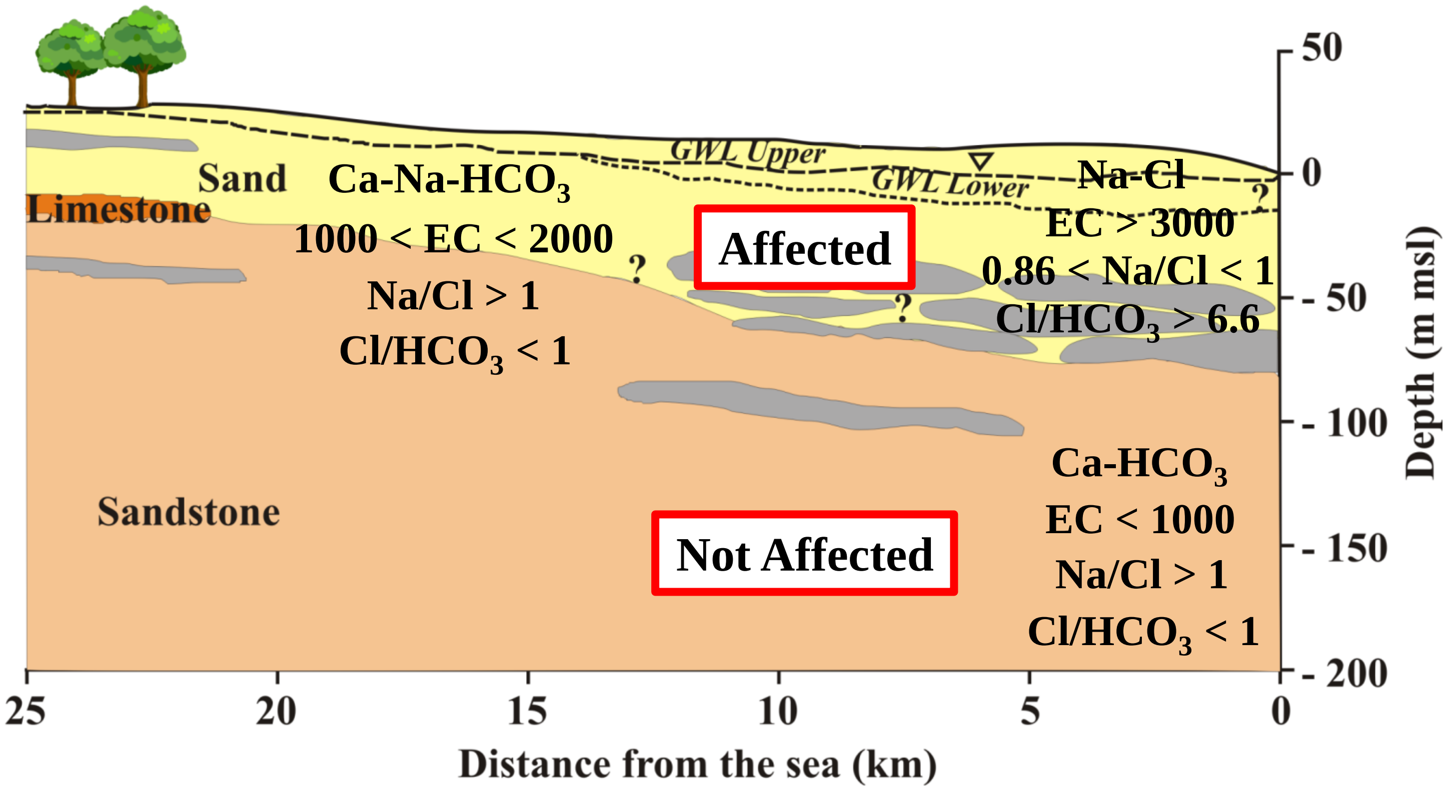
(Vengosh and Rosenthal 1994)



$Cl/HCO_3 < 1$

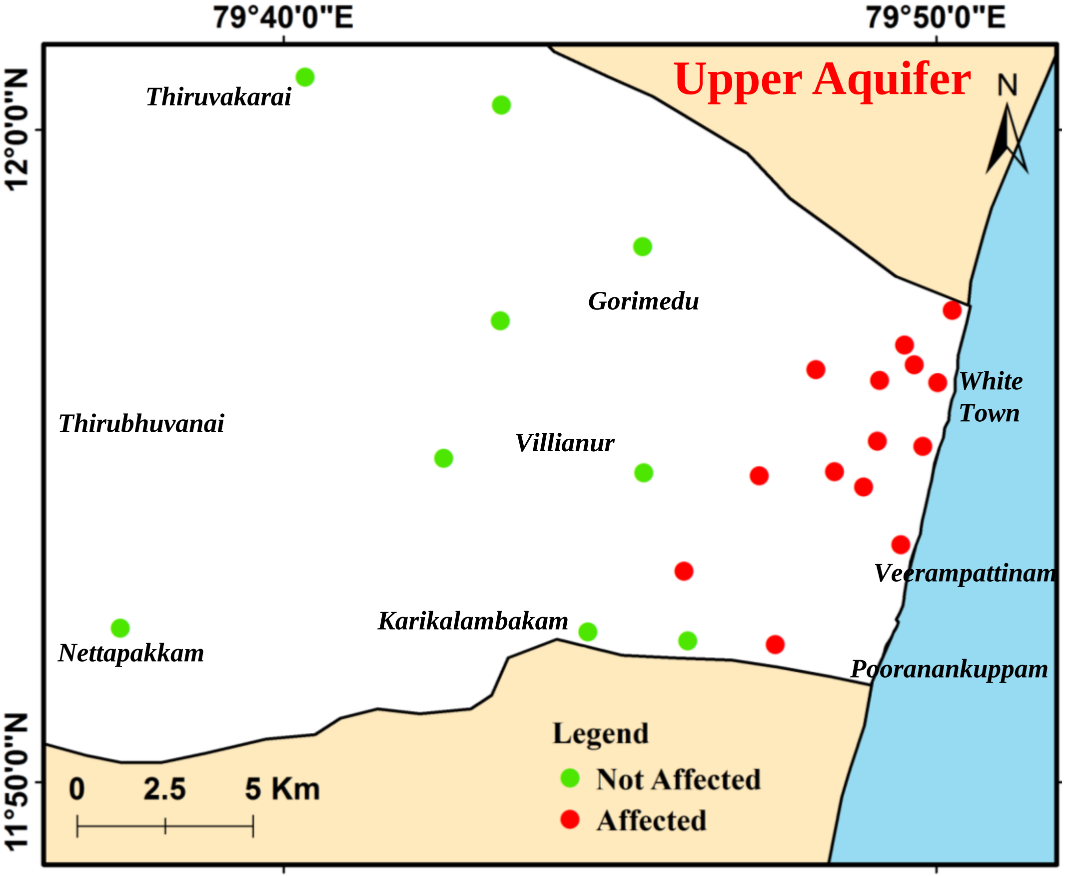
(Todd 1959)

Seawater Intrusion in Multi Aquifer



(Manivannan and Elango 2021)

Extent of Seawater Intrusion



Geochemical Indicators

EC

Na/Cl

Cl/HCO_3

43% of Groundwater Samples Affected by Seawater Intrusion

Extent of Seawater Intrusion

~3 km in the Upper Aquifer

GALDIT Index

$$GALDIT = \frac{(W_1 \times G_R) + (W_2 \times A_R) + (W_3 \times L_R) + (W_4 \times D_R) + (W_5 \times I_R) + (W_6 \times T_R)}{\sum_{i=1}^{6} W_i}$$

Where,

W_1 to W_6 are the weights assigned to each parameter,

G_R, A_R, L_R, D_R, I_R and T_R represent the corresponding rating of each of the parameters.

GALDIT Index	Category
< 2.5	Very Low
2.5 – 5.0	Low
5.0 – 7.5	Moderate
7.5 – 10	High

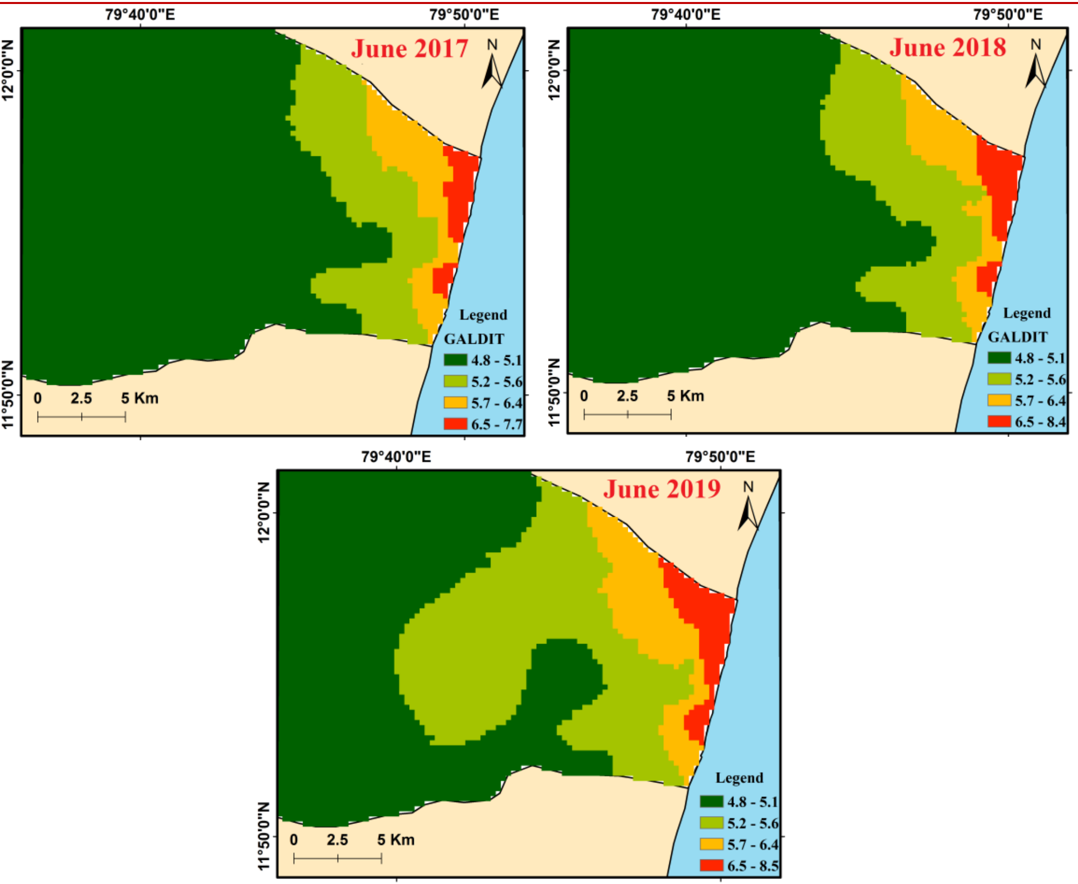
(Chachadi & Lobo-Ferreira 2001)

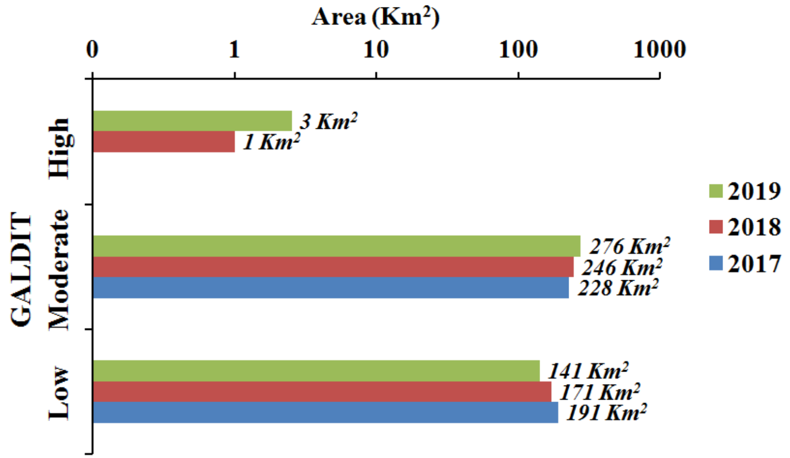
GALDIT Parameters

Parameters	Weight	Range	Rating	Parameters	Weight	Range	Rating
Groundwater occurrence	1	Confined aquifer	10	**D**istance from the coast (m)	4	< 500	10
		Unconfined aquifer	7.5			500 - 750	7.5
						750 - 1000	5
						> 1000	2.5
		Leaky confined aquifer	5	**I**mpact of seawater intrusion (Cl/HCO_3)	1	> 2.0	10
						1.5 - 2.0	7.5
		Bounded aquifer	2.5			1.0 - 1.5	5
						< 1.0	2.5
Aquifer hydraulic conductivity (m/day)	3	> 40	10	**T**hickness of aquifer (m)	2	> 10	10
		10 - 40	7.5			7.5 - 10	7.5
		5 - 10	5			5 - 7.5	5
		< 5	2.5			< 5	2.5
Level of groundwater head (m msl)	4	< 1.0	10				
		1.0 - 1.5	7.5				
		1.5 - 2.0	5				
		> 2.0	2.5				

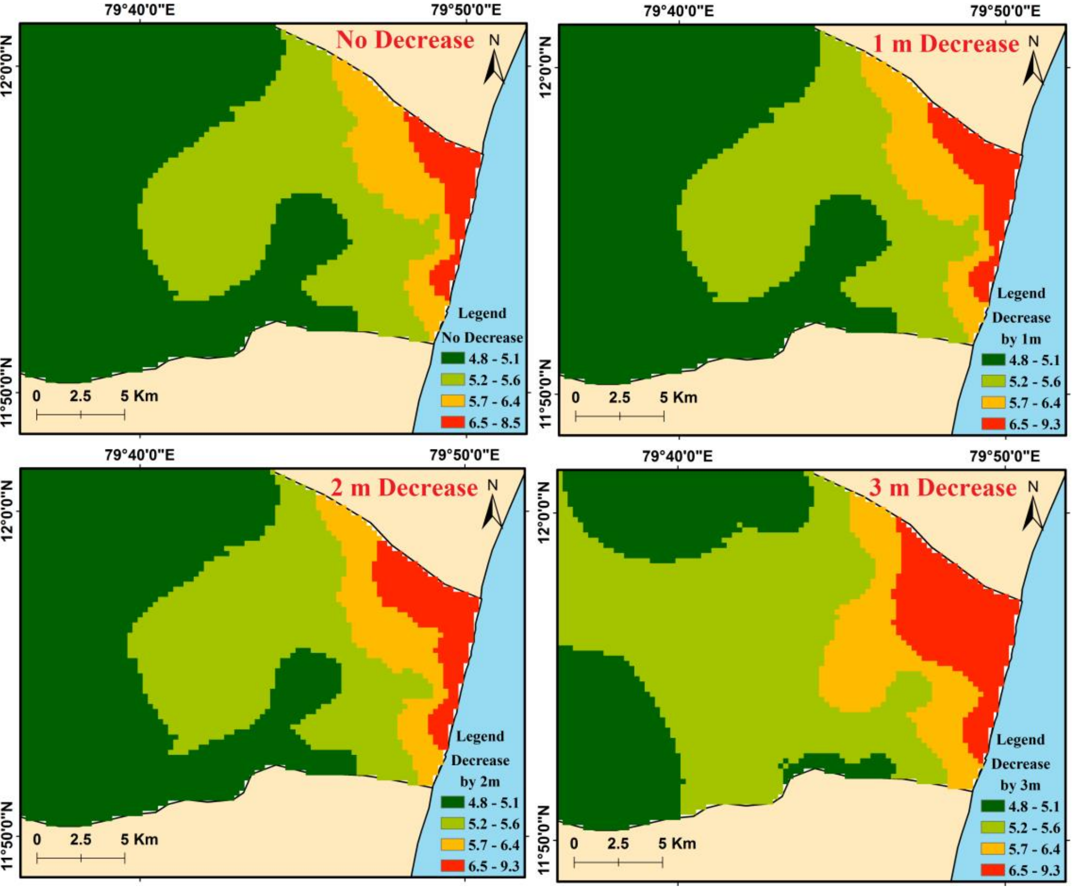
(Chachadi & Lobo-Ferreira 2001)

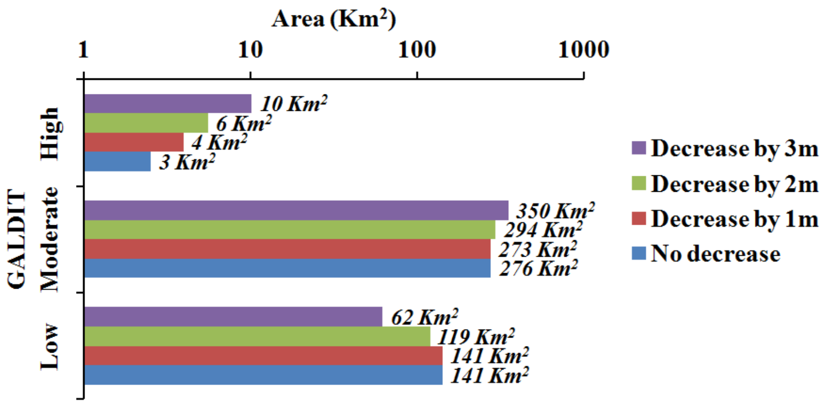
Vulnerability of Coastal Aquifer to Seawater Intrusion



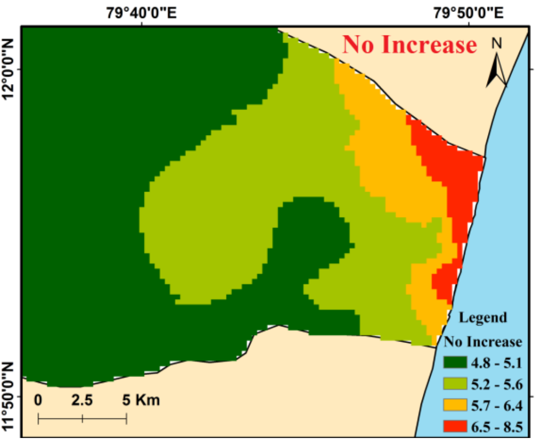


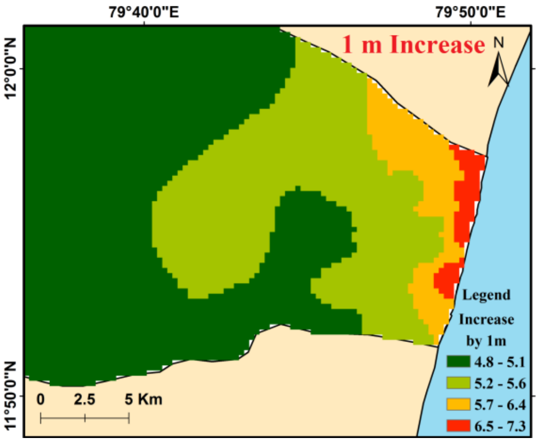
Vulnerability with Decrease in Groundwater Level

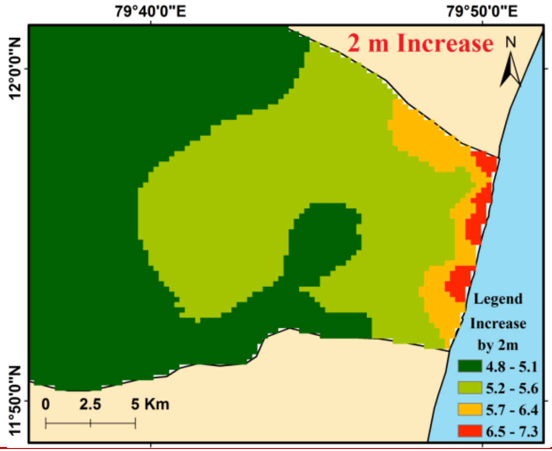


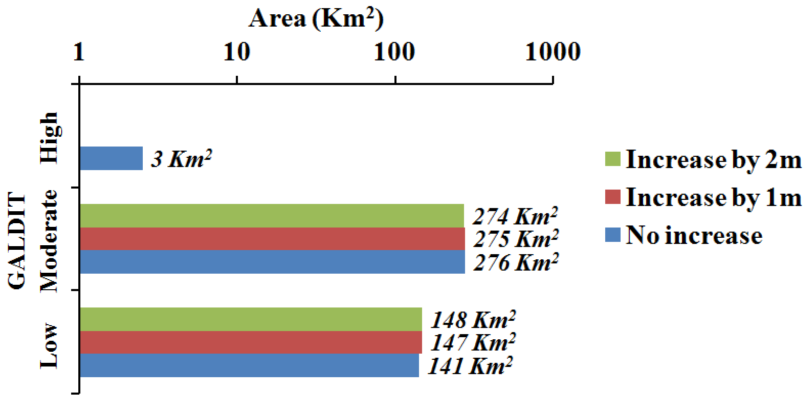


Vulnerability with Increase in Groundwater Level









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Conclusions & Recommendations

- Upper aquifer is affected by seawater intrusion – extent of 3 km
- Lower aquifer is not affected – fresh groundwater
- Coastal region highly vulnerable to seawater intrusion – increases from 1 km^2 to 3 km^2 during June 2018 to June 2019
- Coastal region low vulnerable to seawater intrusion – decreases from 191 km^2 to 141 km^2 during June 2017 to June 2019
- If groundwater level decrease – coastal region highly vulnerable to seawater intrusion is increased up to 10 km^2
- If groundwater level increase – coastal region not highly vulnerable to seawater intrusion
- It is recommend to increase groundwater recharge – increase groundwater level – prevent incursion of seawater into the aquifer

Google Scholar

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FOLLOWING

Postdoctoral Researcher, Department of Civil Engineering, Indian Institute of Technology Madras

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Thank You All!