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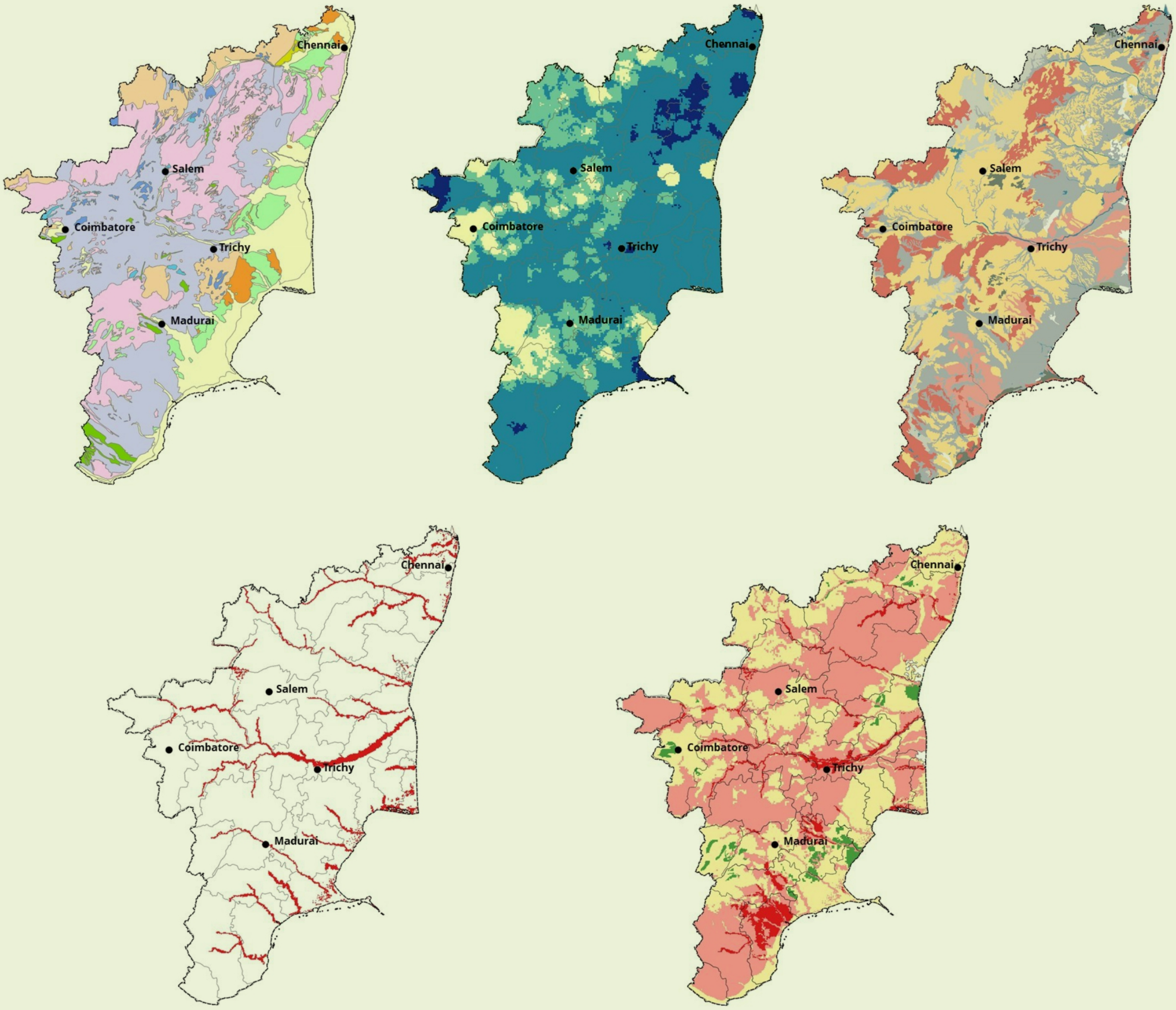
TAMIL NADU URBAN SANITATION SUPPORT PROGRAMME

REPORT

SUITABILITY OF ON-SITE SANITATION SYSTEMS ACROSS TAMIL NADU

February 2018



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Suitability of On-site Sanitation Systems across Tamil Nadu

February 2018

For Citation: TNUSSP, 2018. Suitability of On-site Sanitation Systems across Tamil Nadu.

DOI: https://doi.org/10.24943/tnusspsos.20180201

This document is produced as part of Tamil Nadu Urban Sanitation Support Programme (TNUSSP). TNUSSP supports the Government of Tamil Nadu (GoTN) and cities in making improvements along the entire urban sanitation chain. The TNUSSP is being implemented by a consortium of organisations led by the Indian Institute for Human Settlements (IIHS), in association with CDD Society, Gramalaya, and Keystone Foundation.

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2. BMGF funding acknowledgement: This Research / Work was supported by Bill & Melinda Gates Foundation.

3. Acknowledgement: We thank Public Works Department, GoTN, Tamil Nadu Water and Drainage Board and Central Ground Water Board for providing data on groundwater. We also thank National Bureau of Survey and Land Use Planning, Regional Centre Bangalore for providing data on soil.

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Abbreviations

CGWB	Central Ground Water Board
GoTN	Government of Tamil Nadu
NBSS & LUP	National Bureau of Soil Survey and Land Use Planning
OSS	On-site Sanitation Systems
PWD	Public Works Department
TNUSSP	Tamil Nadu Urban Sanitation Support Programme
TSU	Technical Support Unit
TWAD	Tamil Nadu Water Supply and Drainage Board
ULB	Urban Local Bodies

Executive Summary

Executive Summary

On-site sanitation systems (OSS) remain the dominant household arrangement across the state of Tamil Nadu for urban sanitation. According to the 2011 census 44 per cent of urban households in the state depend on OSS. These on-site systems are presently spread across the state in different hydrogeological conditions. In order to understand the conditions of suitability for OSS like septic tanks, single and twin pits in different hydrogeological conditions, there is a need to look at factors like aquifer systems, soil drainage characteristics, groundwater levels and flood hazard areas based on which safe and appropriate OSS systems can be set up.

The Government of Tamil Nadu (GoTN) is committed to improving urban sanitation and aims at scaling up access to safe and sustainable sanitation to all its urban areas in the next five years. A Technical Support Unit (TSU) has been set up under the Tamil Nadu Urban Sanitation Support Programme (TNUSSP) to assist GoTN achieve its objective. A study on groundwater risk zone mapping was conducted by the TSU to create a spatial map representing the areas suitable for the construction of OSSs. The approach followed the conversion of collected data on aquifer systems, soil drainage characteristics, groundwater levels and flood hazard areas onto a 1km x 1km raster file such that the weights of each 1km x 1km grid can be easily added to create a final interpolated map for the entire state using the universal kriging method. Scores ranging from 2 to 30 were given based on certain levels of suitability, and accordingly a final map was prepared representing areas that fall under very low, low, moderate and high suitability conditions to have safe OSS.

The areas with very low suitability were either flood prone and/or had poorly draining soils along with unsuitable aquifer type and high groundwater levels. The areas near river bodies mostly fell under this category. Areas under the low suitability category were either flood prone or had poor soil drainage or unsuitable aquifer type and groundwater levels. The next level of moderate suitability areas were neither flood prone nor did they have poor soil drainage but had moderately suitable aquifer and groundwater conditions. It was found that the majority of the regions in the state fell under the low and moderate suitability areas. Finally, the high suitability areas were those which were neither flood prone nor had poor soil drainage and had very suitable aquifer and groundwater conditions. However, very few areas in the state fell under this category. The on-site sanitation suitability map can be further used to categorise urban local bodies (ULBs) into different groups based on their aggregate suitability and to plan for intervention to set up safe OSS.

Key Spatial Data

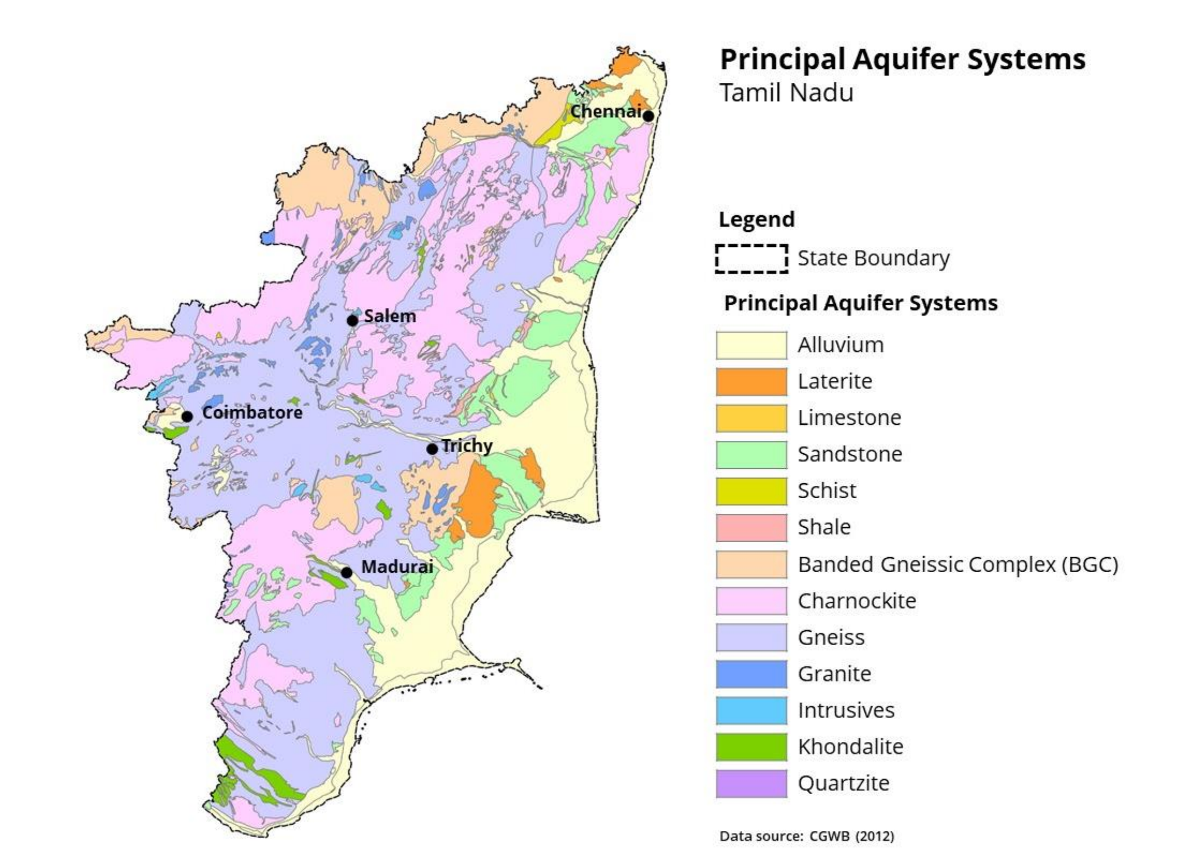
1. Key Spatial Data

Given the prevalence of on-site sanitation systems (OSS) in Indian cities, it is important to understand whether environmental conditions may render such systems inappropriate in some areas. This analysis uses four data layers to categorise areas of the state as either conducive or not to OSS. Using a suitability analysis approach, the datasets were given weights which were aggregated to evaluate whether OSS systems were appropriate for a location or not. Higher weights indicate conditions which present greater constraints (greater unsuitability) for OSS systems. The note below gives a brief description of the datasets used and the rationale behind the analysis performed using them.

1.1. Aquifer Characteristics

Data on principal aquifer systems of Tamil Nadu was obtained from the report titled Aquifer Systems of Tamil Nadu and Puducherry prepared by the Central Ground Water Board (CGWB). The scale of the map is 1:250,000. This map is in vector .pdf format. The map layers were auto extracted using the CorelDRAW software. Further, the polygons are topologically corrected and spatially adjusted to obtain positional accuracy and to create a shapefile using GIS (geographic information system) software. While the report identifies 13 principal aquifer systems in the state (Figure 1.1**)**, for ease of analysis these were grouped into three categories as shown in Figure 1.2.

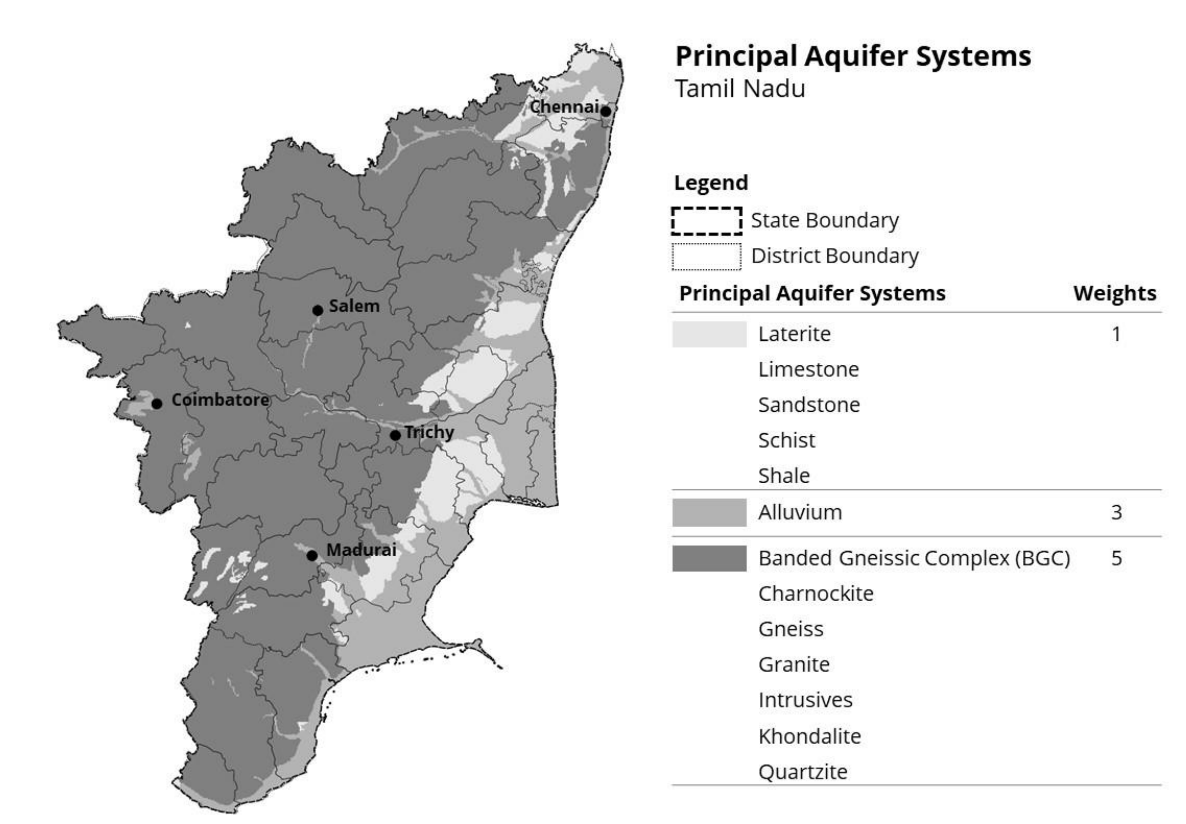
Figure 1.1: **Principal aquifer systems in Tamil Nadu**



Source: Central Ground Water Board (CGWB), 2012

The grouping was based on the primary porosity of the aquifers and the extent to which wastewater from OSS may get filtered in the vadose zone. The assumption here is that crystalline aquifers which have limited primary porosity may not contribute much to pollutant removal in comparison to aquifers with higher primary porosity. Aquifer types which have limited primary porosity are given a higher weight since there is a greater chance of groundwater contamination from OSS (Figure 1.2).

Figure 1.2: **Principal aquifer systems and its weightage**



Source: Based on IIHS analysis, 2018

Therefore, the first group (weight: 1) consists of sedimentary and metamorphic rocks (consolidated formations) which have the highest potential for filtration of groundwater, while the third group (weight: 5) consists of crystalline rock formations in which the water may flow mostly through fractures, and hence be filtered only to a very limited extent. The alluvial formations form the middle category (weight: 3) since the filtration potential may be between the consolidated aquifers and crystalline rock formations.

1.2. Soil Drainage Characteristics

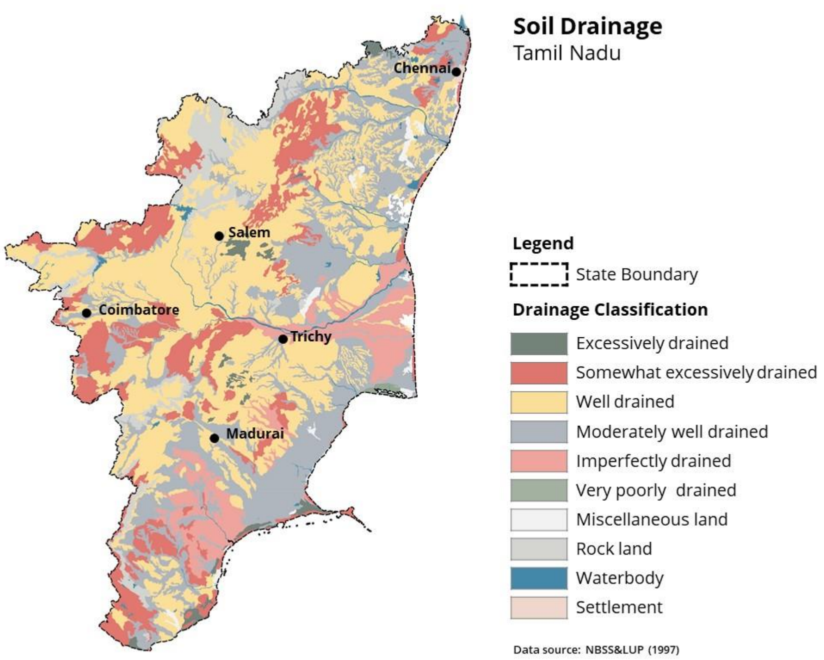
The soil resource inventory and maps were prepared by the National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) in September 1997 to estimate the potential and problem for agricultural activity. This systematic soil resource inventory was initially created at a scale of 1:250,000; and for the purpose of publication, it was reduced to 1:500,000 without any generalisation to condense the information for easy reference.

Of the important soil properties: texture, depth, drainage, calcareousness, mineralogy, available water capacity, and soil drainage - the flow of water through the soil to underground storage- the last one is relevant to the present study.

A soil drainage map was prepared based on morphology of the soil, texture and slope. According to NBSS & LUP, soil drainage is the rate of removal of added water (rainfall) from the soil both by flow through the soil to underground storage and by runoff. The soil map with scale 1:500,000 covering the entire state was spread across four sheets. The four scanned images are mosaic and geo-referenced using GIS software. This map was manually digitised to extract the major soil classes. Further, the soil drainage map was imported to the GIS platform and sub classes were extracted. Topology error correction was also done using the topology tool in the geo-database to create an error-free shapefile. Finally, classes of soil drainage were populated to extracted polygons.

The original dataset identifies six classes of soil drainage along with four other land-cover classes (Figure 1.3). These soil classes have been delineated from the perspective of agricultural suitability of various soils. As far as OSS are concerned only 'Imperfectly Drained' and 'Very Poorly Drained' classes are assumed to be a cause for concern, since in these classes it is possible that OSS systems may not work properly due to poor soil drainage characteristics. All other soil classes ranging from 'Excessively Drained' to 'Moderately Well Drained' are assumed to pose no risk as far as OSS are concerned.

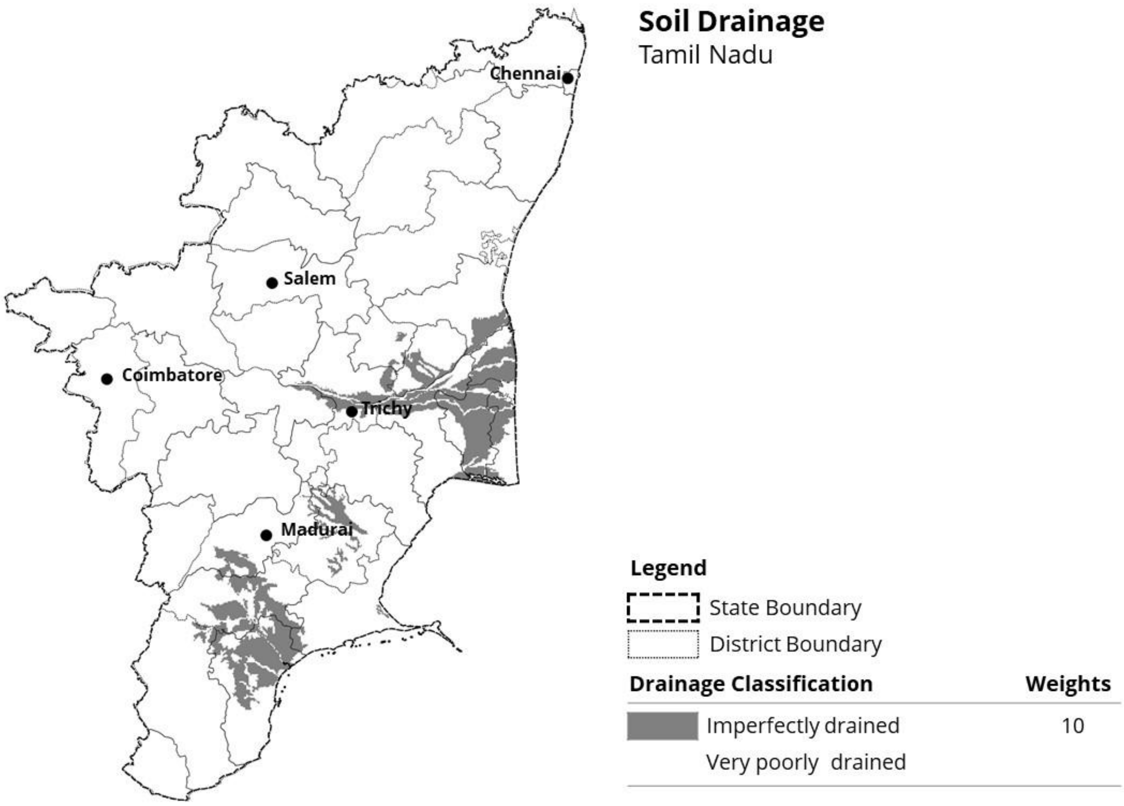
Figure 1.3: **Soil drainage in Tamil Nadu**



Source: National Bureau of Soil Survey and Land Use Planning, 1997

The 'Imperfectly Drained' and 'Very Poorly Drained' classes were assigned a weight of 10 since it was assumed that OSS like ordinary leach pits and septic tanks will not work in these conditions (Figure 1.4). All other classes had a weight of zero since it was assumed that they posed no problems for OSS.

Figure 1.4: **Soil drainage and its weightage**



Source: Based on IIHS analysis, 2018

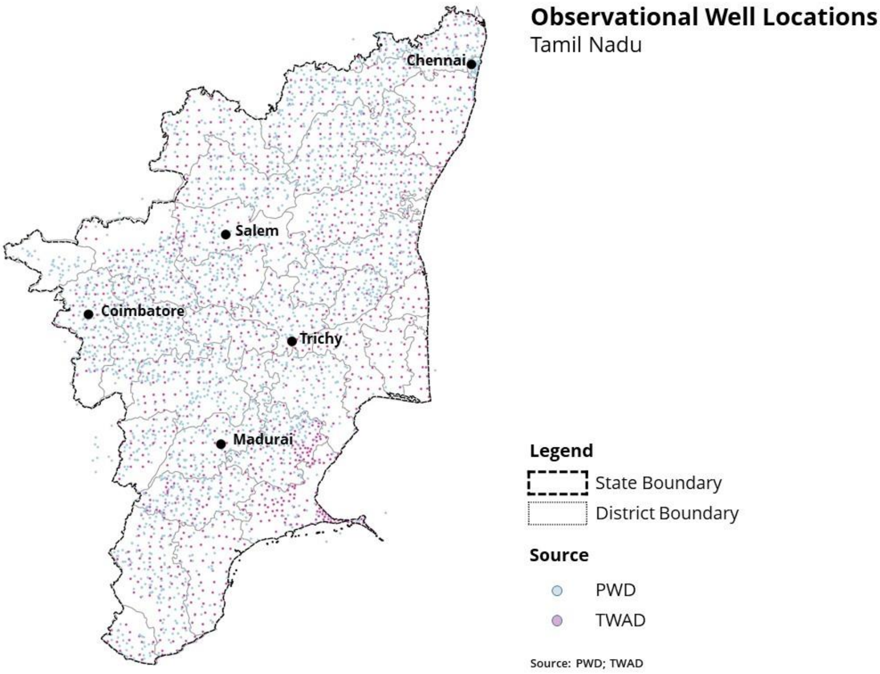
1.3. Groundwater Levels

Groundwater level data was collected from Tamil Nadu Water Supply and Drainage Board (TWAD) and Tamil Nadu Public Works Department (PWD). Both datasets have the same groundwater depth measurement unit, that is, metre below ground level (mbgl).

The groundwater data collected from TWAD is in the form of an excel sheet and a shapefile. The excel sheet has groundwater depth data from 1,286 observation wells and the shapefile contains the location of the observation wells. The groundwater depth data provides the monthly average for two months in a year, which is the post-monsoon month of January and pre-monsoon month of May. Most of the state receives maximum rainfall in the northeast monsoon season from October to December.

Groundwater data collected from the PWD is in the form of a Microsoft Access 2003 database (.mdb file). The monthly mean data was collected for 12 months from 2010 to 2015. This database contains details for 32 districts in separate files with two accessible sheets: one has details about ground water depth, and the second, contains details about observation well locations and latitudes and longitudes. The data from 32 districts was exported to an excel file and was collated. Further, the data was cleaned and converted to a shapefile. The shapefile contains 3,246 well point observations. Both data sets have been merged to create a single dataset. Figure 1.5 shows the locations of the observation wells of both TWAD and PWD.

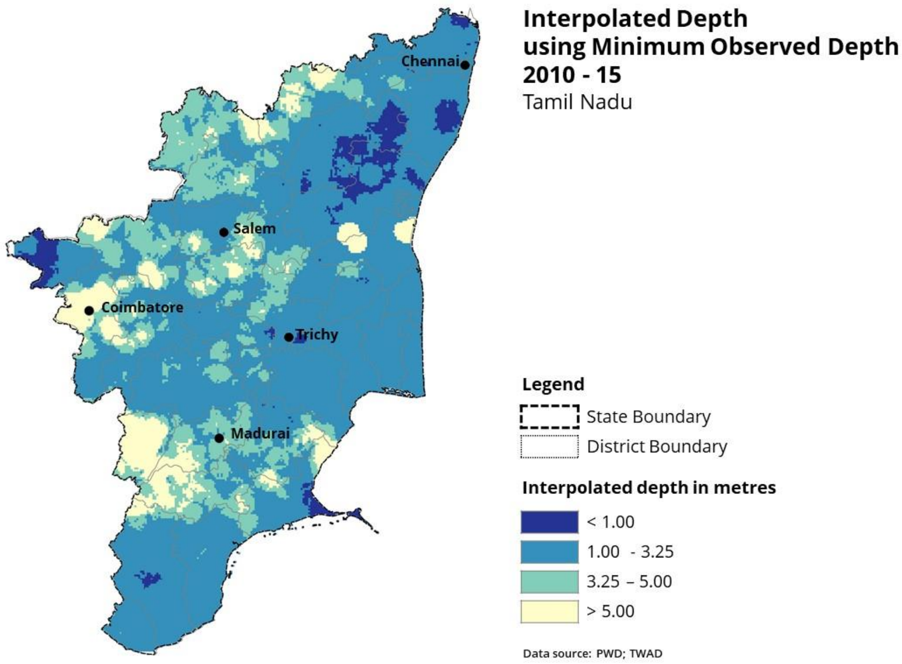
Figure 1.5: **Observational well locations in Tamil Nadu**



Source: Tamil Nadu Water Supply and Drainage Board, 2017 and Public Work Department, 2017

Since high groundwater tables can lead to poor functioning of OSS, our objective here was to identify the highest groundwater levels seen during the period for which data was available. Therefore, the highest water table observations available were extracted and then used to create an interpolated map for the entire state using universal kriging (Figure 1.6).

Figure 1.6: Interpolated depth using minimum observed depth 2010-2015 in Tamil Nadu



Source: Based on IIHS analysis, 2018

The groundwater classes were created based on existing standards for OSS. These are standards are specific to leach pits and septic tanks with effluent disposal systems. This information was used to categorise depth to groundwater table (DTGWT) variable for better visualisation of ambient conditions.

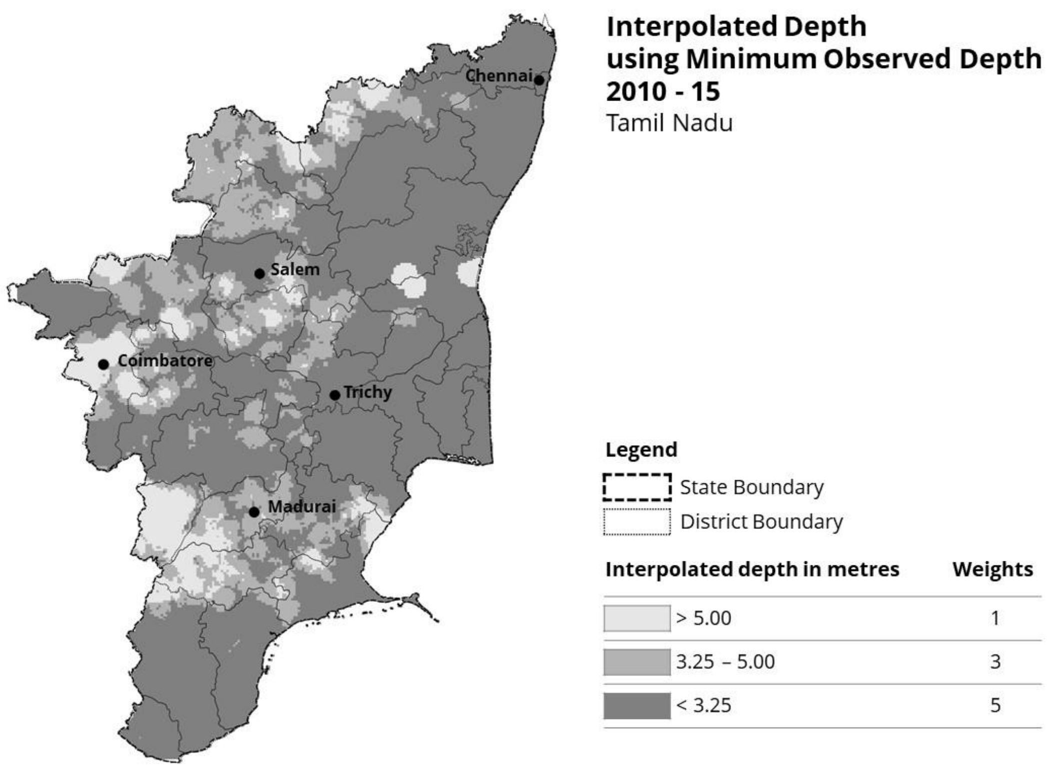
Table 1.1: Recommended OSS for different groundwater depths

Sl. No.	Ambient condition	Systems/ Design recommendations
01	DTGWT ≥ x + 2.0 m; x being the depth of leach pit	Bottom sealing and sand envelope for the leach pit is not needed
02	DTGWT < x + 2.0 m	Bottom sealing and varying degree of sand envelope is needed
03	DTGWT < 1.8 m	For septic tanks with effluent disposal systems: dispersion trench or biological filter is required, depending on soil type
04	DTGWT > 1.8 m	For septic tanks with effluent disposal systems: seepage pit is recommended for porous soil; for other soils, dispersion trench or biological filter is recommended

Source: 1. IS 12314, 1987; 2. IS 2470-2, 1985.

Weights were assigned such that the highest groundwater category had the highest weight since it is assumed that higher groundwater levels pose greater risk for OSS (Figure 1.7).

Figure 1.7: **Interpolated depth to groundwater table and its weightage**

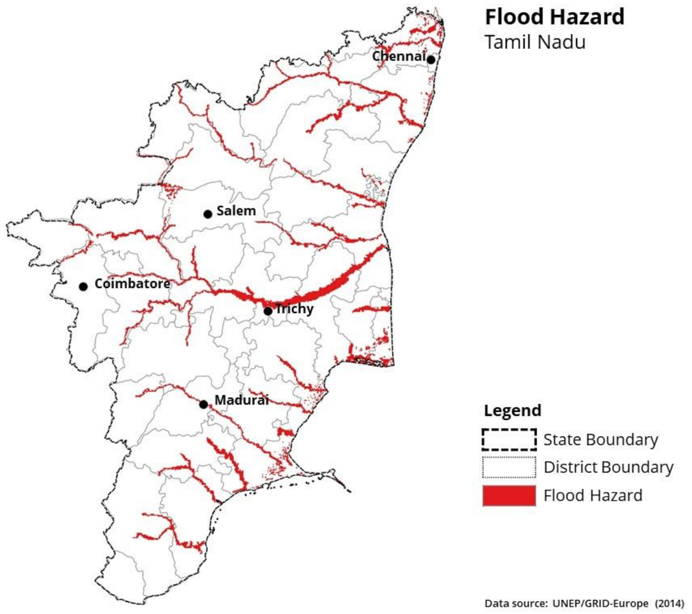


Source: Based on IIHS analysis, 2018

1.4. Flood Hazard

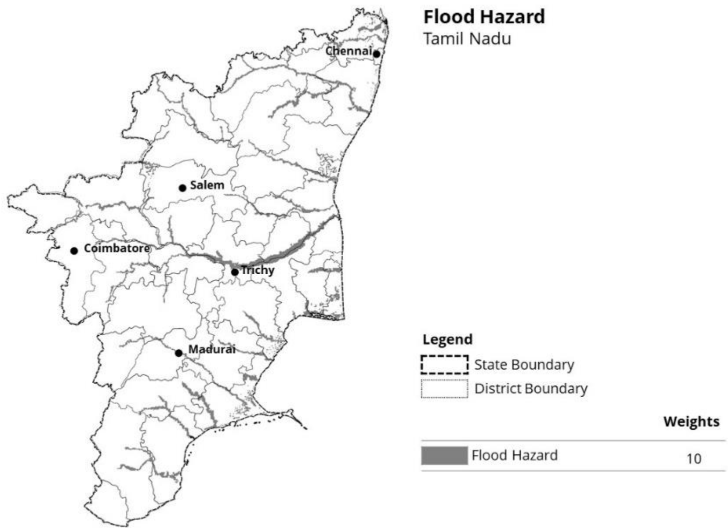
Flooding and resulting water logging can also disrupt the functioning of OSS. Therefore, the flood hazard map[1] (UNEP, 2013) was used as an additional layer in our analysis (Figure 5.1). Areas which are exposed to flood hazards were given a weight of 10, while all other areas were given a weight of zero in this layer (Figure 1.8).

Figure 1.8: **Flood hazard in Tamil Nadu**



Source: UNEP flood hazard map

Figure 1.9: **Flood hazard and its weightage**



Source: Based on IIHS analysis, 2018

[1] The UNEP fluvial flood hazard map was developed using GIS based hydrological model, observed flood from 1999 to 2007 obtained from the Dartmouth Flood Observatory (DFO) and UNEP/GRID-Europe PREVIEW flood dataset.

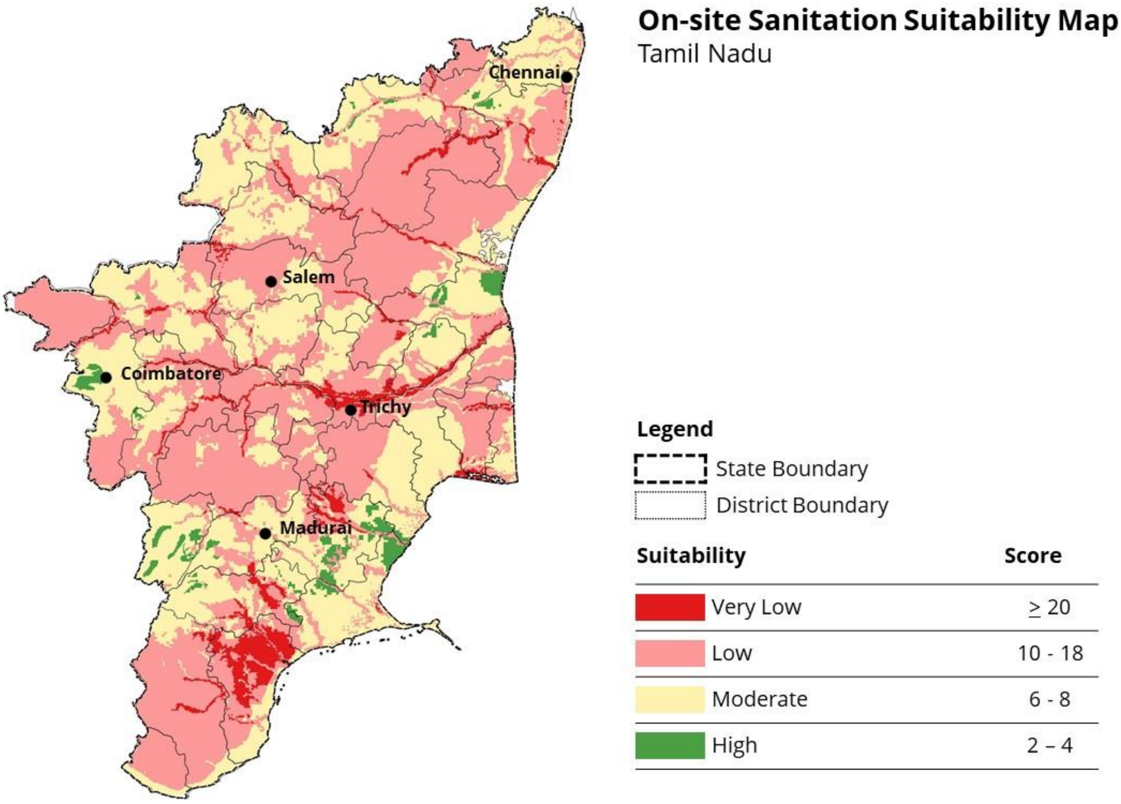
2

Suitability of on-site sanitation systems for Tamil Nadu

2. Suitability of on-site sanitation systems for Tamil Nadu

All four data layers were converted into 1km X 1km raster files such that the weights of each 1km X 1km grid can be easily added together to create the aggregate map (Figure 2.1). This final map was classified into four categories of suitability as shown in Figure 2.1. Lower aggregate scores indicate greater suitability of OSS systems.

Figure 2.1: **On-site sanitation suitability map**



Source: Based on IIHS analysis, 2018

The rationale for this classification is as follows:
Given the weights that were used, the final aggregate score of any 1km X 1km cell can only be an even number. A final score of 2 can be attained only if the given cell has the lowest weights (weight of 1) in the aquifer characteristics and groundwater level datasets, and if it is not constrained in terms of flood hazards or soil drainage. A final score of 4 can be attained if the given cell has weights of either 1 or 3 in both aquifer characteristics and groundwater level datasets. Again, this means that the cell is not flood prone, nor does it have poor soil drainage. The cells with aggregate scores of 2 and 4 therefore form the areas which come under the category of 'high suitability'.

Final scores of 6 or 8 means that while the cell is neither flood prone nor has poor soil drainage, it may have weights of 3 and 3, 5 and 1, 1 and 5, 3 and 5 or 5 and 3 as far as aquifer characteristics and groundwater levels are concerned. Cells which have these score combinations come under the category of 'moderate suitability'.

An aggregate score of 10 indicates that while such a cell is neither flood prone nor has poor soil drainage, it has a weight of 5 (most constrained) for both aquifer characteristics and groundwater level. On the other hand, final scores of 12, 14, 16 or 18 are possible only if the cells are either flood prone or have poor soil drainage. Therefore, scores from 10 to 18 are classified as 'low suitability'.

An aggregate score of 20 indicates that such a cell is either flood prone or has poor soil drainage along with a weight of 5 (most constrained) for both aquifer characteristics and groundwater level. Scores of 22 and above indicate that the cells are both flood prone and have poor soil drainage. The maximum score possible is 30 when the following conditions are met: a given cell has a weight of 5 (most constrained) for both aquifer characteristics and groundwater level; is flood prone; and has poor soil drainage. Therefore, cells with a final score of 20 or above are classified as 'very low suitability'. The classification and weights are summarised in Table 2.1.

The number or percentage of cells within a ULB under each suitability class can be calculated based on the final raster suitability map shown in Figure 2.1. Using this information, ULBs can be categorised into different groups based on their aggregate suitability.

Table 2.1: **Weights assigned for different classes of aquifer systems, soil drainage, groundwater level and flood hazard**

No	Dataset used	Weightage
I	**Principal aquifer systems**	
1	Laterite	1
2	Limestone	1
3	Sandstone	1
4	Schist	1
5	Shale	1
6	Alluvium	3
7	Banded Genissic Complex (BGC)	5
8	Charnockite	5
9	Gneiss	5
10	Granite	5
11	Intrusives	5
12	Khondalite	5
13	Quartzite	5
II	**Soil drainage**	
1	Excessively drained	0
2	somewhat excessively drained	0
3	Well drained	0
4	Moderately well drained	0
5	Imperfectly drained	10
6	Very poorly drained	10
7	Miscellaneous land	0
8	Rock land	0
9	Water body	0
10	Settlement	0
III	**Groundwater level (Interpolated Depth in m)**	
1	< 3.25	5
2	3.25 - 5	3
3	> 5	1
IV	**Flood**	
1	No flood hazard	0
2	Flood hazard	10

Principal aquifer systems (Weights)	Soil drainage (Weights)	Groundwater level (Interpolated Depth in m) (Weights)	Flood (Weights)	On-site sanitation suitability scores	OSS suitability
1	0	1	0	2	High
1	0	3	0	4	High
3	0	1	0	4	High
1	0	5	0	6	Moderate
3	0	3	0	6	Moderate
5	0	1	0	6	Moderate
3	0	5	0	8	Moderate
5	0	3	0	8	Moderate
5	0	5	0	10	Low
1	0	1	10	12	Low
1	10	1	0	12	Low
1	0	3	10	14	Low
1	10	3	0	14	Low
3	0	1	10	14	Low
3	10	1	0	14	Low
1	0	5	10	16	Low
1	10	5	0	16	Low
3	0	3	10	16	Low
3	10	3	0	16	Low
5	0	1	10	16	Low
5	10	1	0	16	Low
3	0	5	10	18	Low
3	10	5	0	18	Low
5	0	3	10	18	Low
5	10	3	0	18	Low
5	0	5	10	20	Very low
5	10	5	0	20	Very low
1	10	1	10	22	Very low
1	10	3	10	24	Very low
3	10	1	10	24	Very low
1	10	5	10	26	Very low
3	10	3	10	26	Very low
5	10	1	10	26	Very low
3	10	5	10	28	Very low
5	10	3	10	28	Very low
5	10	5	10	30	Very low

Source: Based on IIHS analysis, 2018

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TN TAMIL NADU | US URBAN SANITATION | SP SUPPORT PROGRAMME

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