The Cauvery

Sinking Delta and The Dying Wisdom

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Our overall concerns are vulnerability of Land, Water, People

And interactions among them for livelihoods

Coastal Deltas and Coastal wetlands are most vulnerable to direct and large-scale impacts of climate change – due to the impending threat of sea level rise and the increasing frequency and severity of extreme events. These will have a serious consequences on hydrological regime and livelihood options of the people

Continued loss of coastal ecosystems will have tremendous economic as well as biological consequences.

(IPCC and the World Meteorological Organization)

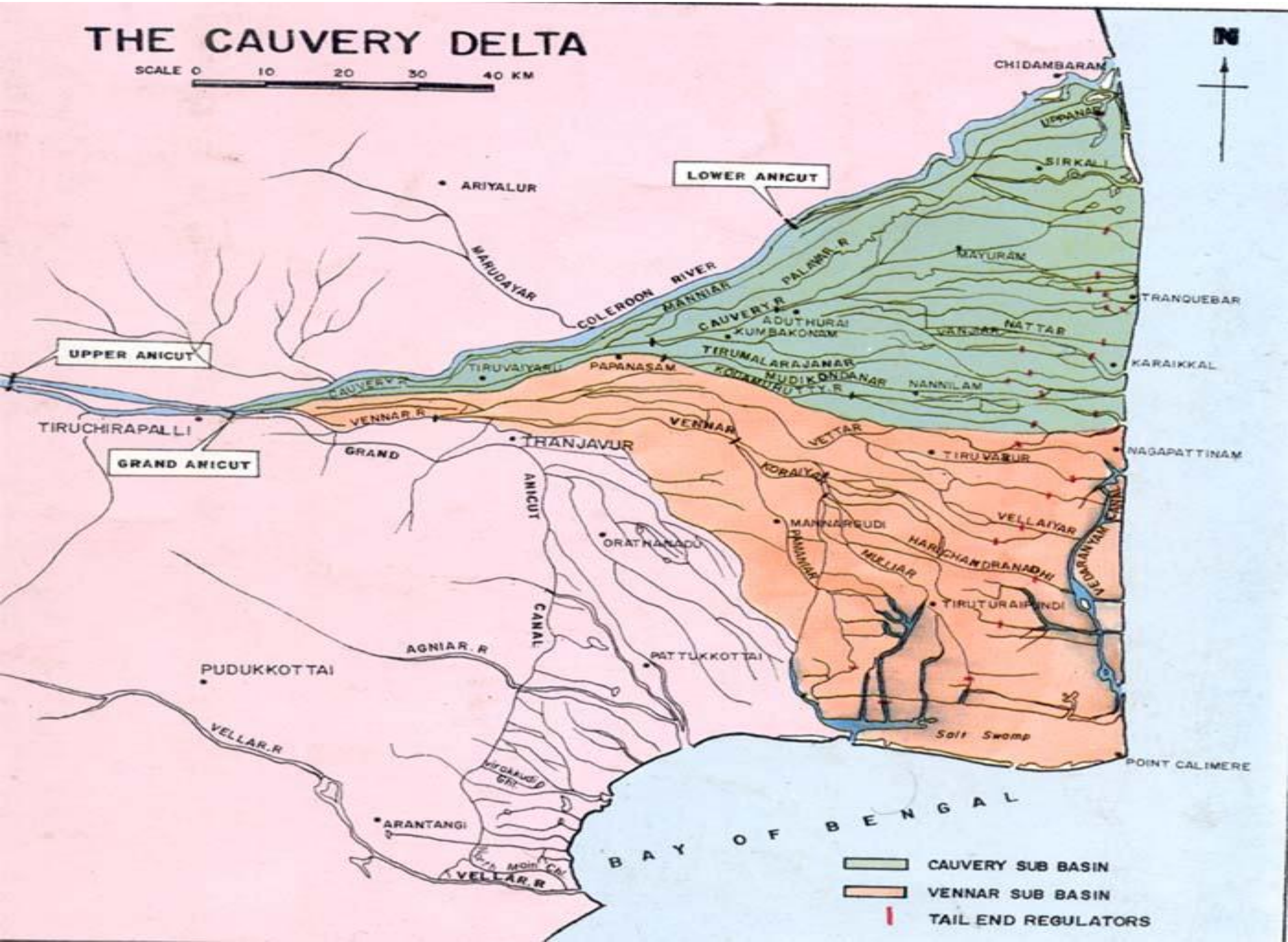
Coastal Vulnerability

Over 60 million people in the low-elevation coastal zones of South Asia could be displaced due to global warming and seawater rise by the end of the 21st century (IPS, 2007).

Many parts of India and Bangladesh are identified as the most vulnerable segments of South Asia.

This is the region where food security and livelihood security of people are seriously challenged due to multiplicity of factors such as **growing high population density, water scarcity, erratic monsoons, high frequency and intensity of cyclones and storms, uncontrolled floods, salinity of soil and water bodies including groundwater and coastal wetlands, growing anthropogenic factors contributing to a high order pollution, rapid urbanization process leading to untreated urban sewage levels and most important of all the high demographic pressure.**

Furthermore, the issues are going to get more compounded and complex due to the impending climate threat


THE CAUVERY DELTA
SCALE 0 10 20 30 40 KM
N
CHIDAMBARAM
UPPANAR
SIRKALI
LOWER ANICUT
ARIYALUR
MARUDAYAR
MAYURAM
PALAVAR R
COLEROON RIVER
MANNIAR
CAUVERY R
ADUTHURAI
KUMBAKONAM
TRANQUEBAR
NATTAR
UPPER ANICUT
TIRUMALARAJANAR
KARAIKKAL
TIRUVAIYARU
PAPANASAM
MUDIKONDANAR
NANNILAM
CAUVERY R
VENNAR R
TIRUCHIRAPALLI
VENNAR
VETTAR
GRAND
TRANJAVUR
GRAND ANICUT
TIRUVARUR
NAGAPATTINAM
KORAIYAR
ANICUT
MANNARGUDI
VELLAIYAR
ORATHANADU
HARICHANDRANADHI
MULLIAR
PAMANIAR
VEDARANYAM CANAL
TIRUTURAIPUNDI
CANAL
AGNIAR R
PATTUKKOTTAI
PUDUKKOTTAI
Salt Swamp
VELLAR R
POINT CALIMERE
ARANTANGI
BAY OF BENGAL
VELLAR R
CAUVERY SUB BASIN
VENNAR SUB BASIN
TAIL END REGULATORS

Specific Features of Delta Vulnerabilities

Physical

Volatile and fragile ecosystem
Groundwater salinization
Soil salinity
LCEZ – flood prone – both from sea and the Cauvery river
Mono cropped area for centuries
Plastic clay (powdered) soil
Low yield due to poor soil fertility

Climate related

Cyclones (According to the Asian Disaster Preparedness Centre, four times more cyclones are formed in the Bay of Bengal than in the Arabian Sea).
Heavy rainfall in a few days
Erratic monsoons
Intense or heavy spells in a few days
Changing agricultural seasons
Kuruvai is facing the threat of extinction
Seawater rise / beach erosion / seawater inundation

Specific Features of Delta Vulnerabilities (CONTD)

Demographic

High incidence of landless agricultural labourers (SC)
Lack of alternate source of livelihood
Poor industrial development
High inequality and poverty
High population density 592 / sq km

Coastal water bodies and wet lands

Vulnerability of marsh lands due to raising salinity level and beach erosion
Estuaries
Lagoons
Tanks and ponds
Backwater rivers and canals
High sedimentation levels

Specific Features of Delta Vulnerabilities (CONTD)

Water access

Uncertainty in the river due to upstream development by Karnataka
Erratic opening of the reservoir due to uncertainty / poor storage
Age old irrigation system and canal net work

Anthropogenic

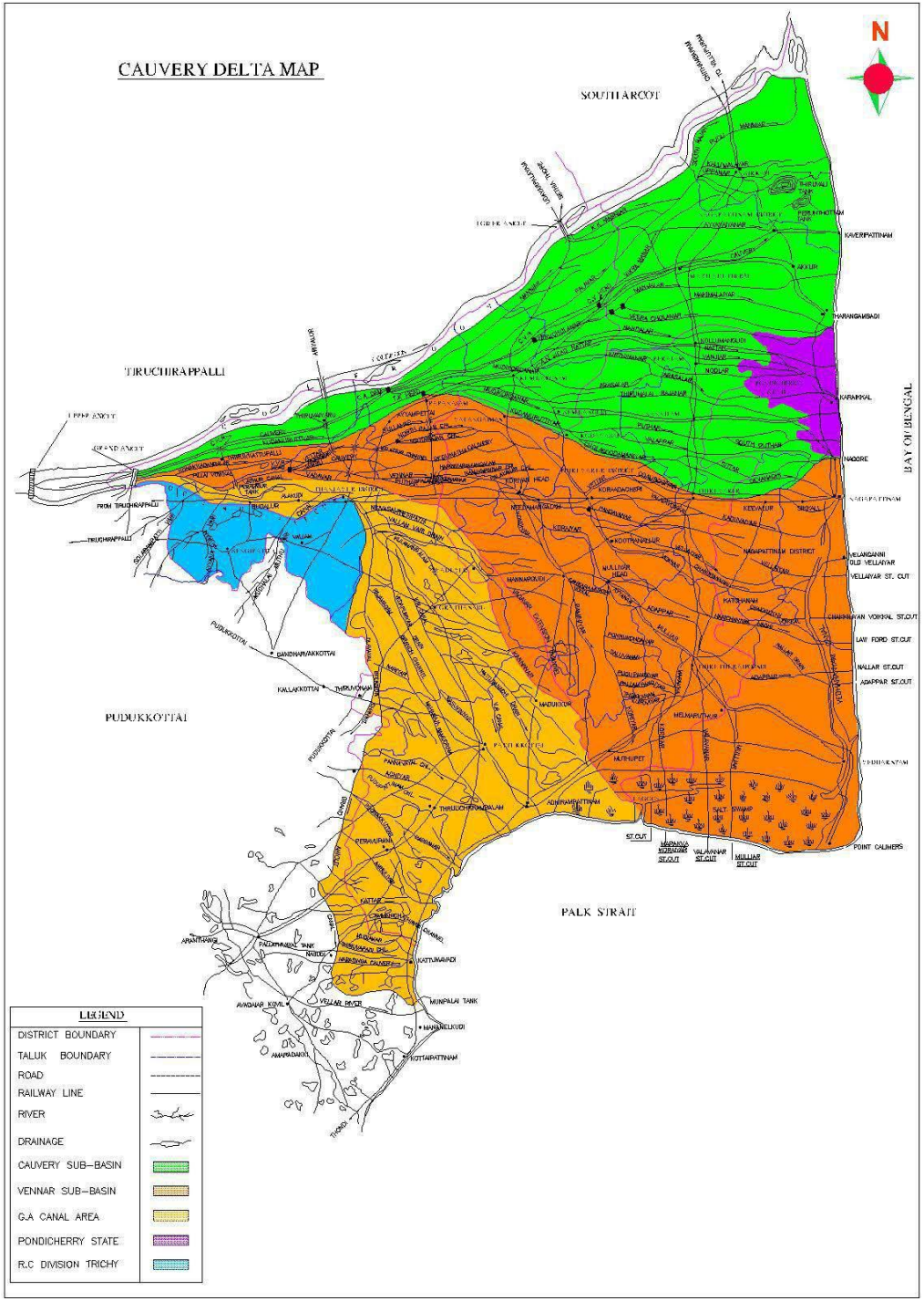
Many industries all along the river contributes to pollution load
Urban sewage dumped in the river

Need for Delta Resilience

Understanding vulnerability of deltas would also mean examining scope for resilience.

If the degree of resilience is weak or poor, then it may mean that delta vulnerability is high; On the other hand, if the degree of resilience is strong then the delta is less vulnerable

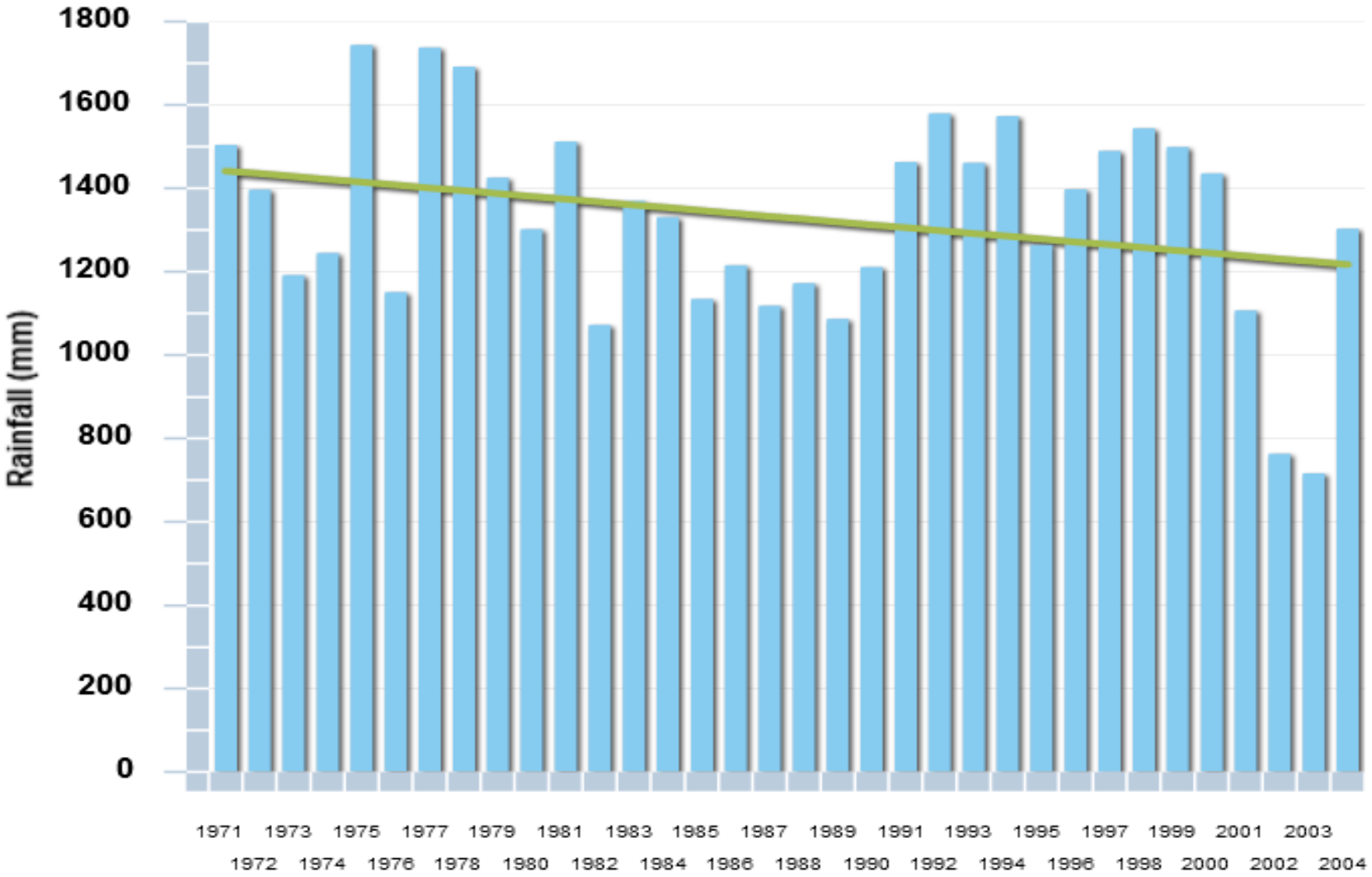
Therefore, understanding or documenting vulnerabilities in a delta would help to know the scope for resilience for shocks and disasters.



Source: PWD, Tiruchi region, Government of Tamil Nadu

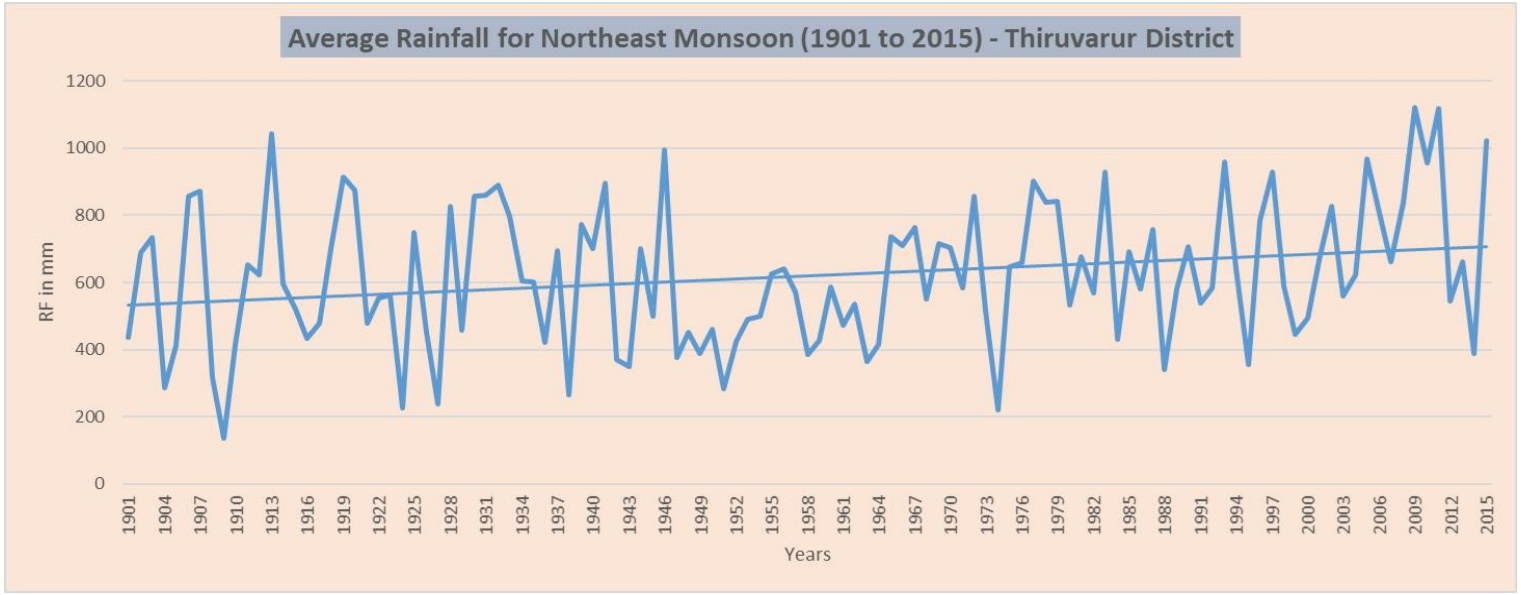
Showing Cauvery, Vennar and GA canal system

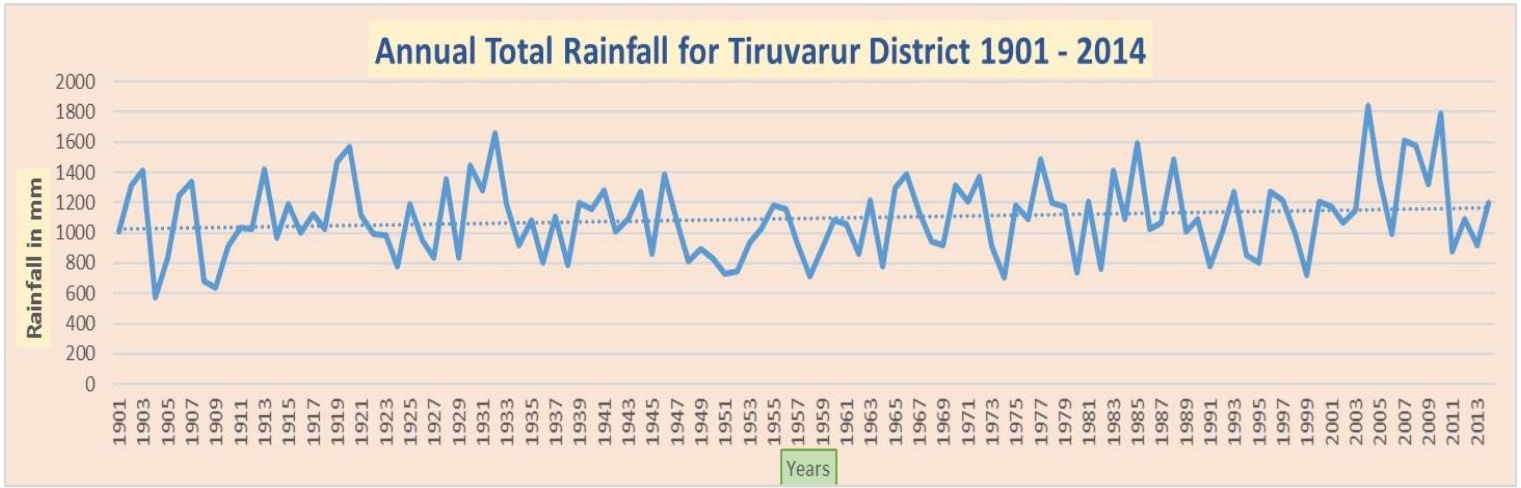
Trends in rainfall in the Cauvery basin – 1971- 2004



Source: Government of India, Ministry of Water Resources, Central Water Commission/NRSC, Cauver Basin Report, 2014 P.12

However, the picture we get while looking at the rainfall statistics for the delta districts is somewhat different


Average Rainfall for Northeast Monsoon (1901 to 2015) - Thiruvarur District
RF in mm
Years


Annual Total Rainfall for Tiruvarur District 1901 - 2014
Rainfall in mm
Years

BUT, *Remember,*

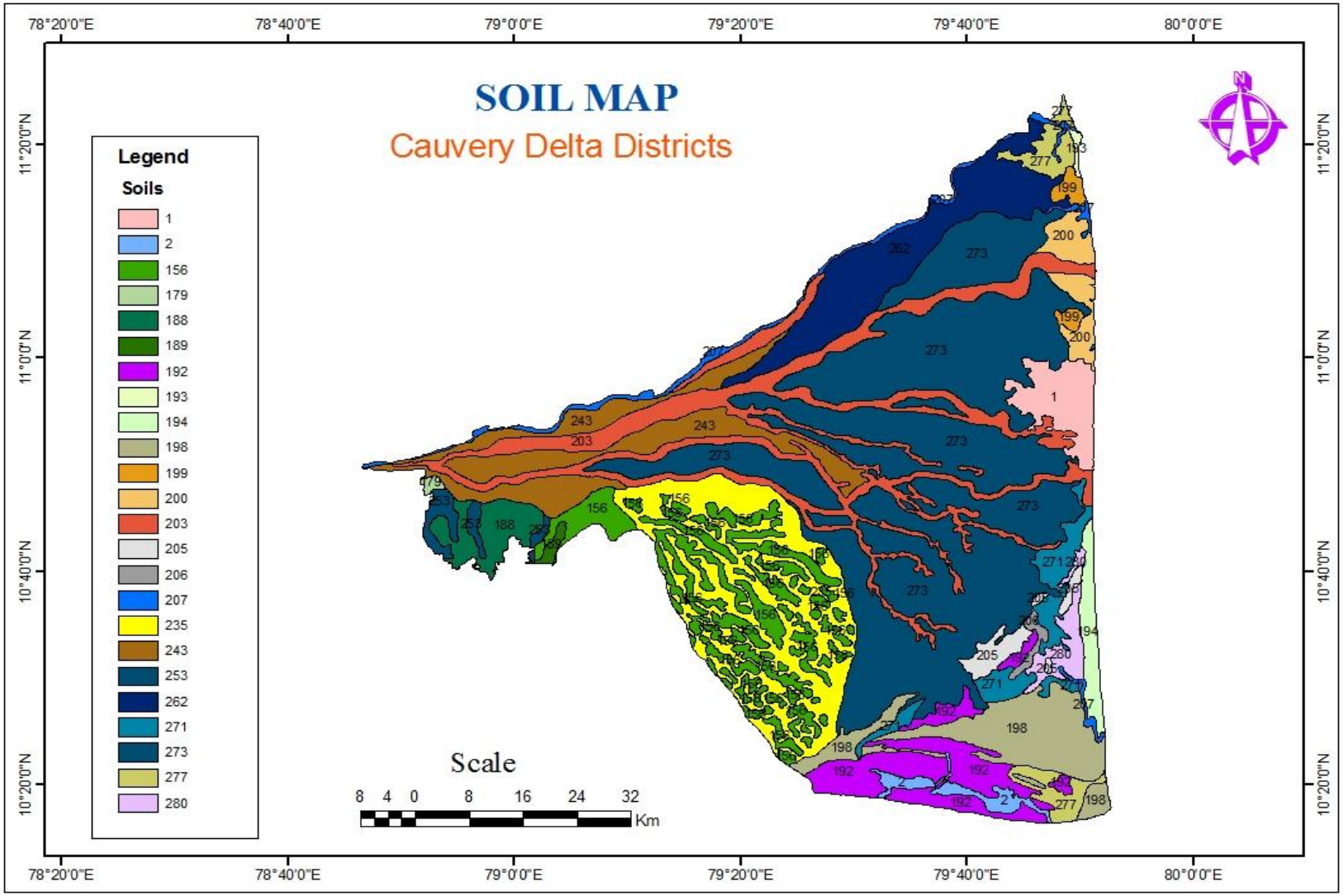
The increase in rainfall is offset by increase in temperature and extended dry spell

But, the rainfall projections show large increases in storm rainfall (19%) and storm runoff (29%).

This may cause more frequent and serious flooding

Source:
GOTN, WRO, Tiruchi Region, ADB IND – Climate Adaptation Through Sub-basin Development Programme, Detailed Project Report, PP.26

Soil mapping in the delta districts



Source: National Bureau of Soil Survey and Land use Planning (ICAR), in collaboration with Department of Agriculture, Government of Tamil Nadu, 1996

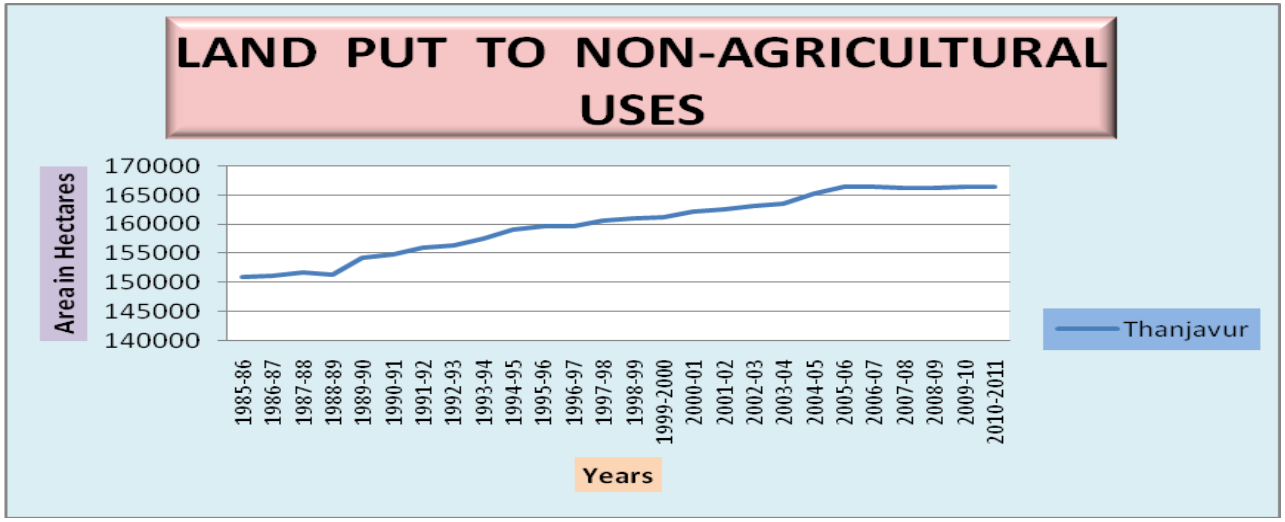
Disturbing feature and cannot be undone

Clay soil 68% of which Cracking clay 51%

Implications – need continuous irrigation and very low permeability

Land use changes in the delta districts have been stunning

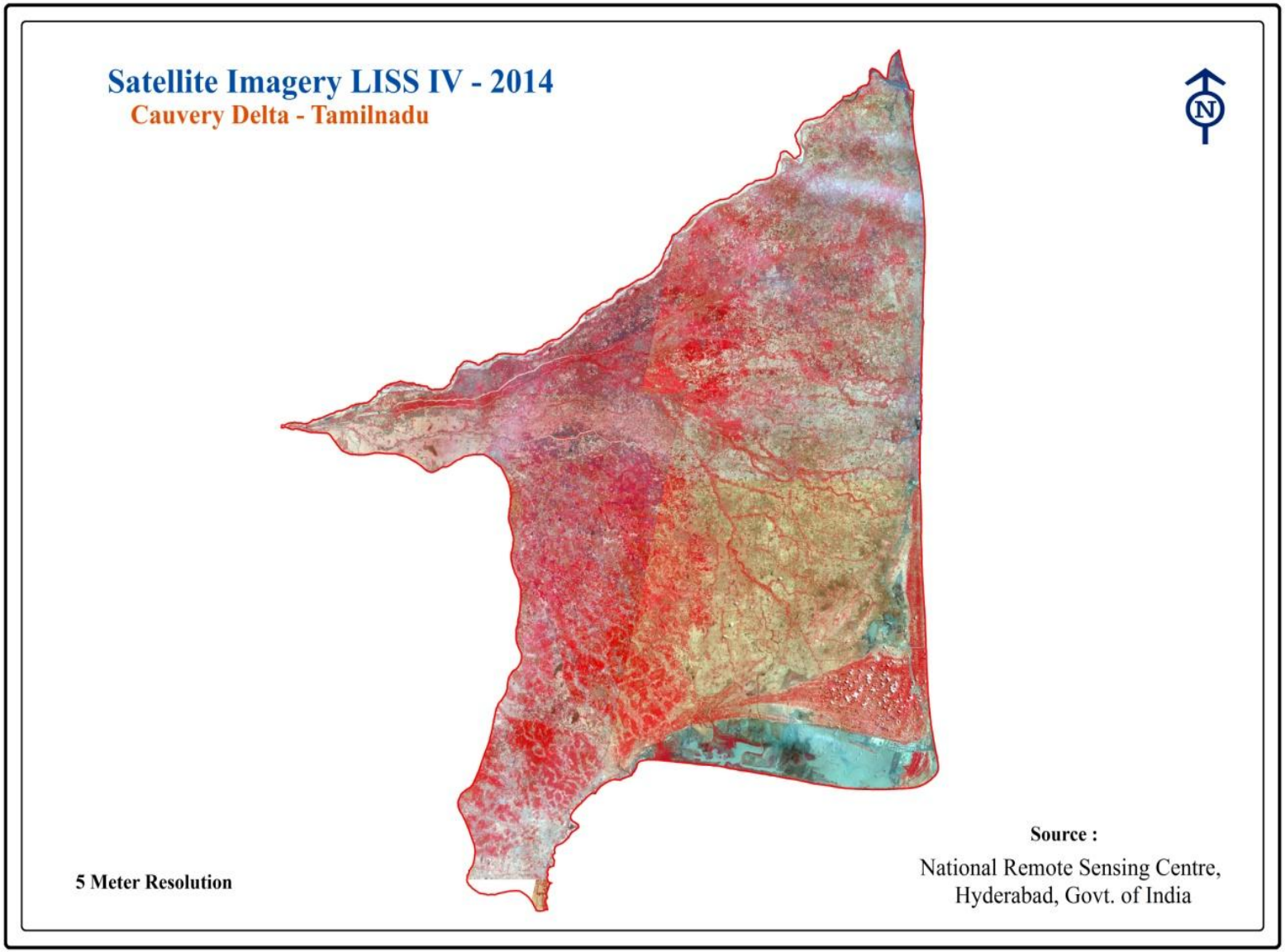
Land put to non-agricultural purposes in the composite Thanjavur district



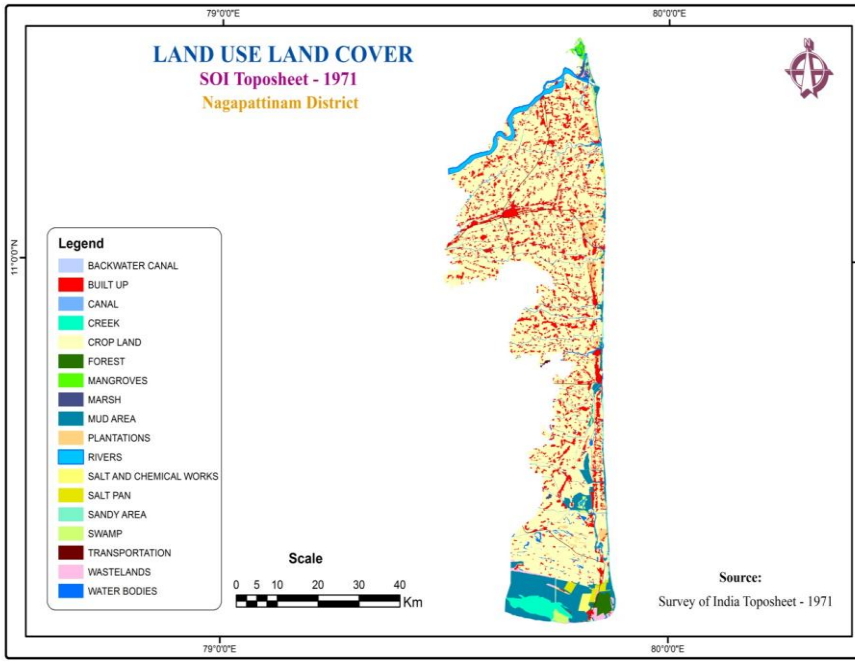
Source: Season and Crop Reports for various years published by GOTN

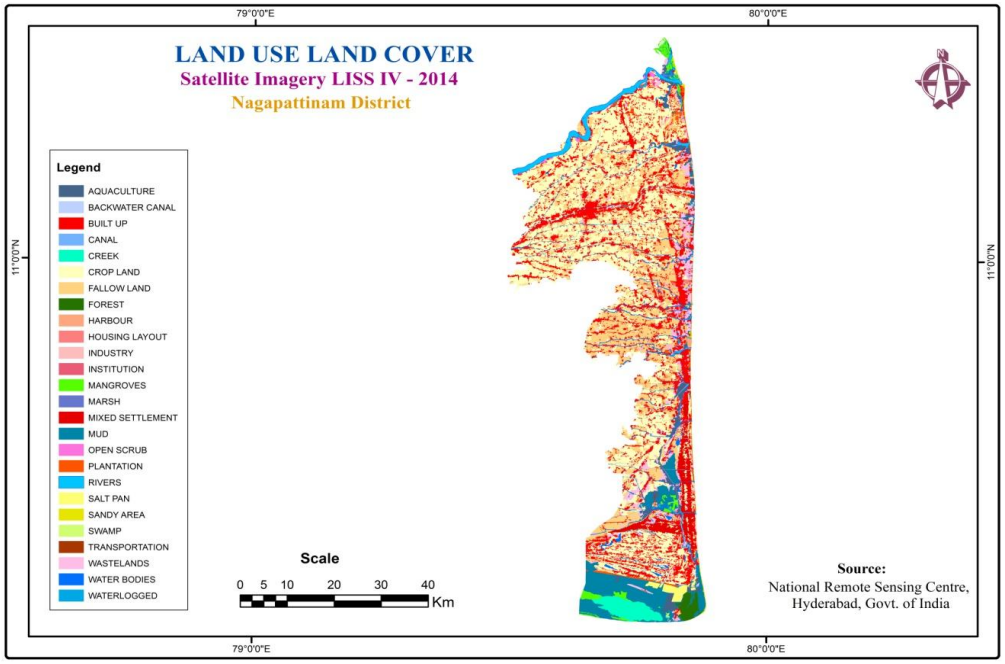
GIS analysis based on the remote sensing satellite imageries as obtained from NRSA for the year May 2014 with respect to three delta districts are much more revealing

The Cauvery delta map comprising of Thanjavur, Tiruvarur and Nagappattinam districts, Satellite Imagery LISS IV - 2014 - Shape File (5 meter resolution)

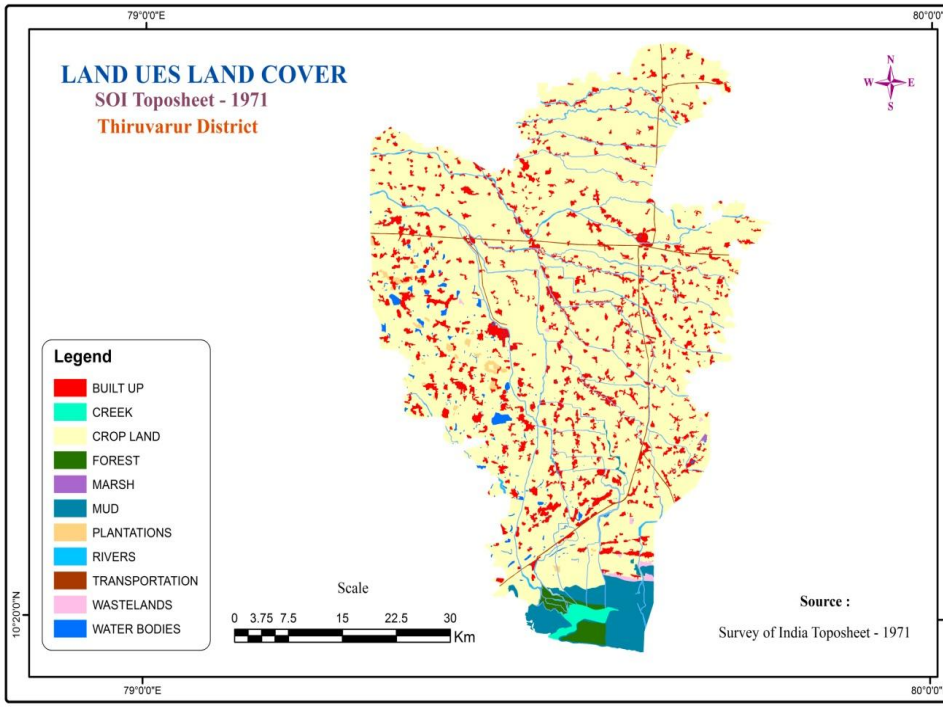


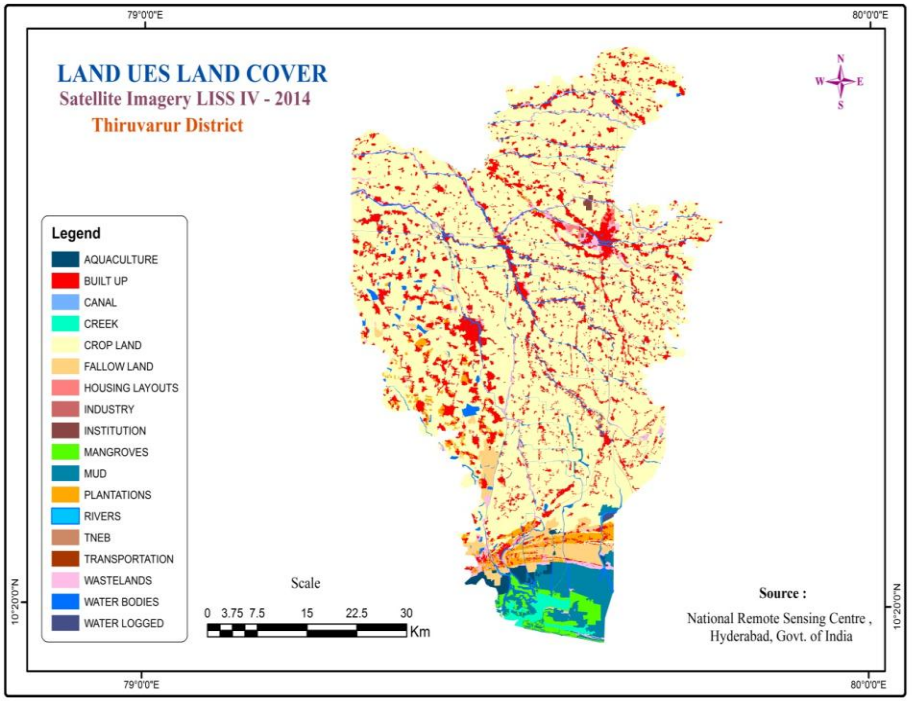
Land use and land cover change in Nagappattinam district, 1971 and 2014



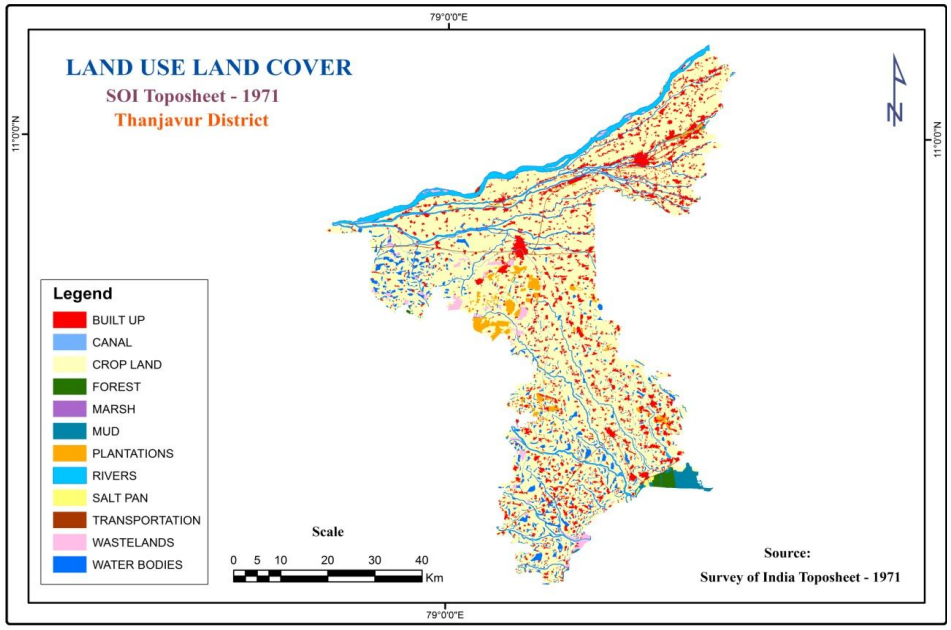


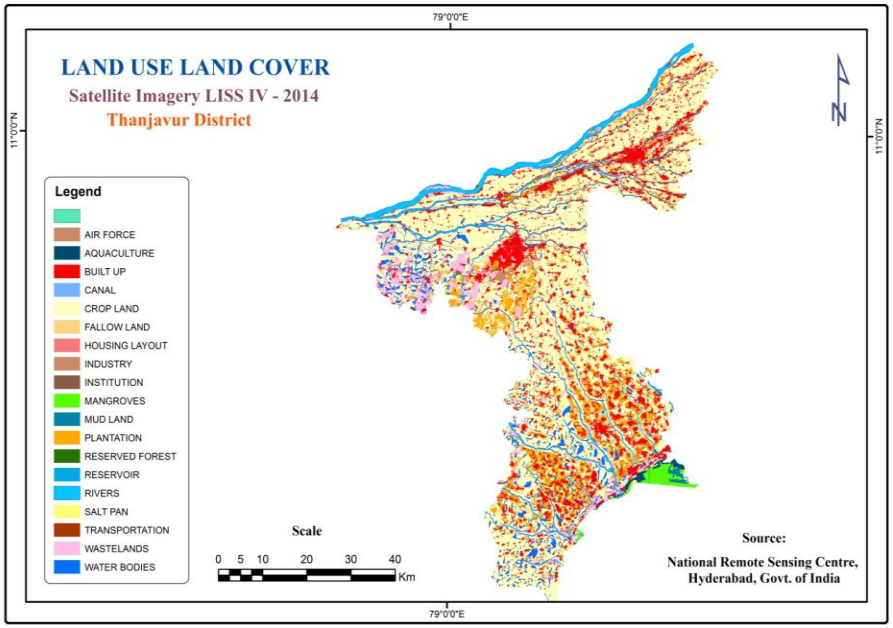
Land use and land cover change in Tiruvarur district, 1971 and 2014



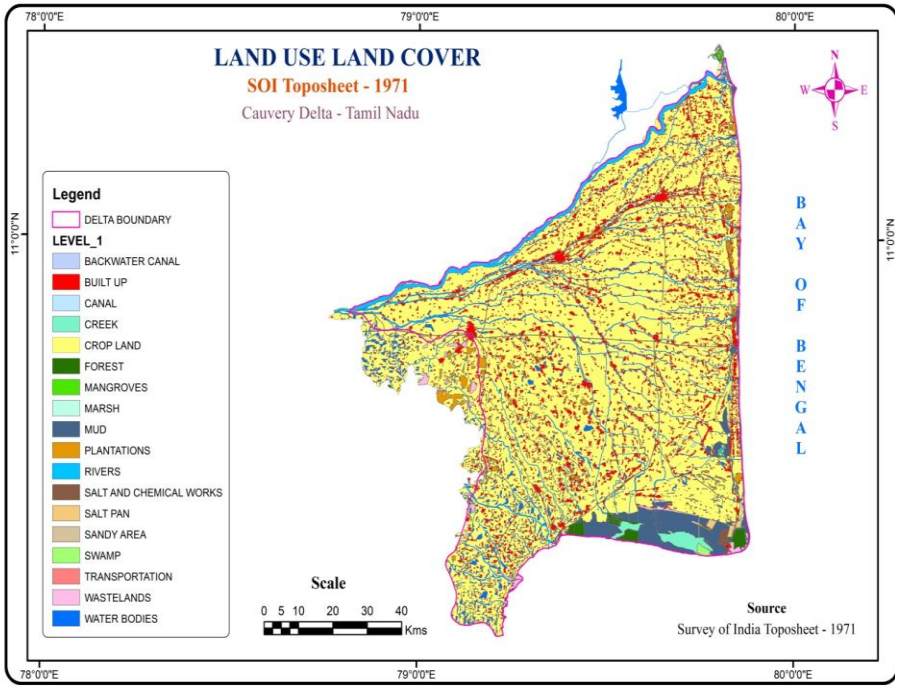


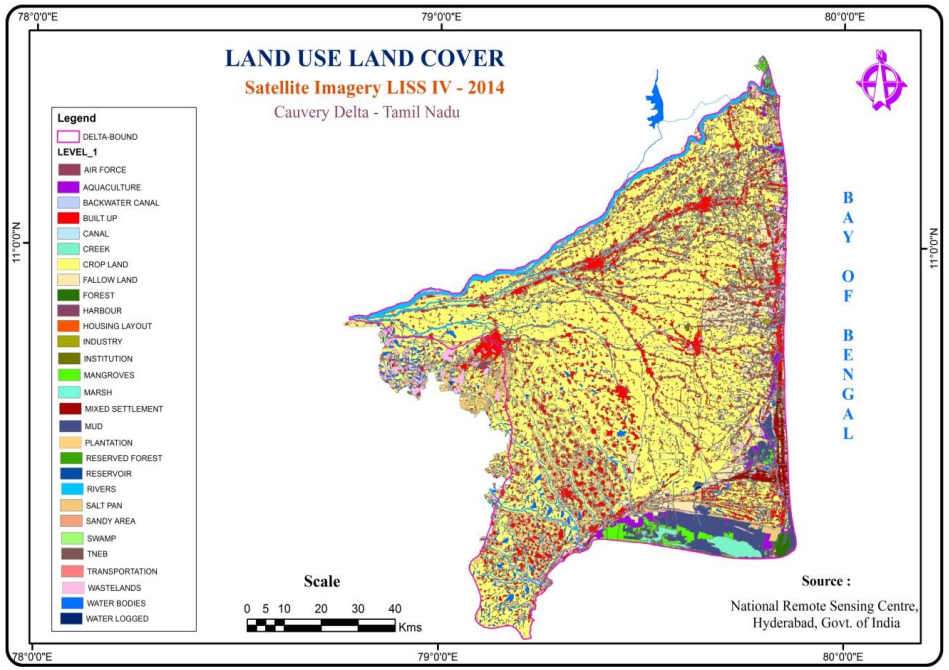
Land use and land cover change in Thanjavur district, 1971 and 2014





Land use and land cover change in the three delta districts, 1971 and 2014





Land use and land cover change in the Cauvery Delta districts 1971 and 2014

LAND USE	Area in Sq.Km 1971	Area in Sq.Km 2014
AQACULTURE	**0.00**	**93.39**
BACKWATER CANAL	0.77	2.95
BUILT UP	**984.60**	**1475.64**
CANAL	18.74	23.72
CREEK	**58.41**	**68.17**
CROP LAND	**6601.00**	**4806.00**
FOREST	55.53	20.01
MANGROVES	**6.76**	**99.66**
MARSH	5.32	1.48
MUD	312.50	257.30
PLANTATIONS	130.90	504.50
RIVERS	310.30	312.50
SALT PAN	27.13	25.86
SANDY AREA	**12.48**	**9.24**
SWAMP	17.52	0.63
TRANSPORTATION	53.31	63.46
WASTELANDS	**70.32**	**926.00**
WATER BODIES	203.20	227.20
TOTAL	**8868.79**	**8917.70**

Source: SOI Topo-sheet (1971) & NRSC Satellite Image (2014)

Most important to note:

The area under crop land has declined by 20% of the total delta land

Built up area has gone up 5.5% of the total delta land

Area under wasteland has gone up by 9.5% of the total delta land

Sea-level rise

- **In coastal areas flooding will be gradually exacerbated by rising sea levels of between 0.29m (low scenario) and 0.87m (high scenario) by 2100 (Dastgheib and Ranasinghe, ADB 2014).**

- **The 100-year tidal storm surge is estimated to be 0.74m**

- **Observed trends in the mean sea level along the Indian coast indicate a rising trend of about 1 cm per decade, which is close to that recorded in other parts of the globe**
- **(Lal, M.: 2001). The current estimate is 3 cm per decade**

- **Already, the east coast, in which the Tamil Nadu state has a coastline of 1060 KM, is seriously affected due to coastal flooding, erosion, coastline changes and storm surges**
- **The intensity is likely to go up due to the projected SLR**

- **The World Bank (2000) estimates that one meter sea level rise will have a devastating impact on coastal wet lands and habitats and predicts that the entire Sundarban Mangroves and associated wetlands will be lost.**

- **If this happens, the most parts of Nagappattinam district which lies at 5 meters and below from the mean sea level, is likely to be submerged.**

Sea level rise (contd)

- **" For five coastal districts, Nagapattinam, Thiruvarur, Thanjavur, Pudukottai, and Ramaanathapuram, the area along the coast that is below 10m above current mean sea level is estimated to be at risk from a 1 meter SLR" ;**
  " A 1m rise in average sea level would permanently inundate about 1091 square kilometers along the Tamil Nadu coast, but the total area at risk would be nearly six times as much".
  (Byravan, Sudhir Chellarajan and Rajesh Rangarajan (2010)

- **A recent study conducted by Mishra A (2014) shows that incidence of tropical cyclones in the east coast is on the rise: "Studies show that in the Bay Bengal region more cyclonic disturbances are now intensifying into tropical cyclones during November and the frequency of severe cyclones has increased at a faster rate compared to the total frequency of total cyclones".**

Land Area at various heights above current sea level in the Delta districts in Tamil Nadu
(Area in acres)

District	Up to 1 m	Up to 2 m	Up to 3 m	Up to 5 m	Up to 10 m
Nagappattinam	145,869	197,519	257,300	379,831	569,567
Tiruvarur	35,570	50,433	65,701	99,801	217,353
Thanjavur	12,869	17,321	21,926	32,602	61,996
Total for Delta	194,306 (72%)	265,273 (66%)	344,927 (61%)	512,234 (54%)	848,916 (44%)
State	269,625	402,424	565,588	947,629	1,926,446

Source: Byravan, Sudhir Chellarajan and Rajesh Rangarajan (2010)

The immediate impact of SLR

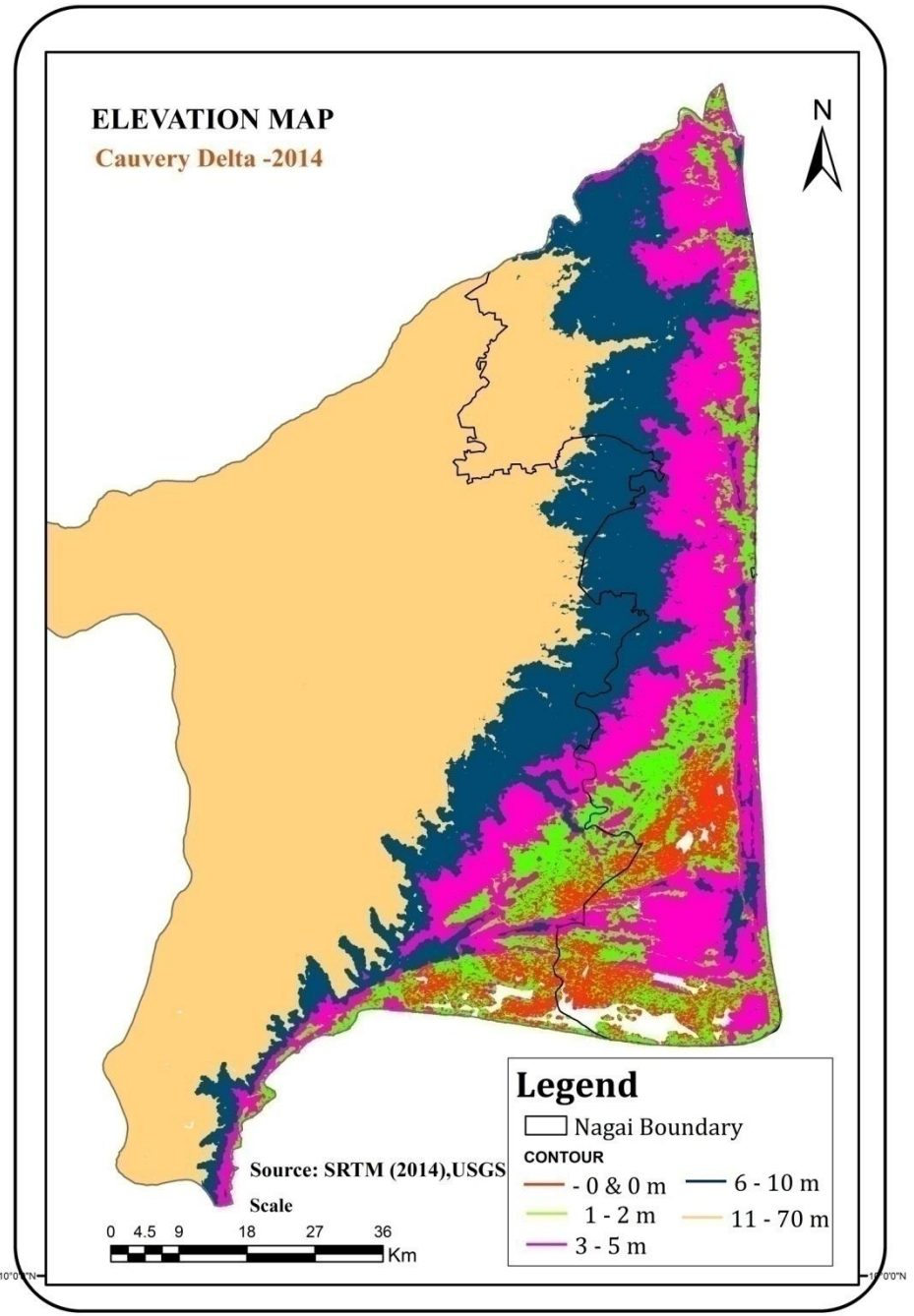
There are 14 Tail end regulators (TER) in the Nagappattinam district which impounds the drainage water flowing from the Cauvery river system (which otherwise will go to the sea) is used for irrigation mostly through pumping.

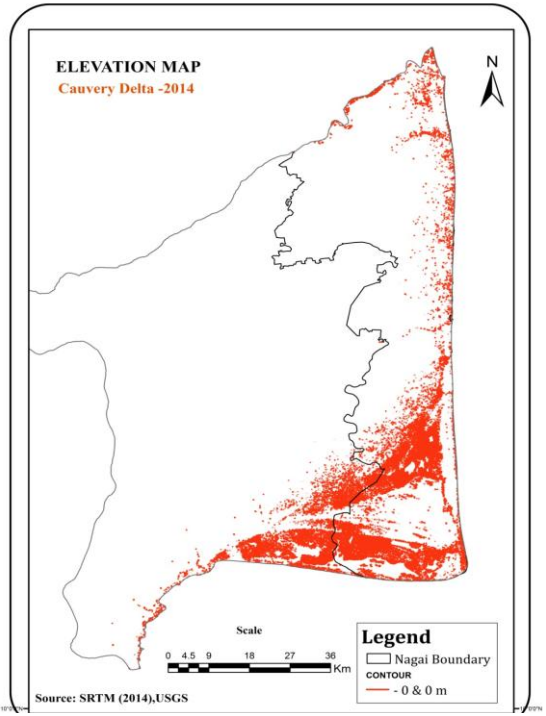
The total irrigated area by the water impounded by the TERs is 25,509 hectares is already under stress due to periodic storm surges.

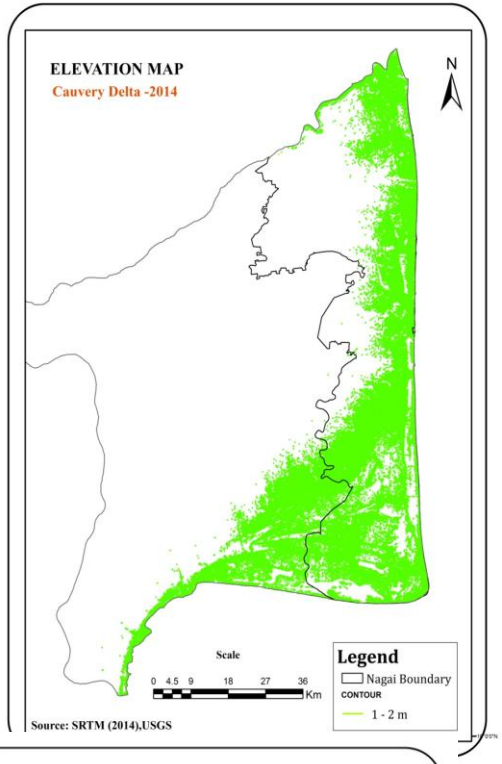
The SLR may result in complete loss of this irrigation facility as well as paddy land hitherto was irrigated.

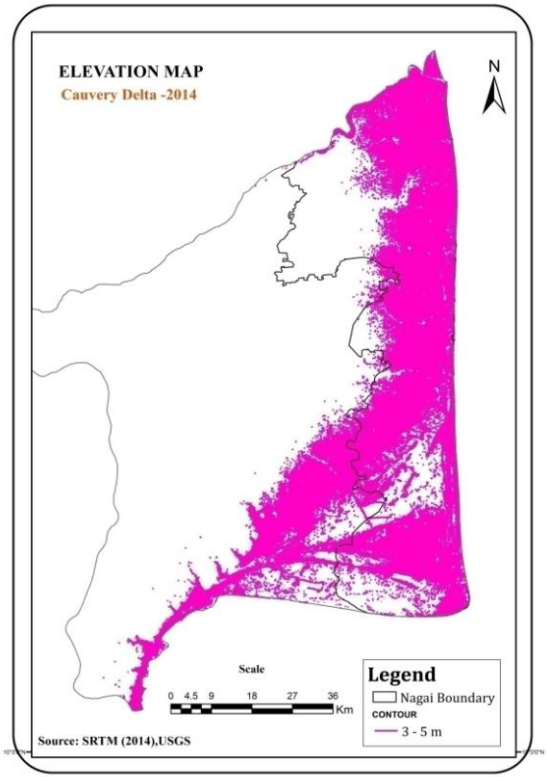
Elevation levels in the delta districts

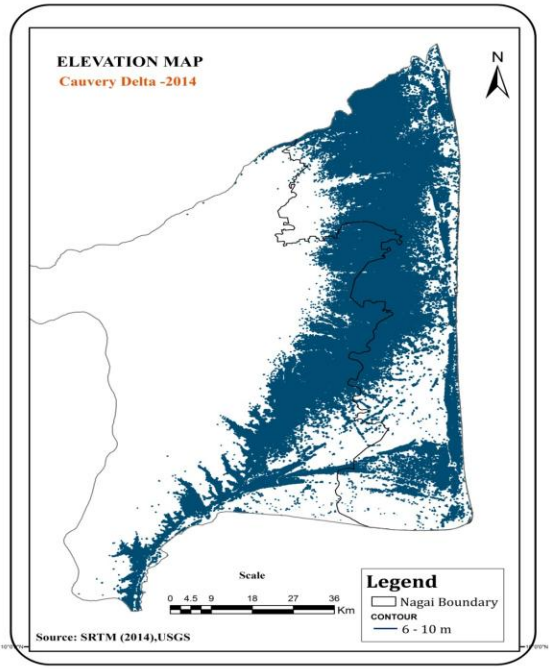
Source: SRTM (2014), USGS

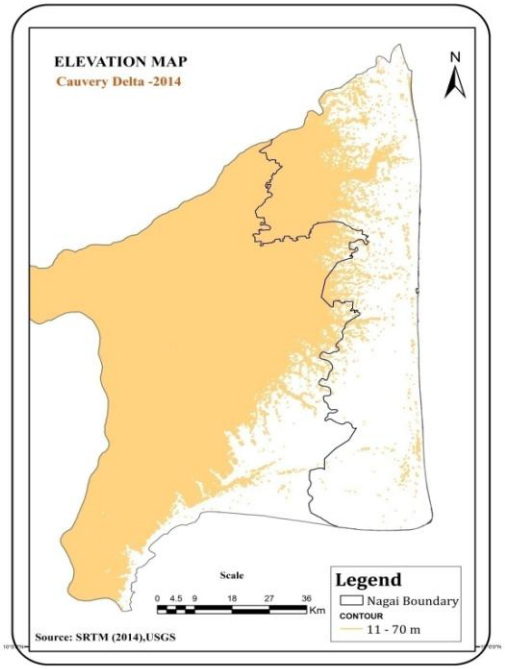












Source: SRTM (2014), USGS

The Tsunami of 2004 that hit the Tamil Nadu Coast – impact of vulnerable elevation level of Nagappattinam district of tail end of the delta

The tsunami has davastated the Nagappatinam district. It killed ovwr 10,000 people spread over 376 coastal hamlets / villages, over one million people lost their habitation and livelihoods at least temporarily or permanently and thousands of cattle population were killed.

Thousands of acres of agricultural land were inundated with seawater for months.

As a result the damage occurred to land and soil and groundwater is almost permanent.

The United Nations-Asian Development Bank-World Bank Joint Assessment Mission valued the total direct damage at US$ 437.8 million, with an additional estimated US$ 377 million in loss of livelihoods.

Inundation of agricultural lands due to tsunami have occurred mostly in the villages which were at 10 meters and below and the worst affected villages were those located below 5 meters from the sea level.

NAGAPATTINAM

(NAGAPATTINAM TALUK)

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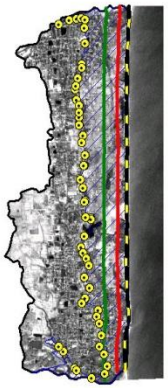
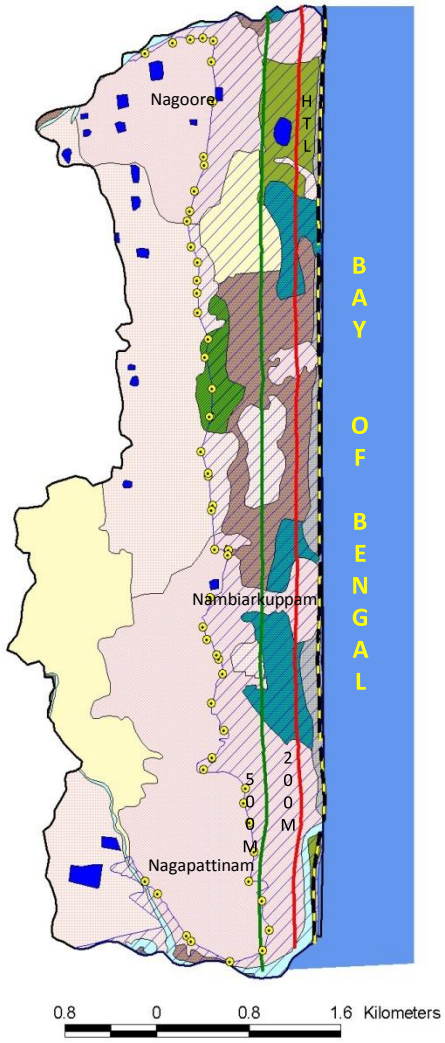
TAMIL NADU - DISTRICTS MAP

NAGAPATTINAM DISTRICT - TALUKS AFFECTED

NAGAPATTINAM TALUK -VILLAGES AFFECTED



IRS-1D, PAN , JUNE 2003



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INUNDATION OBSERVATION POINTS

INUNDATED AREA

HIGH TIDE LINE

200M LINE

500M LINE

VILLAGE BOUNDARY

LANDUSE

- BUILT-UP LAND
- BUILT-UP WITH VEGETATION
- CROP LAND
- LAND WITH/WITHOUT SCRUB
- MUDFLAT
- NATURAL VEGETATION
- PLANTATION
- RIVER/CANAL/BACKWATER
- SANDY BEACH/SAND DUNE
- TANK
- WATER LOGGED/MARSHY LAND
- OCEAN

MAXIMUM EXTENT OF INUNDATION FROM HTL : 1100 M

PROBABLE AREA OF INUNDATION : 7.26 SQ.KM

MAJOR LANDUSE AFFECTED : SETTLEMENT

Maximum extent of Inundation is based on field observation and area of inundation has been calculated using the field data and the landuse / landcover in the region derived from satellite data.

AKKARAIPETTAI VILLAGE

(NAGAPATTINAM TALUK)

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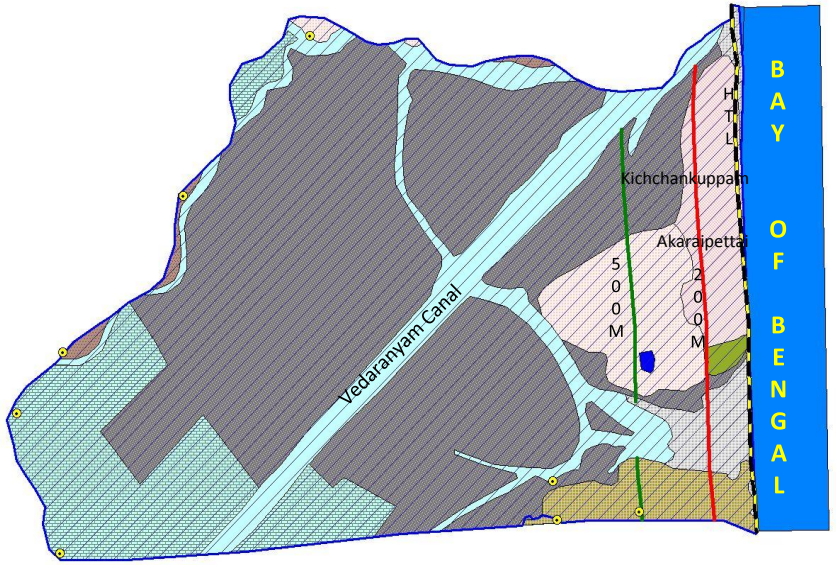

0.6 0 0.6 1.2 Kilometers

N

LANDUSE

- INUNDATION OBSERVATION POINTS
- INUNDATED AREA
- HIGH TIDE LINE
- 200M LINE
- 500M LINE
- VILLAGE BOUNDARY
- BUILT-UP LAND
- BUILT-UP WITH PLANTATION
- BUILT-UP WITH VEGETATION
- LAND WITH/WITHOUT SCRUB
- MUDFLAT
- NATURAL VEGETATION
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- SALTPAN/AQUACULTURE
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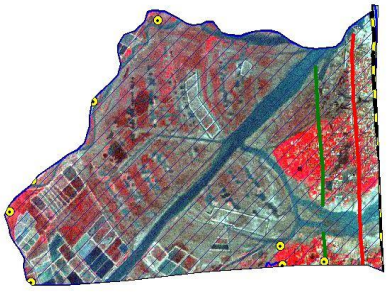
- TANK
- OCEAN



QUICKBIRD DATA, DEC 2004

MAXIMUM EXTENT OF INUNDATION FROM HTL	: 3000 M
PROBABLE AREA OF INUNDATION	: 5.0 SQ.KM
MAJOR LANDUSE AFFECTED	: SETTLEMENT

Maximum extent of Inundation is based on field observation and area of inundation has been calculated using the field data and the landuse / landcover in the region derived from satellite data.

VADAKKU POYYUR VILLAGE

(NAGAPATTINAM TALUK)

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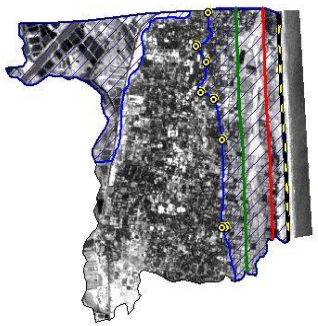

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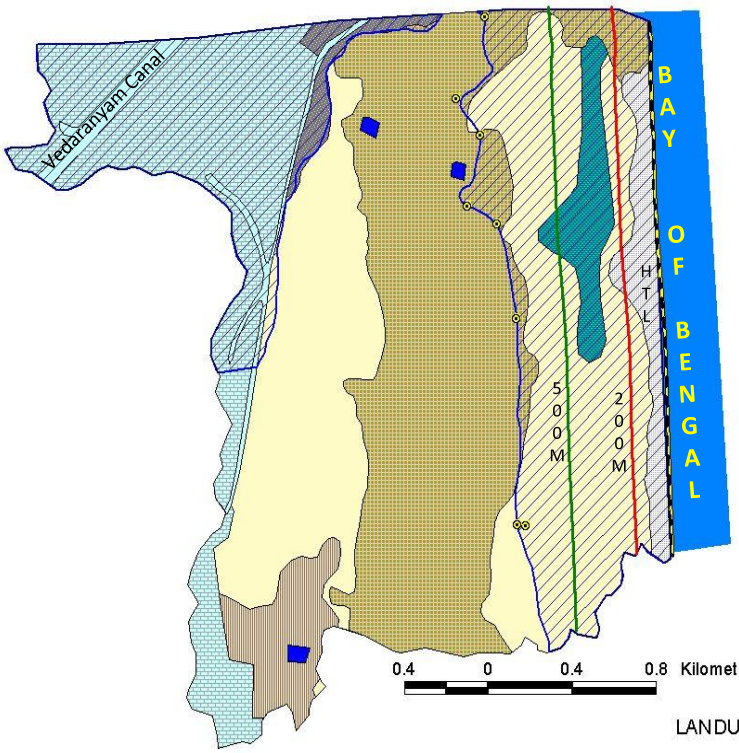

LANDUSE

- INUNDATION OBSERVATION POINTS
- INUNDATED AREA
- HIGH TIDE LINE
- 200M LINE
- 500M LINE
- VILLAGE BOUNDARY
- BUILT-UP WITH PLANTATION
- CROP LAND
- HARVESTED/FALLOW LAND
- MUDFLAT
- RIVER/CANAL/BACKWATER
- SALTPAN/AQUACULTURE
- SANDY BEACH/SAND DUNE
- TANK
- WATER LOGGED/MARSHY LAND
- OCEAN

MAXIMUM EXTENT OF INUNDATION FROM HTL	: 880 M
PROBABLE AREA OF INUNDATION	: 1.96 SQ.KM
MAJOR LANDUSE AFFECTED	: SETTLEMENT

Maximum extent of Inundation is based on field observation and area of inundation has been calculated using the field data and the landuse / landcover in the region derived from satellite data.

THERKU POYYUR VILLAGE

(NAGAPATTINAM TALUK)

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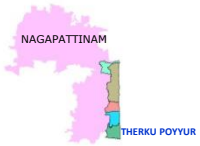
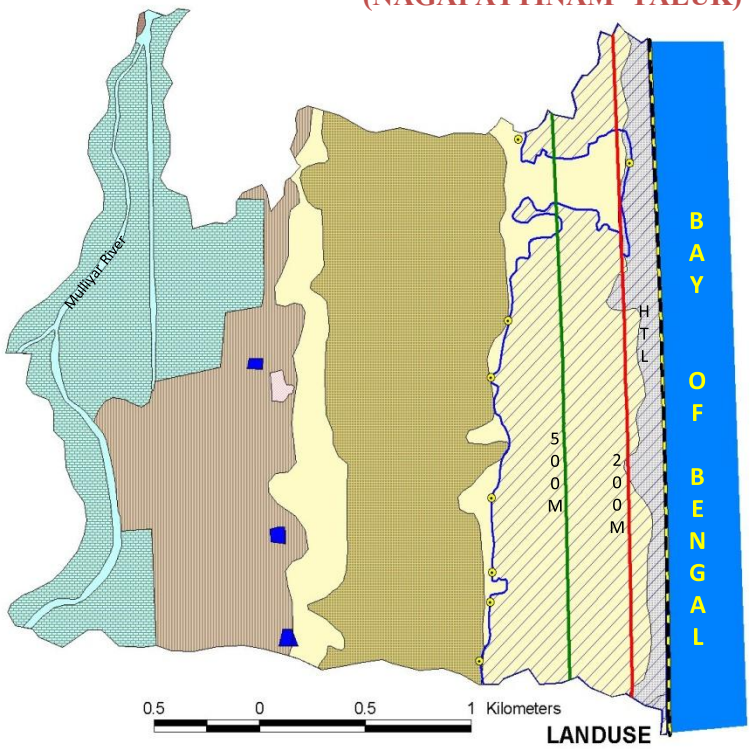
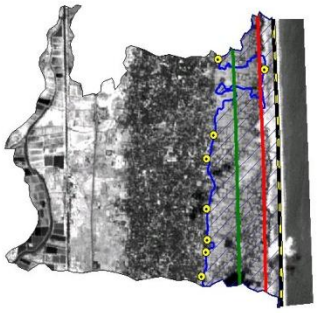


NAGAPATTINAM TALUK -VILLAGES AFFECTED





IRS-1D, PAN , JUNE 2003

MAXIMUM EXTENT OF INUNDATION FROM HTL	: 740 M
PROBABLE AREA OF INUNDATION	: 1.85 SQ.KM
MAJOR LANDUSE AFFECTED	: SETTLEMENT

Maximum extent of Inundation is based on field observation and area of inundation has been calculated using the field data and the landuse / landcover in the region derived from satellite data.

POOVAM VILLAGE

(NAGAPATTINAM TALUK)

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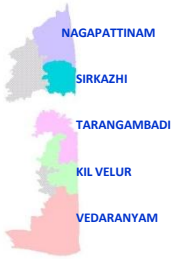
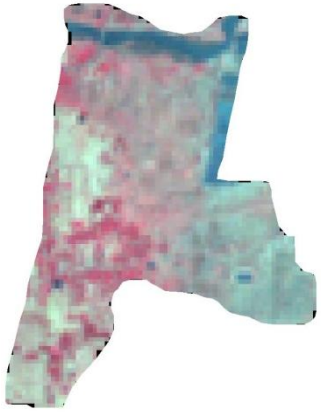
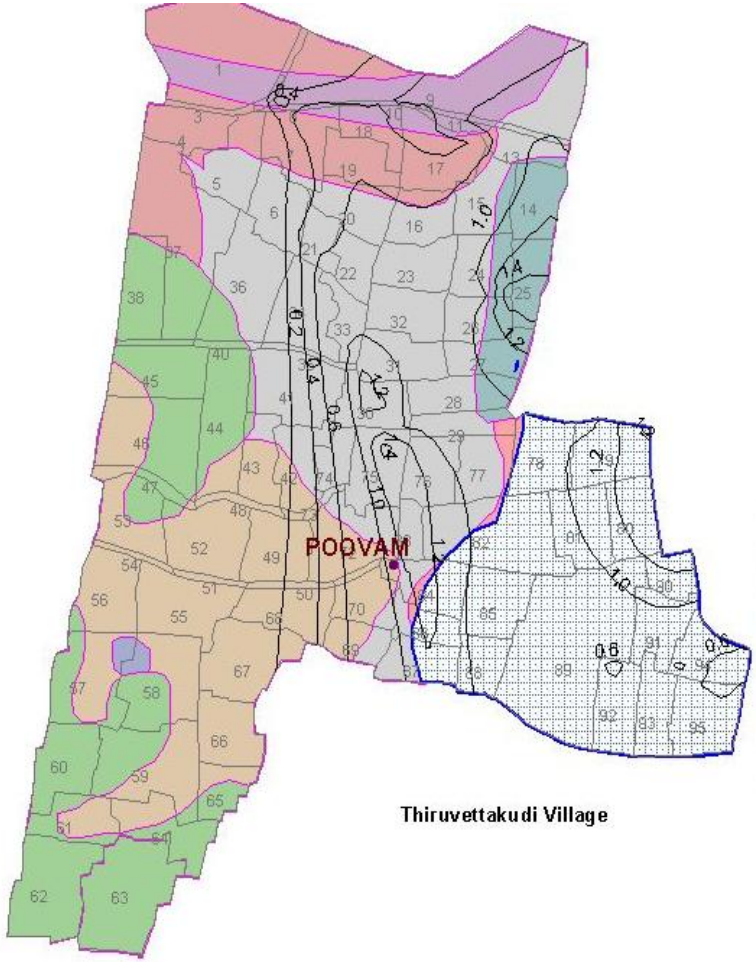
TAMIL NADU - DISTRICTS MAP



NAGAPATTINAM DISTRICT - TALUKS AFFECTED



IRS- 1D, LISS III, JUNE 2001



N
W
E
S

POOVAM
Contour Heights (m)
Cadastral Boundary
Inundated Areas

Landuse
Agricultural land
Aquaculture Pond
Built-up area
Fallow land
Plantation
River
Salt affected land
Tank

0 200
Meters

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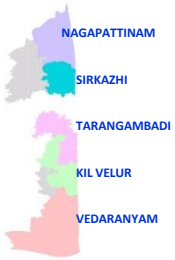
TAMIL NADU - DISTRICTS MAP

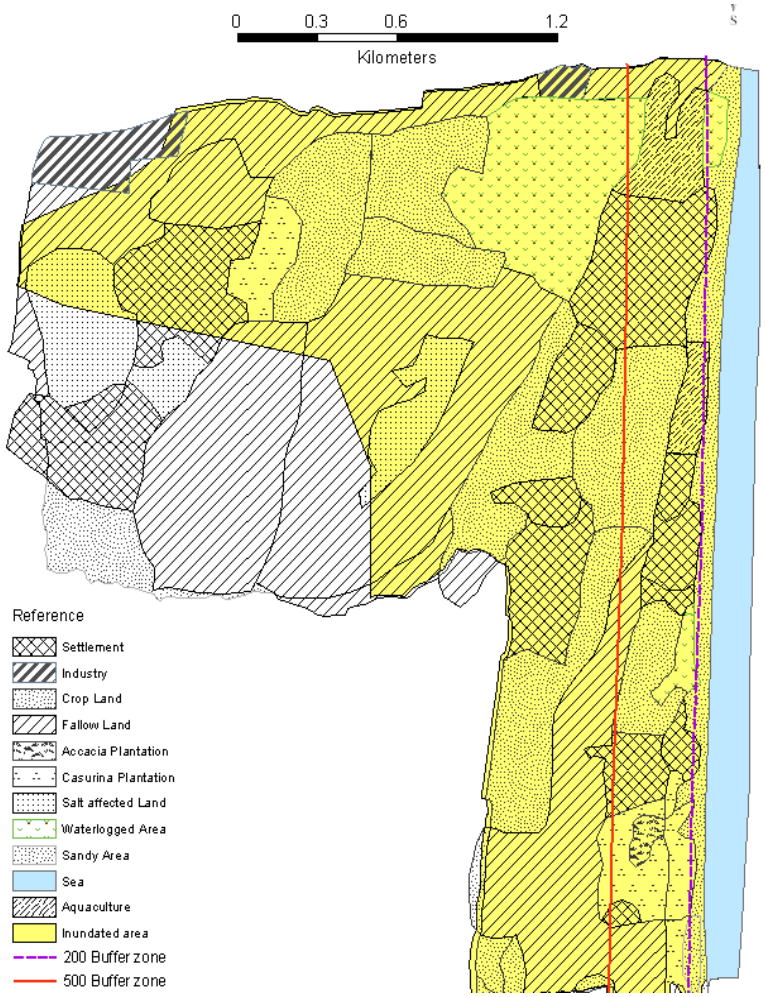


NAGAPATTINAM DISTRICT - TALUKS AFFECTED

MANIKAPANGU VILLAGE

(SIRKAZHI TALUK)

N



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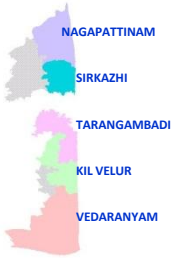
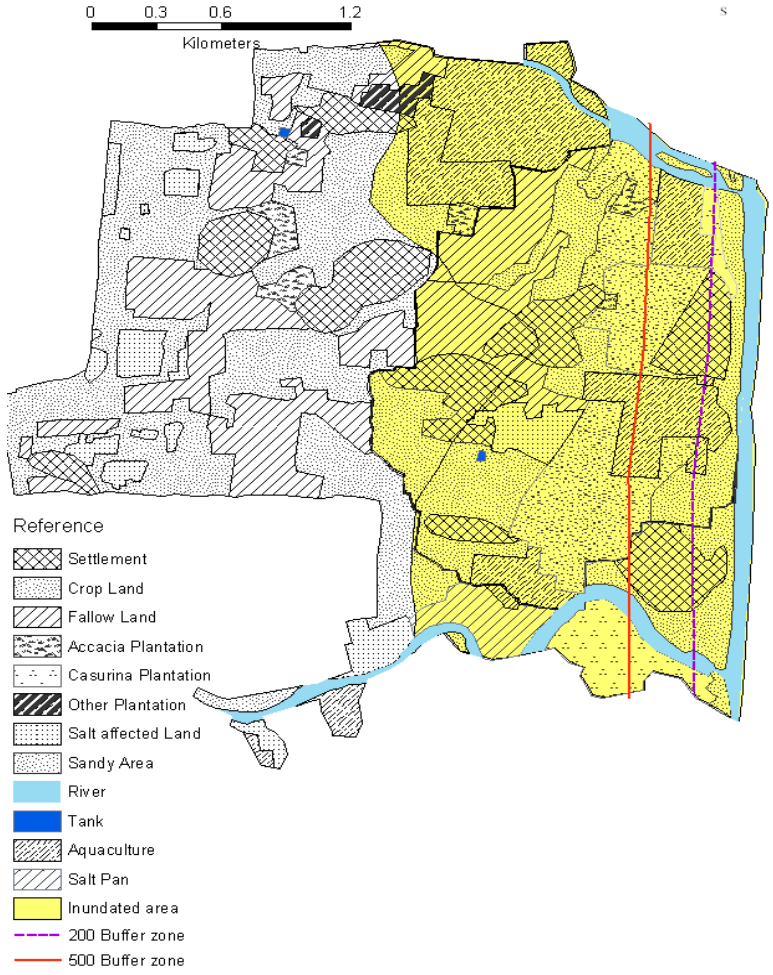
TAMIL NADU - DISTRICTS MAP



NAGAPATTINAM DISTRICT - TALUKS AFFECTED

KALAMANALLUR & MARUNDAMPALLAM VILLAGE
(SIRKAZHI TALUK)

N



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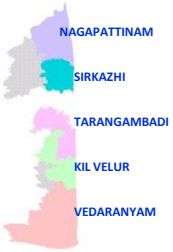
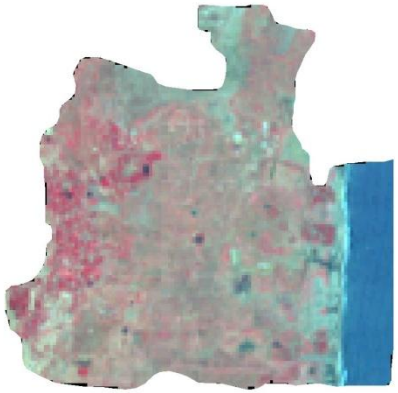
TAMIL NADU - DISTRICTS MAP



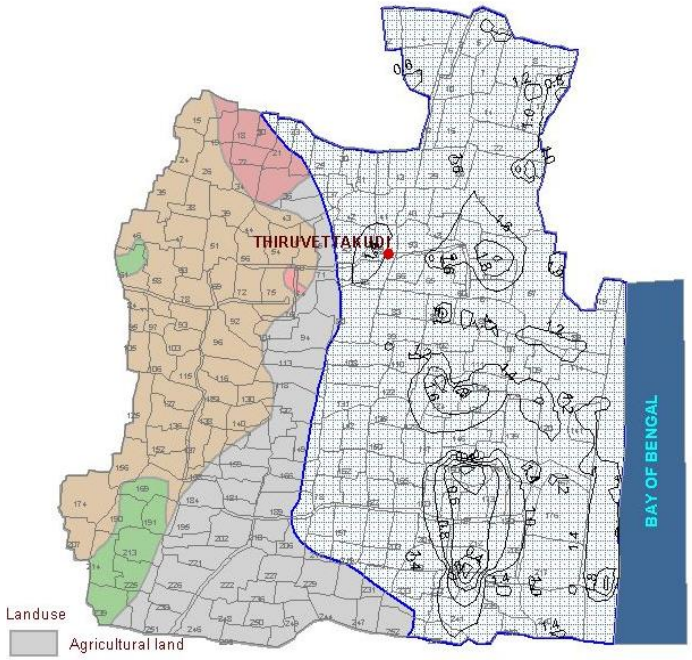
NAGAPATTINAM DISTRICT - TALUKS AFFECTED



IRS- 1D, LISS III, JUNE 2001

THIRUVETTAKUDI VILLAGE

(NAGAPATTINAM TALUK)



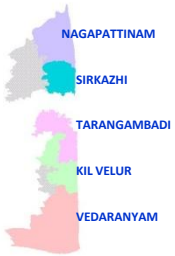
Landuse
- Agricultural land
- Back water
- Built-up area
- Fallow land
- Salt affected land
- Scrub land
- Tank

THIRUVETTAKUDI
Contour Heights (m)
Cadastral Boundary
Inundated Areas

0 300
Meters

INDEX

TAMIL NADU - DISTRICTS MAP

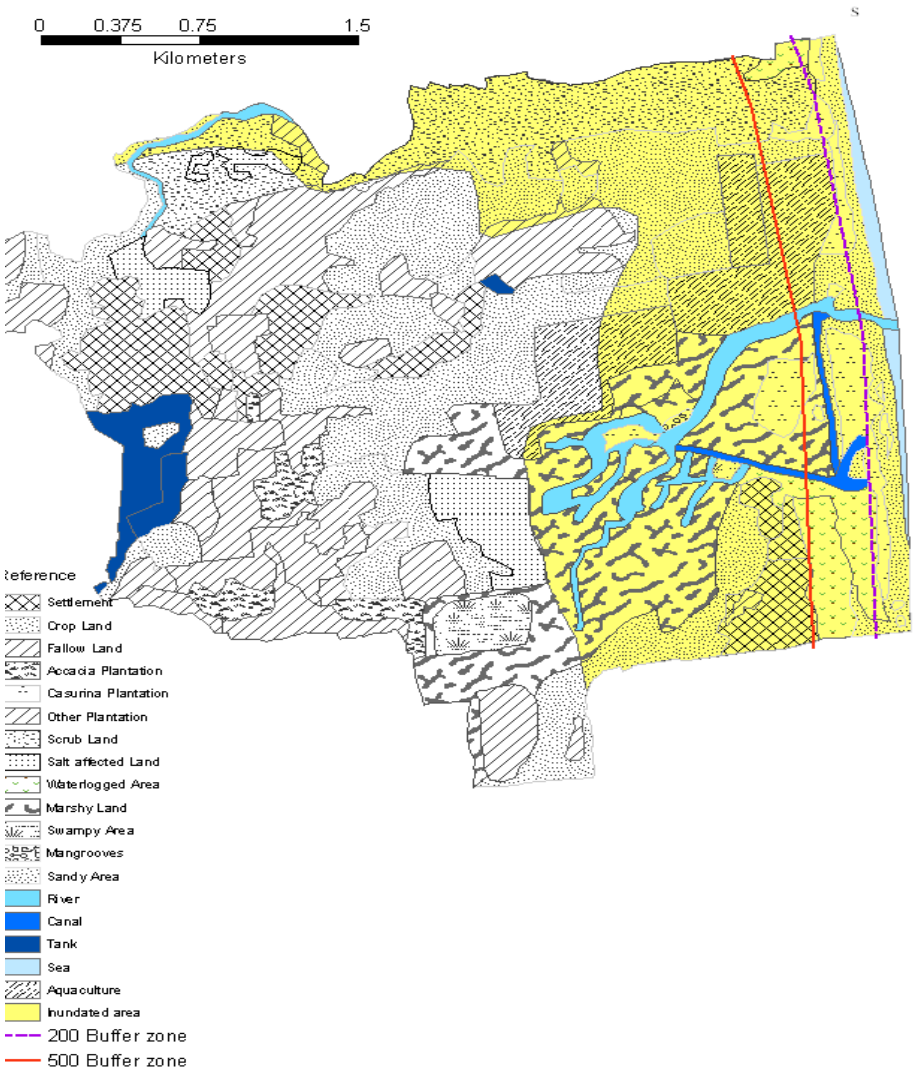


NAGAPATTINAM DISTRICT - TALUKS AFFECTED

PERUNTHOTTAM VILLAGE

(SIRKAZHI TALUK)

N



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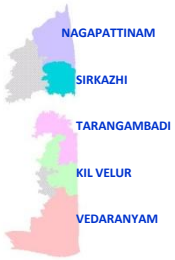
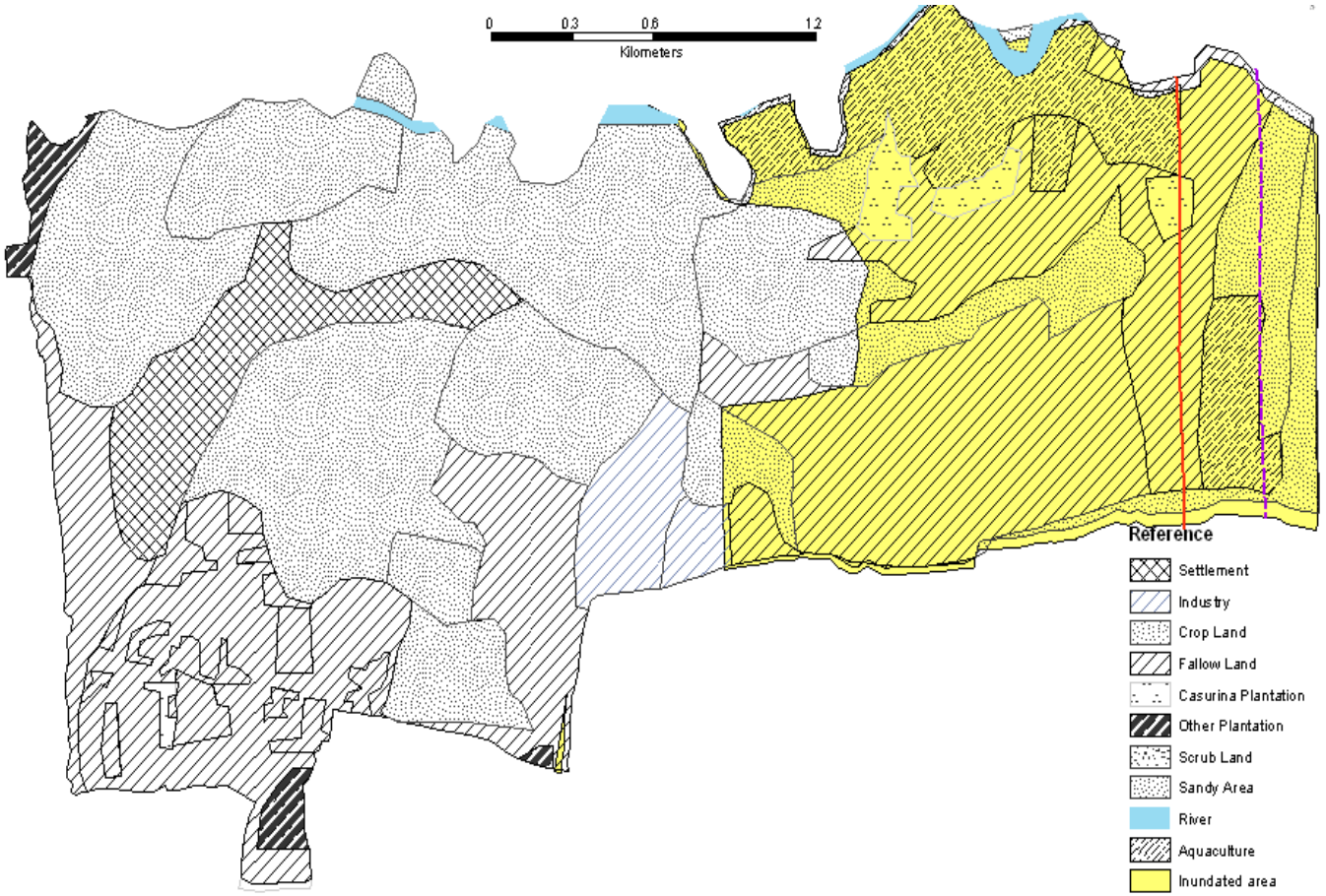
TAMIL NADU - DISTRICTS MAP



NAGAPATTINAM DISTRICT - TALUKS AFFECTED

PILLAIPERUMANALLUR VILLAGE

(SIRKAZHI TALUK)



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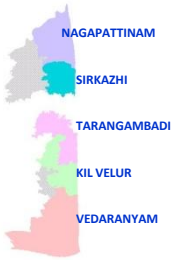
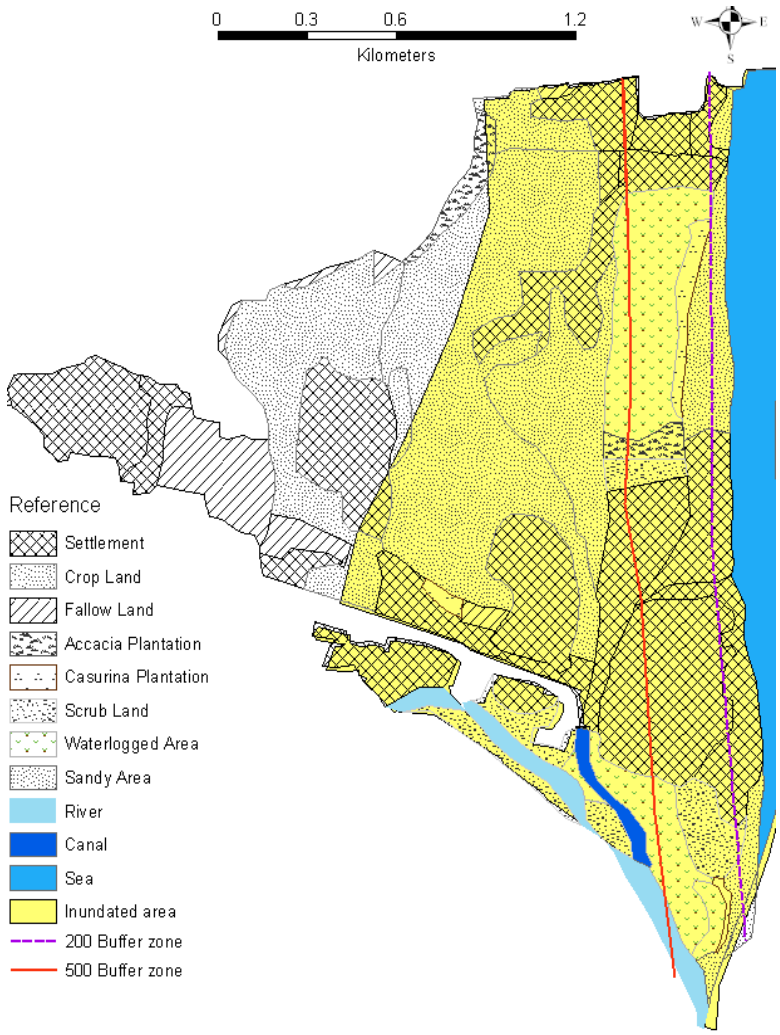


NAGAPATTINAM DISTRICT - TALUKS AFFECTED

SATTANGUDI VILLAGE

(SIRKAZHI TALUK)

N



KIZHAVELY VILLAGE

(NAGAPATTINAM TALUK)

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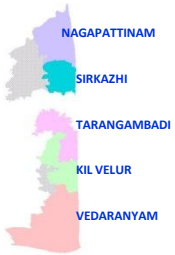
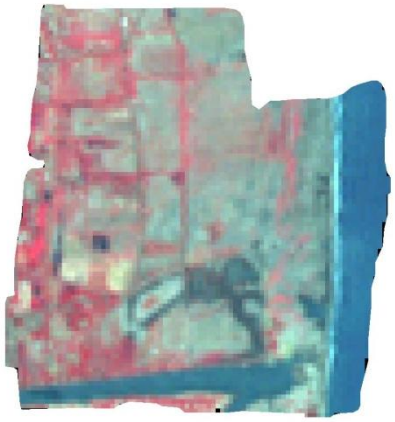
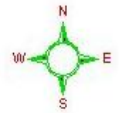
TAMIL NADU - DISTRICTS MAP

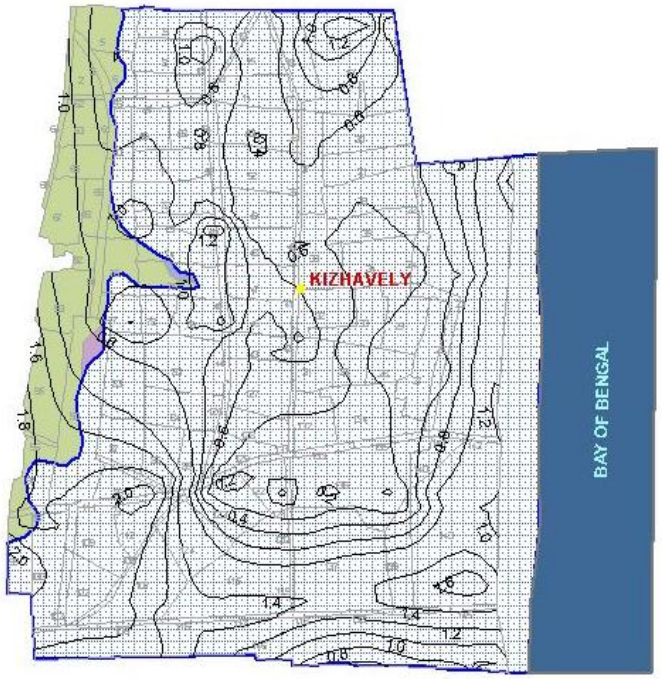


NAGAPATTINAM DISTRICT - TALUKS AFFECTED



IRS- 1D, LISS III, JUNE 2001





Seawater intrusion and Groundwater salinity

It is generally believed that groundwater is available in abundance in the delta districts.

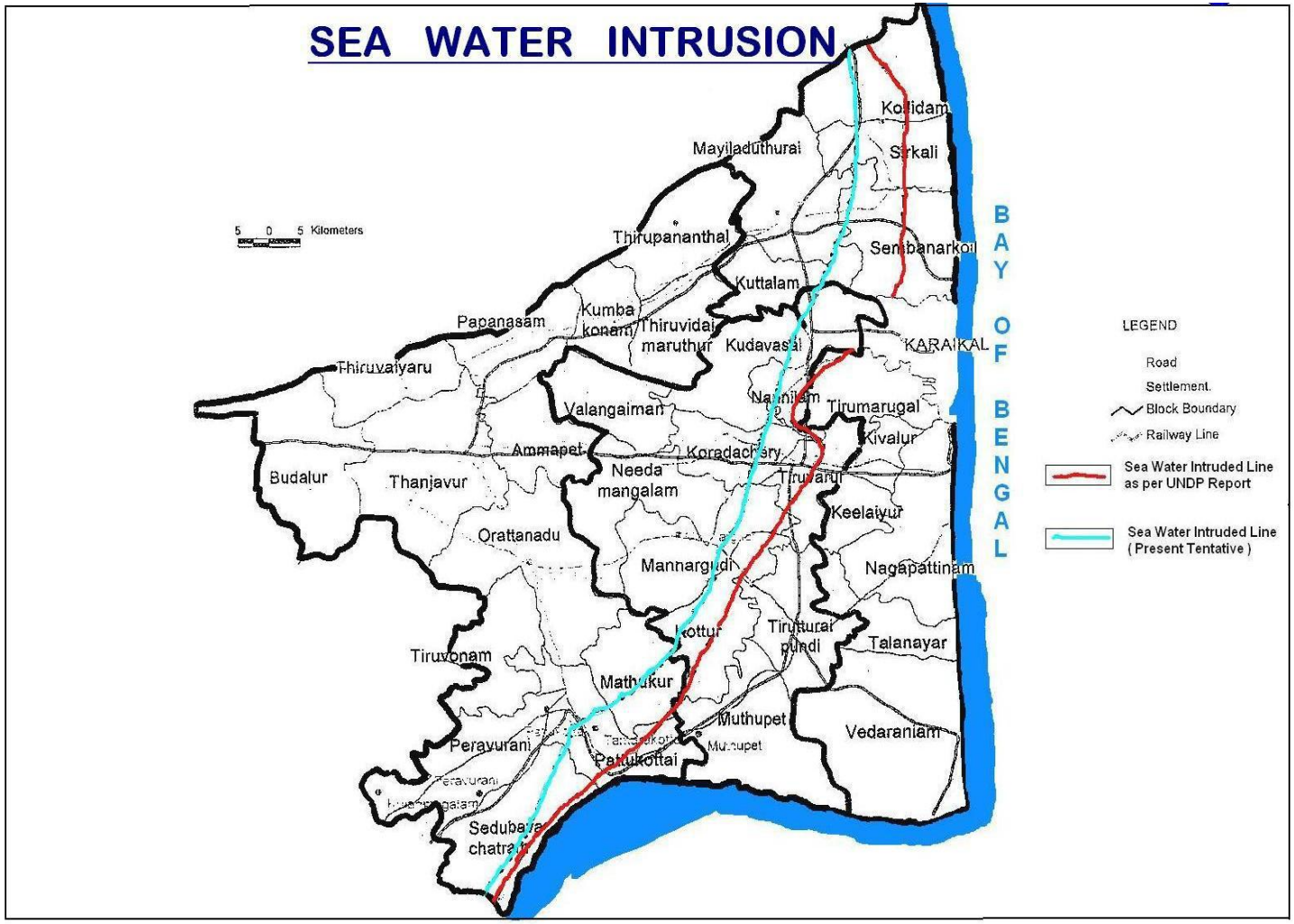
But as per the data provided by the Central Groundwater Board the conditions seem to be different. As early as in 2004, the stage of groundwater development was semi-critical both in Thanjavur and Tiruvarur districts and it was over-exploited in Nagappattinam district. Since then, the conditions have become worse.

Since 2004, not only that the use of groundwater has gone up, but there has been a severe decline in the groundwater quality

Block-wise stage of GW development in Nagappattinam district as on 31st March 2004

Name of the Block	Stage of GW development	Status
Keelaiyur	Complete saline	Unusable
Kilvelur	Complete saline	Unusable
Nagappattinam	Complete saline	Unusable
Thalainayar	Complete saline	Unusable
Thirumarugal	Complete saline	Unusable
Vedaranyam	Complete saline	Unusable
Kollidam	128%	Over-exploited
Kuthalam	181%	Over-exploited
Myladurthurai	87%	Semi critical
Sembanar koil	121%	Over-exploited
Sirkalai	114%	Over-exploited

Seawater intrusion in the Delta Districts



Source: Cauvery Delta Modernization Plan 2008 - printed in. Support to the National Water Mission NAPCC Appendix - 4 Cauvery Delta Sub Basin, p.30

Empty backwater rivers / canals and seawater invasion

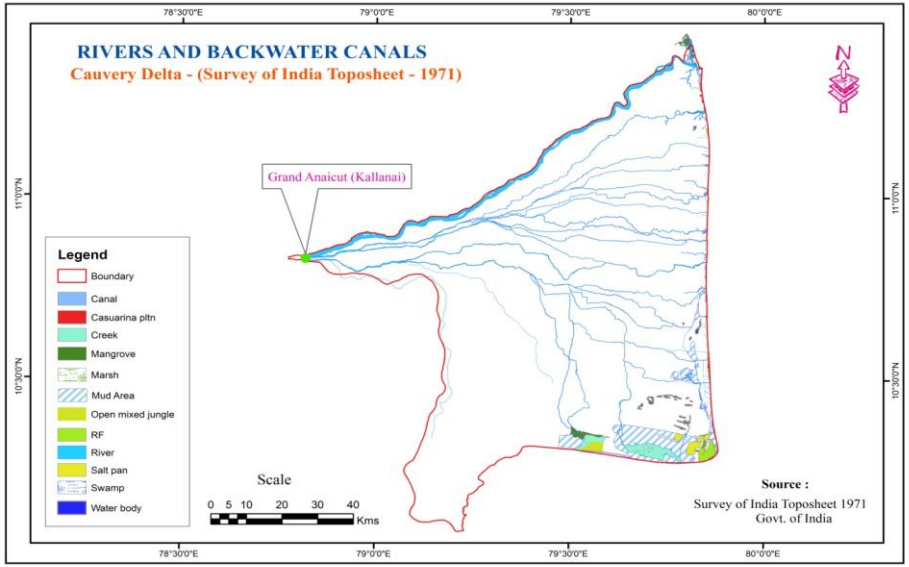
The river Cauvery drains into the ocean through many major rivers and canals

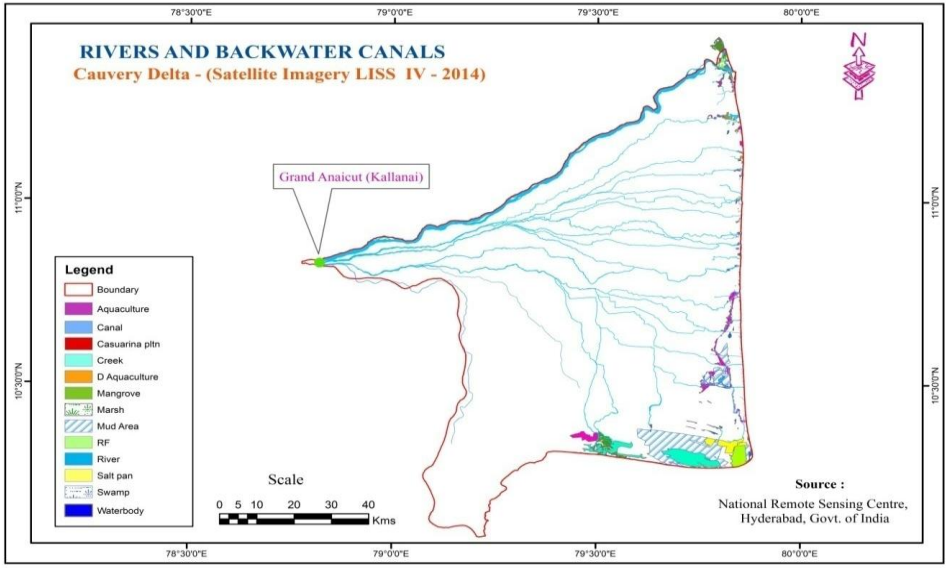
An attempt was made to digitize all the major canals, sub-rivers and streams using the 1971 topo sheet and cross checked it with the NRSC Satellite imageries for 2014

Almost all the rivers and backwater canals have been subject to encroachment

Our field survey have indicated that most of the rivers were carrying seawater through reverse flow –in some cases reaching inland even up to 20 KM

Rivers and backwater canals





Total area under 30 major rivers and canals in 1971 was 239.09 sq km and it has declined to 228.81 sq km in 2014

Source: Topo-sheet 1971 and NRSC data,2014

Shoreline Changes in the delta

Shoreline is a line where seawater meets land.

Shoreline is never constant but keeps changing due to variety of reasons.

Shoreline is very dynamic and subject to various coastal, climatic and anthropogenic factors

The study of shoreline changes are very important for delta, for it helps to understand the dynamic nature of sea, its influence on the surface of land and underneath (groundwater) and most importantly to measure the spread of salinity on land and coastal water bodies

Shoreline changes resulting in erosion and accretion are conditioned by tidal and anthropogenic influences

Although shoreline changes are not considered permanent, increasingly, erosions and accretions are becoming permanent. This causes enormous worry particularly for deltas.

Mapping shoreline Changes in the Cauvery Delta

An attempt was made to measure shoreline changes in the Cauvery delta region by picking up 51 points on the coast starting from Pichavaram to Muthupettai River Mouth covering a distance 167 KM.

The shoreline changes were measured for two different sets of time: 1971 and 2014

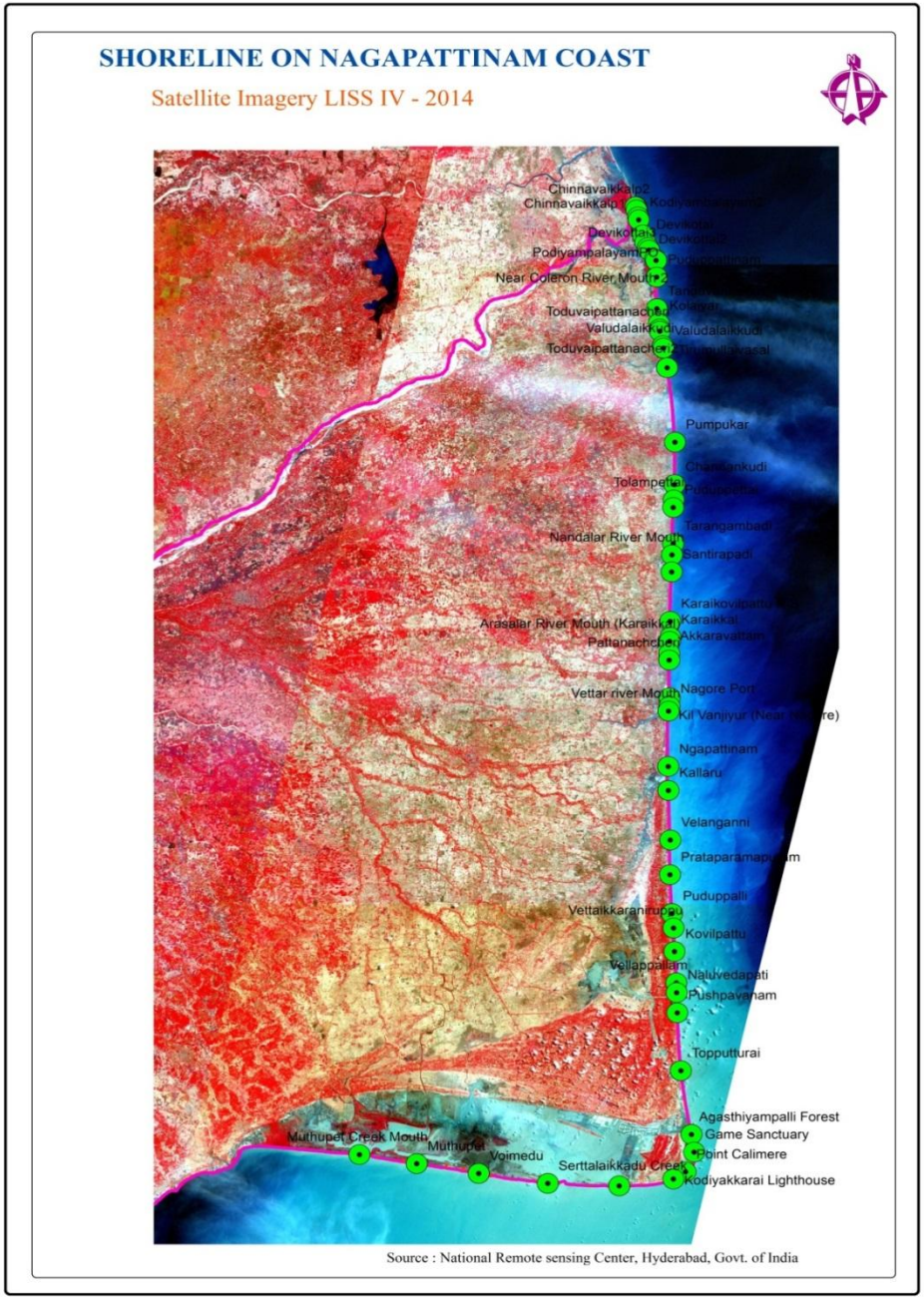
In addition, we also measured shoreline chnages by comparing the Landsat Thematic Mapper (TM) data 30 m resolution for the year 1991 linked through 2016 Land Sat 8 data with 30m Resolution.

In this case we picked up 152 points covering the distance of 167 KM.

And, to measure the area of accretion and erosion, we picked up the areas covered in between two points and measured accretion or erosion by averaging the area in four or five locations within a given two points.

In this presentation, only a sample points are presented

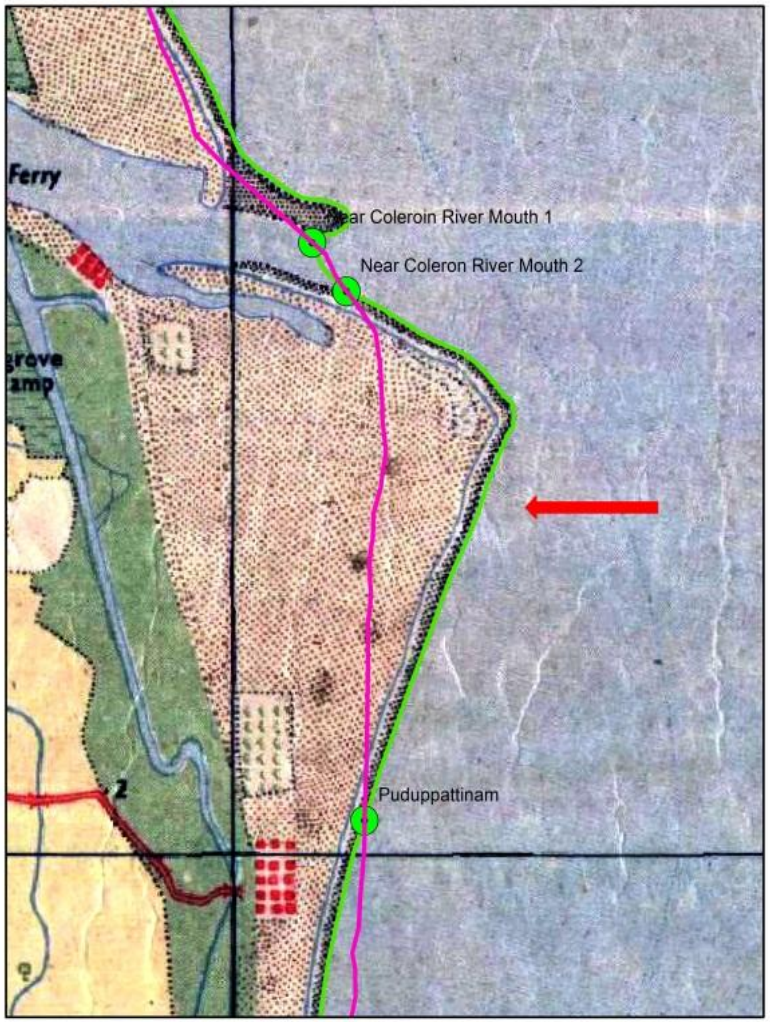
Points (51) chosen for studying shoreline changes



SHORELINE CHANGES ON NAGAPATTINAM COAST

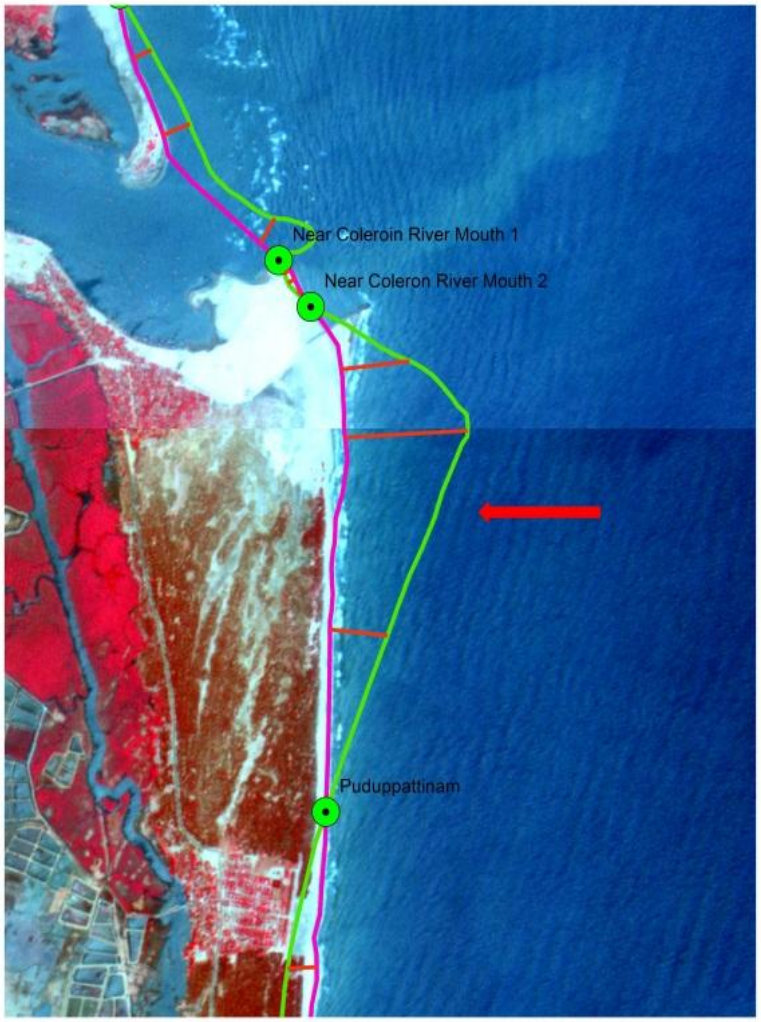
Eroded Area (Near Coleron River to Puthuppattinam)

SOI Toposheet - 1971



Source : Survey of India Toposheet - 1971

Satellite Imagery LISS IV - 2014



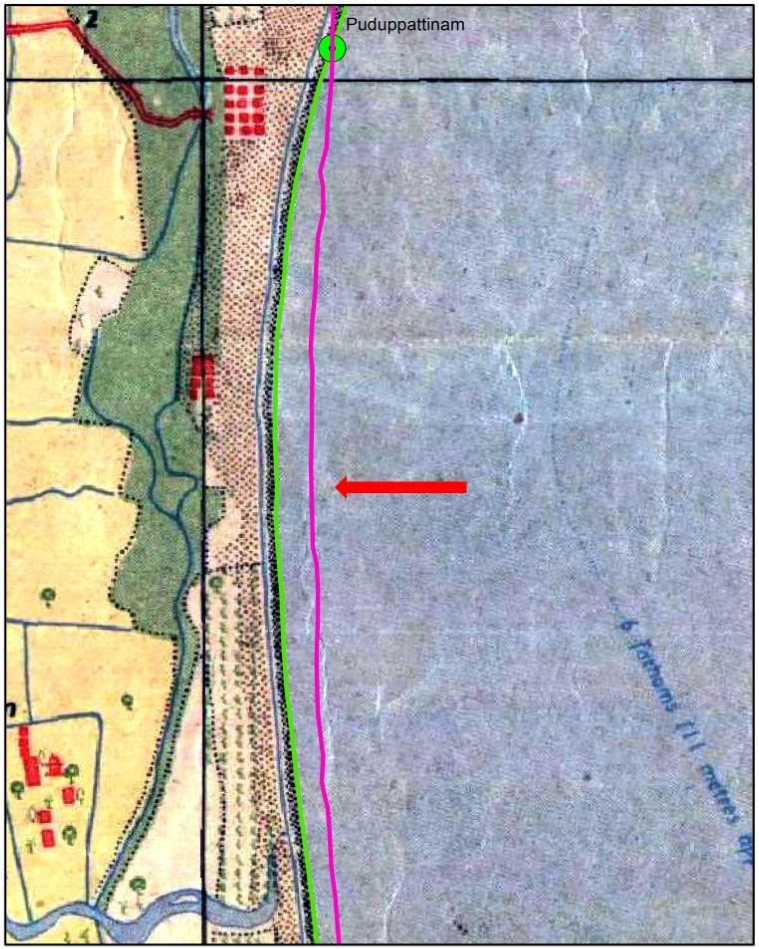
1971 2014

Source : National Remote Sensing Center, Hyderabad, Govt.of India

SHORELINE CHANGES ON NAGAPATTINAM COAST

Accretion Area (Near Puthuppattinam)

SOI Toposheet - 1971



Source : Survey of India Toposheet - 1971

Satellite Imagery LISS IV - 2014

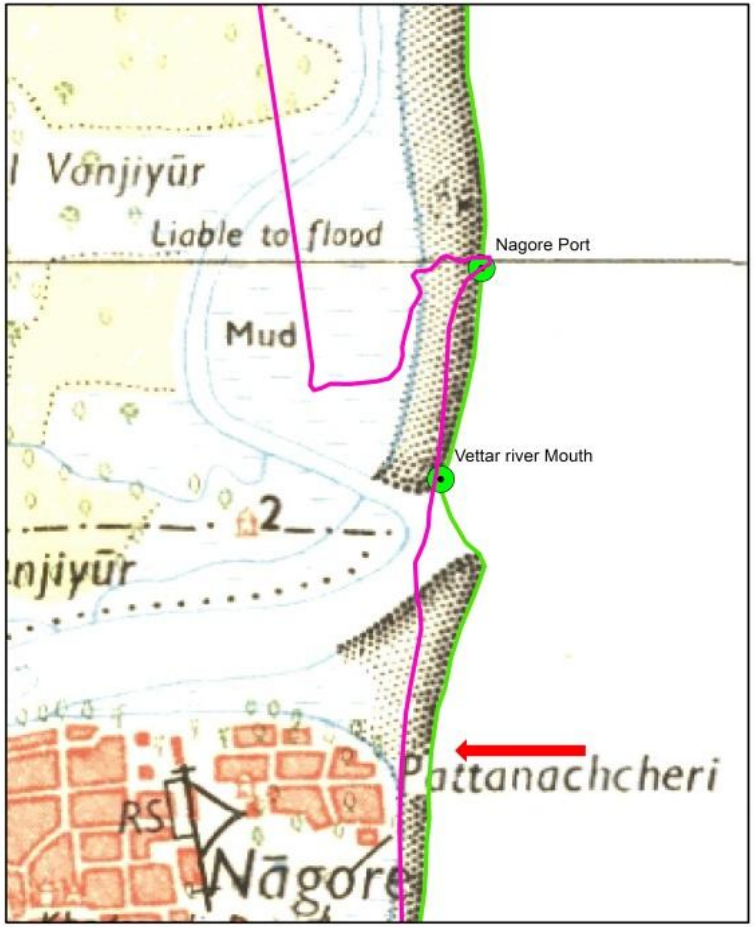
1971 2014

Source : National Remote Sensing Center, Hyderabad, Govt.of India

SHORELINE CHANGES ON NAGAPATTINAM COAST

Eroded Area (Near Nagore)

SOI Toposheet - 1971



Source : Survey of India Toposheet - 1971

Satellite Imagery LISS IV - 2014

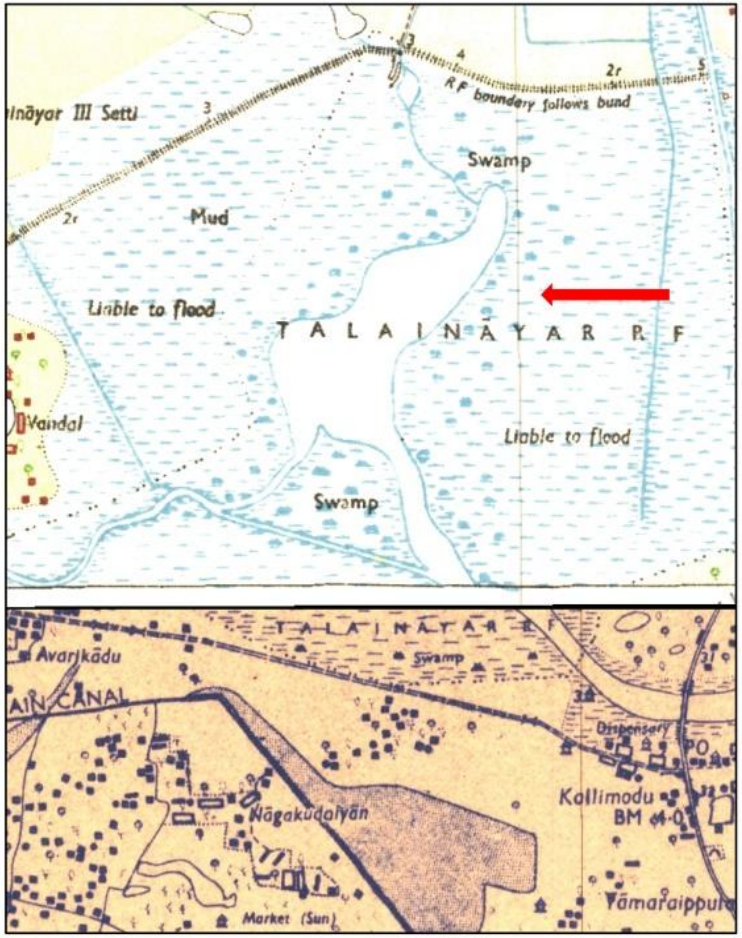
1971 2014

Source : National Remote Sensing Center, Hyderabad, Govt.of India

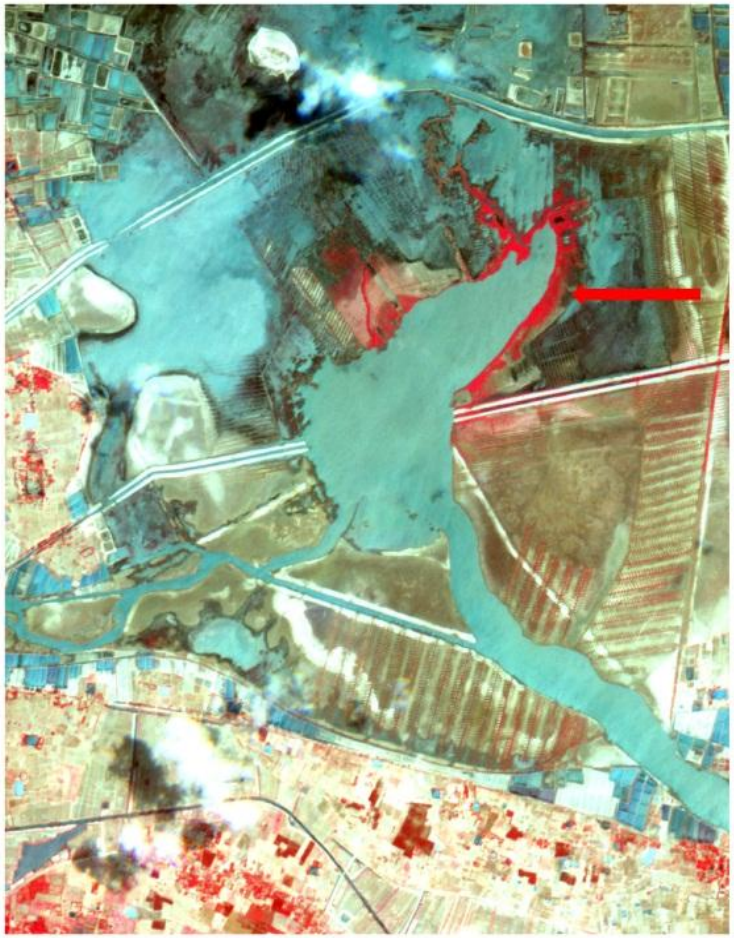
SHORELINE CHANGES ON NAGAPATTINAM COAST

Swamp Area (Near Thalainayar)

SOI Toposheet - 1971



Satellite Imagery LISS IV - 2014



Source : Survey of India Toposheet - 1971

1971 2014

Source : National Remote Sensing Center, Hyderabad, Govt.of India

Summary results of 151 points chosen between 1991 (TM Image and Land Sat 8, 2016, USGS

Total area lost in erosion (in acres) and number of points where erosions have occurred	**2535**	**Erosion in 78 points**
Total area gained in accretion (in acres) and number of points where accretions have occurred	307	Arretion in 41 points
Number of points where there is no change	Nil	No change in 32 points

For want of time, I am skipping the maps showing shoreline changes

Delta Subsidence - sinking delta

Certain critical minimum levels of elevation has to be maintained to separate deltas from the sea-level

Deltas carried sediments for thousands of years from the upstream which helped to maintain the critical elevation level

There is almost a near unanimity among researchers that the withholding river flow in the upstream through construction of series of dams is the fundamental reason for the reduced or no sediment flow to the downstream and the delta subsidence is in large measure attributable to this kind of human interventions in the rivers.

The Mettur dam constructed in 1934, had the storage capacity of 2708.8 MCM. This is reduced to 1994.2 MCM in the year 2004. Therefore, the total loss of capacity up to 2004 was 714.6 MCM. Besides, estimates show that the capacity is further reduced to 1889 MCM in the year 2015. The annual rate of percentage loss of capacity is 0.4. In other words, a major proportion of sediment deposited in the reservoir would have got transferred to the delta lands which at the moment are practically nil (Central Water Commission, 2015)

It has been estimated that the sediment deposit during the past one century has declined by 94% in Krishna, 95% in Narmada, 80% in Indus, 80% in Cauvery, 96% in Sabarmati, 74% in Mahanadi, 74% in Godavari and 50% reduction Brahmani.

“As per our current analysis, we are (India) losing at least 1.95 BCM storage capacity through siltation every year, valued at about Rs 2017 crores at replacement costs” (Himanshu Thakkar, 2014)

It is even said that delta subsidence due to human interventions could be more threatening than climate change induced sea-level rise
(ParineetaDandekar,SANDRP,South Asia Network onDams Rivers and People, http://sandrp.in/). This issue has been discussed and acknowledged by the IPCC (see IPCC, Working Group Report, II, 2014).

Delta Subsidence (contd)

Jakarta city is sinking at an average annual rate of 5 to 10 cm per year which is more rapid compared global seawater rise due to global warming.

The Mekong Delta which is home for 20 million people is sinking at 1.6 cm per year
(Delta Subsidence an Imminent Threat to Coastal Population, Environmental Health Perspectives, Vol 123, No.8, August 2015, PP. A205)

The Indus has already collapsed says Syvitski and Ganges and Brahmaputra deltas also move in that direction. Bangladesh is apparently the worst hit due to delta subsidence process.

James Syvitski, a well-known professor of geological sciences at the University of Colarado, Boulder, who has specialized in sediment transport, land-ocean interactions and earth –surface dynamics has pointed out that deltas are sinking at an alarming rate due to upstream development, over-extraction of groundwater as well as oil and gas. He said while the sea-level rise is about 3 mm a year, deltas are sinking at a much faster rate – some 100 mm per year. **The yellow river delta in China is sinking at 250 mm every year**.

Delta subsidence due to hydro-carbon extraction

"The Po Delta (near Venice in Italy) subsided largely because methane was being pumped from underground. They stopped the pumping and the delta is sinking 10 times less fast than it was…… The Chao Phraya River Delta subsided because of groundwater being pumped out to supply Bangkok. So they introduced a tax on water use".
http://www.futureearth.org/blog/2014-apr-4/deltas-are-snowflakes-each-one-different-qa-james-syvitski

On the one hand, due to global warming induced climate change and ice melts, the seawater warms up and sea-level rises and on the other due to reduced or no sediment flow the deltas are sinking. Delta collapse is thus something which has been occurring all across the world, more so in South Asia. **The Cauvery delta is no exception**

Delta subsidence (contd)

There are serious questions which warrant immediate answers:

- **At the given rate of insignificant and no flow (or transport of sediments in the rivers), at the given rate of sea-level rise and at the given rate of shoreline changes what will happen to deltas? Will they survive or will be sunk?**
- **What will happen to the people who depend upon deltas for their livelihoods?**
- **Millions who depended upon groundwater for drinking, agriculture and other uses will be very badly hit. Are there alternative sources of water for affected population?**
- **What will happen to the food security of nations?**
- **What will be the repercussion on the local / coastal ecology?**
- **Most important of all, do governments (Centre and the State) have an adaptation strategy for restoring livelihoods of people who depended upon deltas for millennia?**

Pollution load in the basin and Delta

All the major tributaries of Cauvery are polluted

- Bhavani
- Noyyal
- Amaravathi
- Kodaganar
- Kalingarayan canal (not tributary)

Biggest sources of in the surface water are industrial effluent, domestic sewage, dumping of the solid and bio-medical waste and building debris

Number of small, medium and large Industries located in various towns falling under the Cauvery basin 2014-15

Sl No	Name of the town	Name of the sub-basin /tributary of Cauvery	Number of industries
1	Tiruppr	Noyyal	3230
2	Erode	Bhavani	1225
3	Salem	Cauvery main	2015
4	Perundurai	Bahavani and Cauvery join	989
5	Karur	Amaravvathi	1270
6	Namakkkal	Cauvery main	1378
7	Dindigul	Kodaganaru	1364
8	Tiruchi	Cauvery main	1120
9	Thanjavur	Cauvery main	624
10	Nagapptinam	Cauvery main	897

Source: Annual Report, 2014-15, Tamil Nadu Pollution Control Board, Government of Tamil Nadu

River Bhavani, The tributary of river Cauvery

“Increasing threat: Untreated effluent discharged by the textile processing and tannery units flow in a water carrying channel in Erode”. — PHOTO:M.GOVARTHAN

Source: The Hindu, Erode, Aug 29, 20111

“Effluent from Nanajarayan irrigation tank in Tirupur flowing through one of the canals that supply water for irrigation”.

Source: Tiruppur, Feb 11, 2014

“Effluents being discharged into River Cauvery at Pallipalayam.— Photo: M. K. Ananth”

Source: The Hindu, Namakkal, June 7, 2013

Inventory of Industries in Tamil Nadu (January 2002)

Category	Inventory									
	Large			Medium			Small			Total
	Red	Orange	Green	Red	Orange	Green	Red	Orange	Green	
Coastal Districts Total	401	131	35	441	518	274	2740	3259	708	8507
Non-Coastal Districts Total	312	361	19	429	1065	73	5521	6097	324	14201
State Total	**713**	**492**	**54**	**870**	**1583**	**347**	**8261**	**9356**	**1032**	**22708**

Source: TNPCB

The menace of Sand mining

Serious ecological impacts

Complete loss of base flow

In many areas, people have do not even drinking water from the riverbed aquifers

Summing up

The immediate action is needed not only to protect farmers' livelihoods but also to ensure food security

Most important, the ecosystem damages will be irretrievable if not attended to immediately

Do we have a plan ofaction?

Do our governments know about these perils being confronted by the basin / delta farmers?

Thank you