# The Soil Survey and Land Use Planning of Puducherry Region of Union Territory of Puducherry by Soil Profile Analysis Model using Soft Computing Approaches

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**Abstract**

In developing countries, hunger is forcing people to cultivate land that is unsuitable for agriculture and which can only be converted to agricultural use through enormous efforts and costs. Due to lack of plant growth information and expert advice, most of the farmers fail to get good yields. The growth of the plant depends upon multiple factors such as soil type, crop type and weather. This research paper proposes a novel Soil Profile Analysis Model to Characterize Soil Profile using Soft Computing approaches like Rough Set approaches, Principal Component Analysis, Clustering or Classification methods and derived patterns characterized or evaluated and presented in various forms like visualized diagrams, generalized relations or in rule forms called characteristic rules. The process involves cleaning or preprocessing from Soil Profile databases, reducing data from a Soil Profile data by Rough Set approaches Fuzzy, Genetic based Hybrid methods to produce a pattern or knowledge, and then evaluating the derived pattern. The benefits of a greater understanding of soil pattern could improve productivity in farming, to maintaining biodiversity, to reduce reliance on fertilizers and create a better integrated soil management system for both private and public sectors. A case study is done on Soil Profile of Puducherry Region which derives a good number of rules for farming society.

***Keywords:*** *Fuzzy Logic, Genetic, Hybrid, Reduction, Rough Set, Soil Profile, Soil Texture.*

## 1. Introduction

The Soil Survey and Land Use Planning of Puducherry Region of Union Territory of Puducherry by Soil Profile Analysis Model using Soft Computing Approaches carried out by this research paper. Soil is our most precious resource. Maintaining the soil in a state of high productivity on a sustainable basis is important. It is particularly important in a country like India which is largely dependent on agriculture. During the past few decades we made significant strides to achieve self-sufficiency in food grains production. In order to meet the ever-increasing food requirement for the growing population and to maintain the quality of the environments we live in, it is essential that the soil and water resources are used rationally and in a way which does not affect the productivity but to leave a better heritage for the posterity [1, 9].

A knowledge of soils in respect of their extent, characteristics, and potential is, extremely important for optimizing usage of land [10]. This paper serve as a charter of soils of the Puducherry Region of Union Territory Puducherry giving problems and potentials for optimizing land use. Soil survey of the Union Territory of Puducherry (Puducherry Region) covering an area according to village papers, was carried out as a part of work - Soil Resource Inventory of the States [2].

## 2. Location and Extent of Union Territory of Puducherry

The Union Territory of Puducherry consists of four regions namely, Puducherry, Karaikal, Mahe and Yanam in the Indian Union with an area of 492 sq.km according to the records of Survery of India. The four regions are not geographically contiguous. The Puducherry and Karaikal Regions are situated on the East Coast adjoining Cuddalore, Villupuram and Nagapattinam districts respectively of Tamil Nadu, Mahe is situated on the West Coast adjoining Kerala, and Yanam lies on the East Coast adjoining Andhra Pradesh.

This work deals with Puducherry Region only. Puducherry Region is situated on the Coromondel Coast. It covers an area of 29377 ha according village revenue records, and consists of 179 villages. The region is divided into 7 communes, viz., Puducherry, Ariankuppam, Ozhukarai, Mannadipet, Villianur, Bahour and Nettapakkam. The Communes are not contiguous and are interspersed with parts of Tamil Nadu (Fig. 1).

## 3. Physiography and Soils of Puducherry Region

In Puducherry Region, 700 objects were studied and object simulated to 12000 Nos. for suitable processing. The soil map prepared for the Puducherry Region are tabulated [2] in Table 1. This table give the relationship between soil and physiography in each unit in the Region. The soils of Puducherry Region occur on different physiographic units such as uplands, lowlands, floodplains, tank valleys, beaches, creeks and lagoons and sandy plain/coastal dunes. A close relationship between physiography and soils in the Region in the evident. Fifteen soil series along with miscellaneous land types and gullied land were identified in Puducherry Region. Eight soil series associations, four consociations of soil series, and one miscellaneous land type have been mapped in Puducherry Region.

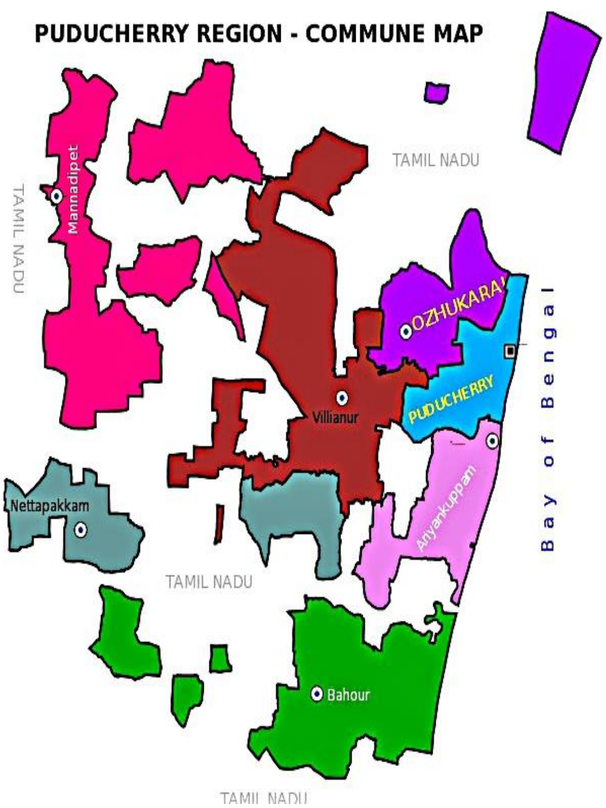


Fig.1. Puducherry Region-Commune Map

Table 1: Physiography and Soils, Puducherry Region

| Unit No. | Mapping Unit | Soil series association and their description |
|---|---|---|
| 1. | Sandstone Landscape: Gently sloping upland, eroded | **Gorimedu:** Very deep, moderately Well drained, brown loamy sand, sandy loam to clay loam, slightly acid surface soil, and dark red, sandy clay loam to sandy clay, medium acid subsoil with argillic horizon; 3 to 5 % slope; moderately eroded. **Kalapet:** Very deep, well drained, Dark brown neutral, sandy loam surface soil, and dark red, sandy loam to sandy clay loam, neutral to mildly alkaline subsoil with argillic horizon; 3 to 5% slope; moderately eroded. |
| 2. | Sandstone Landscape: Gently sloping upland | **Ayyankuttipalayam**: Very deep, moderately well drained, dark red, sandy clay loam, strongly acid surface soil, and dark red and gravelly sandy clay to sandy clay loam; strongly acid subsoil with argillic horizon; 40-60% rounded quartz pebbles; 3 to 5% slope; moderately to severely eroded. |
| 3. | Limestone Landscape: Gently sloping upland | **Sedarpet:**Very deep, moderately well drained, dark yellowish brown, clay, moderately alkaline, cracking surface soil, and dark greyish brown, clay, strongly alkaline subsoil with cambic horizon; 1 to 3 % slope; slightly to moderately eroded. **Tuthipet:**Shallow to moderately deep, moderately well drained, very dark greyish brown, sandy clay, moderately alkaline surface soil, and dark yellowish brown, sandy clay loam, moderately alkaline subsoil; 1-3% slope; moderately eroded. |
| 4. | Limestone Landscape: Lowland | **Kuppam:** Very deep, imperfectly drained, dark brown, clay loam, moderately alkaline, cracking surface soil, and dark brown, clay, very strongly alkaline, cracking subsoil with intersecting slickensides; 1-2% slope; slightly eroded. |
| 5. | Fluvial Landscape: Very recent floodplain | **Gingee:** Deep, excessively drained, brown sand, mildly alkaline surface soil, and brown to dark yellowish brown, loamy sand, strongly alkaline subsoil, 1 to 3% slope; slightly eroded. **Penniar:** Very deep, moderately well drained, yellowish brown, loamy sand, moderately alkaline surface soil, and sandy clay loam, dark brown to dark reddish brown mildly |

| | | |
|---|---|---|
| | | alkaline sandy loam subsoil with cambic horizon; 1 to 2% slope; slightly eroded. |
| 6. | Fluvial Landscape: Recent floodplain | **Sanyasikuppam:** Deep, moderately well drained, dark brown, sandy loam, strongly alkaline surface soil, and brown, sandy clay loam, strongly alkaline and sandy loam subsoil with cambic horizon and 5 to 15%, 2 to 5mm iron-manganese concretions, underlain by dark yellowish brown, strongly alkaline sand; 1 to 3% slope; slightly eroded. **Puducherry:** Very deep, well drained, brown sand, mildly alkaline surface soil, and brown and dark brown, sandy loam to sandy clay loam, moderately alkaline subsoil with cambic horizon and 2 to 5%, 2 to 3mm iron-manganese concretions, underlain by brown, strongly alkaline sand; 1 to 3% slope; slightly eroded. |
| 7. | Fluvial Landscape: Old floodplain | **Mannadipet:** Very deep, moderately well drained, very dark greyish brown, clay loam moderately alkaline, cracking surface soil, and dark brown, sandy clay loam to clay, moderately alkaline subsoil with pressure faces and cambic horizon, underlain by very dark greyish brown and light brownish clay; 1 to 2% slope; slightly eroded. |
| 8. | Tank Valleys: Very gently sloping tank valley (small parcels) | **Bahour:** Very deep, imperfectly well drained, dark greyish brown, clay loam moderately alkaline, cracking surface soil, and dark greyish brown, clay loam to clay, strongly alkaline, cracking subsoil with cambic horizon with non-intersecting slickensides; 1 to 2% slope; slightly eroded. |
| 9. | Tank Valleys: Very gently sloping tank valley (medium parcels) | **Villianur:** Very deep, imperfectly drained to poorly drained, very dark greyish brown, clay, slightly alkaline, cracking subsurface soil, and very dark greyish brown, clay,slightly alkaline, cracking subsoil with intersecting slickensides; 1 to 2% slope; slightly eroded. |
| 10. | Tank Valleys: Very gently sloping tank valley (diffused parcels) | **Palayam:** Very deep, moderately well drained, dark yellowish brown, sandy clay loam to sandy clay, strongly alkaline subsoil with pressure faces and few, fine iron-manganese concretions; 1 to 3% slope; slightly eroded. |
| 11. | Marine Landscape: Beaches (Miscella-neous Land type) | **Beaches:** Sandy shore; the land is covered partly with water during high tides and stormy period. Does not support vegetation and has no agricultural value. |
| 12. | Marine Landscape: Creeks and Lagoons | **Manapattu:** Moderately deep, Imperfectly drained to poorly trained. Very dark greyish brown, sandy loam, moderately alkaline surface soil and dark greyish brown, sandy clay loam to clay, strongly alkaline, calcareous subsoil with cambic horizon; 1 to 2% slope; high water table. |
| 13. | Marine Landscape: Sandy plain/coastal dune | **Kottucherry:** Very deep, excessively drained, dark brown, sand, neutral surface soil, and brown to yellowish brown sand, neutral to mildly alkaline, subsoil; 2 to 5% slope; moderately eroded. |

## 4. Soil Survey Interpretations of Puducherry Region using Soil Profile Analysis Model

Soil Profile Interpretations of Puducherry Region using proposed Soil Profile Analysis Model form a very important part of the soil survey and mapping programme, since they help in making practical use of soils.

The Proposed model (Fig. 2) consists of cleaning or preprocessing from Soil Profile Databases, reducing data from a Soil Profile data by Rough Set approaches or PCA, applying a Clustering or Classification by k-Means, ANN, Fuzzy, Genetic based Hybrid methods to produce a Pattern or Knowledge, and then evaluating the derived pattern. The life cycle of a Soil Profile Analysis Model consists of six phases. The sequence of the phases can be changed. Moving back and forth between different phases is always required. It depends on the outcome of each phase, or which particular task of a phase, that has to be performed next.

### 4.1. High Dimensionality Data Reduction using Rough Set for Soil Profile Data

**Rough Set Advantages:**

Rough Set is one of the efficient reduction method. It Reduce all redundant objects and attributes and create models of the most representative objects in particular classes of decisions [8].

A rough set approach is used to discover classification rules through a process of knowledge induction which selects decision rules with a minimal set of features for classification of real valued data [8].

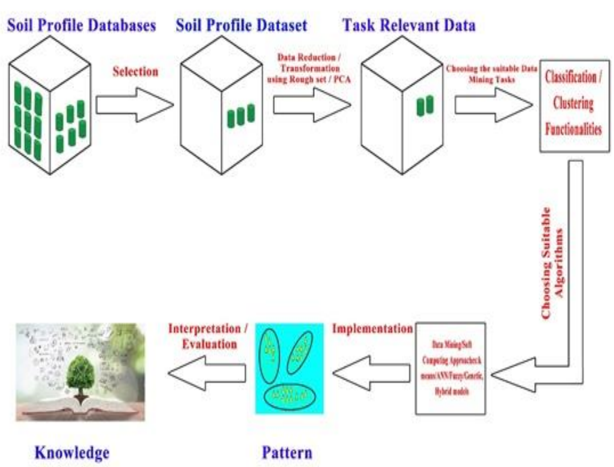


Fig.2. Soil Profile Analysis Model

A rough sets are used to approximately or "roughly" define equivalent classes [4].

In Information Table (Fig. 3) there are 11 attributes with 16384 objects are presented in Puducherry soil physio-chemical data set. Decision Table (Fig. 4) consists of both condition and decision attributes. Attribute D is used as decision attribute and the remaining 11 attributes are used as condition attributes. So decision table consists of 12 attributes with 16384 objects.

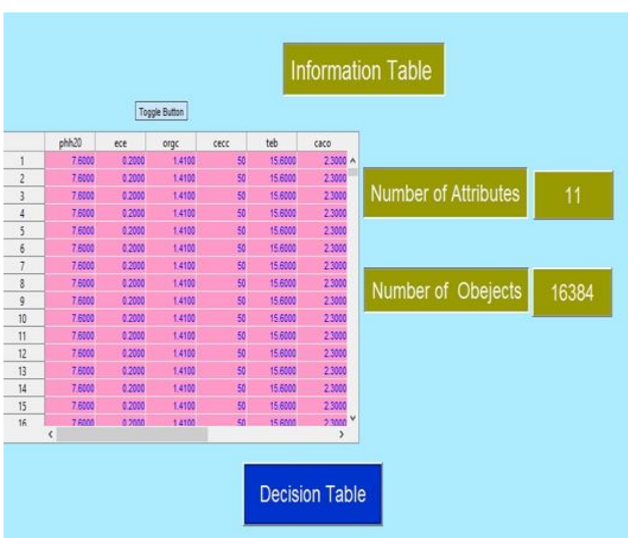


Fig. 3. Information Table


Fig. 4. Decision Table

According to IF-THEN rules, the decision attribute is added. Based on the attribute values including 7 chemical attributes and 4 physical attributes and there are 14 rules created (Fig.5). These attributes are having different values based on the condition attribute. So this condition attribute considered as output of each reduction process. Each condition have different Total Porosity value.

Equivalence classes plays a vital role in rough set approach to calculate the number of equivalence classes associated with attribute which is a great deal of rough set technique. The equivalence classes are also known as indiscernibility of attribute set. The complete reduction matrix tabulated in Fig. 6 for preparing the equivalence class of each attribute along with the minimum attributes are needed from the soil profile dataset consisting a total of 11 attributes.

All the equivalence class of each attribute of soil profile dataset is experimented with defined rules and the reductions are tabulated from Table 2 to Table 4. In each reduction table with unique fuzzy rule derived universe class of objects as mentioned in the dataset and the minimal subset of attributes as marked in the reduction matrix that enables the same classification of elements of the universe as the whole set of attributes in the soil profile dataset and all these reduction tables produced Table 5 to Table 14 for all major soil textural classes and also these tables tested and proved with USDA - Particle Size and Porosity Ranges for Sand, Silt and Clay, Relative % of Sand, Silt and Clay for Major Textural Classes and Total Porosity Value - pH ratio [11] to produce Task relevant dataset of Puducherry Region to Characterize Soil Profile using Soft Computing approaches.

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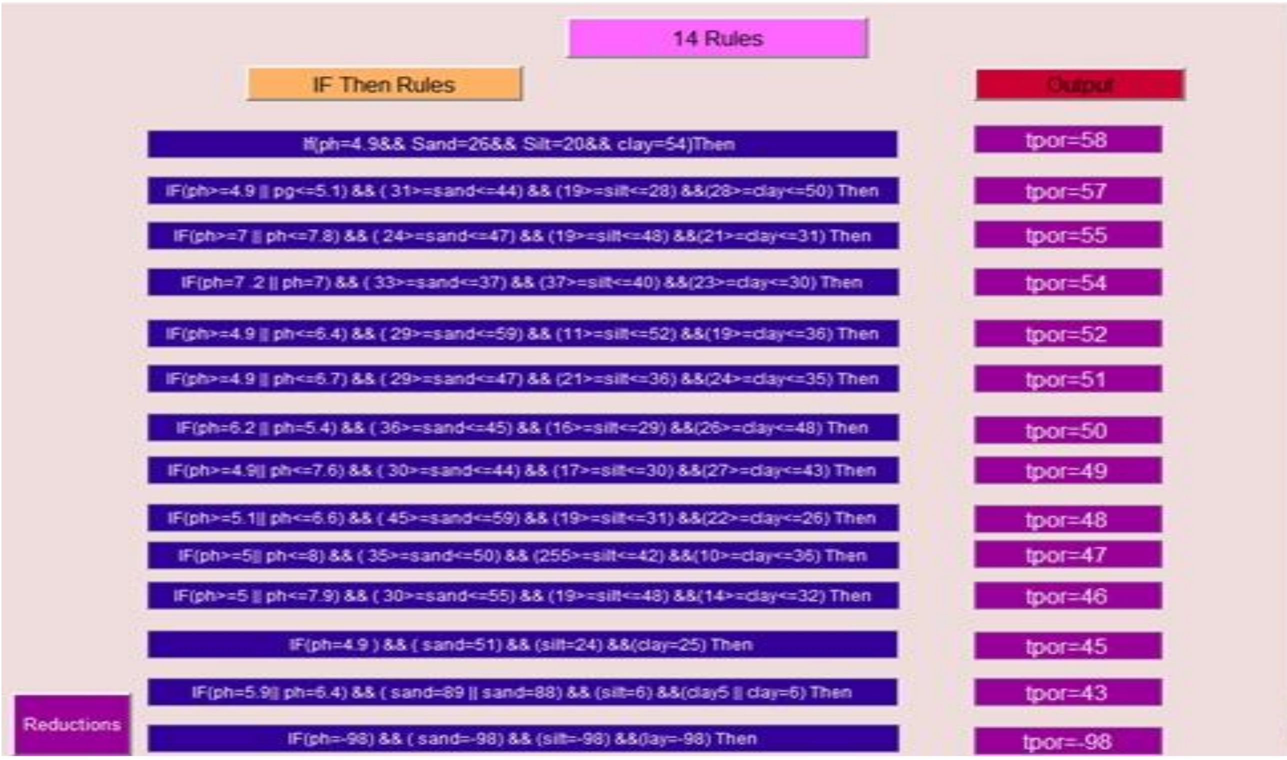


Fig. 5. Generated IF-THEN Rules

| Phh20 | ece | orgc | cecc | teb | caco | gyps | Sand | silt | clay | tpor | D | No.of attributes needed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| √ | X | √ | √ | √ | X | X | √ | √ | √ | √ | 2 | 8 |
| √ | √ | √ | √ | √ | √ | X | √ | √ | √ | √ | 3 | 10 |
| √ | X | √ | √ | √ | √ | X | √ | √ | √ | √ | 4 | 9 |
| √ | X | √ | √ | √ | X | X | √ | √ | √ | √ | 5 | 8 |
| √ | X | √ | √ | √ | X | √ | √ | √ | √ | √ | 6 | 9 |
| √ | X | √ | √ | √ | X | X | √ | √ | √ | √ | 7 | 8 |
| √ | √ | √ | √ | √ | √ | X | √ | √ | √ | √ | 8 | 10 |
| √ | X | √ | √ | √ | X | X | √ | √ | √ | √ | 9 | 8 |
| √ | √ | √ | √ | √ | √ | X | √ | √ | √ | √ | 11 | 10 |
| √ | X | √ | √ | √ | X | X | √ | √ | √ | √ | 12 | 8 |
| √ | √ | √ | √ | √ | X | X | X | √ | √ | √ | 13 | 8 |
| √ | X | √ | √ | √ | X | X | √ | √ | √ | √ | 1 | 8 |

Fig.6. Reduction Matrix with Minimum Attributes Needed

The set of task relevant data for data mining is called a minable view. This can be collected using relational query. Task relevant data may be i) Database ii) Database tables iii) Conditions for data selection iv) Relevant attributes or dimensions v) Data grouping criteria [6, 7].

In order to make some savings, only one element of the equivalence class is needed to represent the entire class. The other aspect in data reduction is to keep only those attributes that preserve the indiscernibility relation and, consequently, set approximation. There are usually several such subsets of attributes and those which are minimal are called reducts, which is described in Equation 1 [4].

IND (B) = IND (B) - a (Eq. 1)

where 'a' is indispensable in B [9].

Table 2: Reduction 1 Based on Rule 4

Rule 4: If (pH>=7.2 || pH <= 7) && (33 >=sand<=37) && (37 > silt <=40) && (23>=clay<=30) then Total Porosity=54

| Universe and Equivalent Classes | Objects |
|---|---|
| IND(B) | {1,303}, {304,423}, {424,517} |
| IND(B)-ece | {1,303}, {304,423}, {424,517} |
| IND(B)-gyps | {1,303}, {304,423}, {424,517} |

Table 3: Reduction 2 Based on Rule 6

Rule 6: If (pH>=4.9 || pH <= 6.7) && (29 >=sand<=47) && (21 > silt <=36) && (24>=clay<=35) then Total Porosity=51

| Universe and Equivalent Classes | Objects |
|---|---|
| IND(B) | {1,265}, {266,1135}, {1136,1196}, {1197,1348},{1349,1817},{1818,2229},{2230, 2302}, {2303,2310} |
| IND(B)-ece | {1,265}, {266,1135}, {1136,1196}, {1197,1348},{1349,1817},{1818,2229},{2230, 2302}, {2303,2310} |
| IND(B)-gyps | {1,265}, {266,1135}, {1136,1196}, {1197,1348},{1349,1817},{1818,2229},{2230, 2302}, {2303,2310} |

Table 4: Reduction 3 Based on Rule 7

Rule 7: If (pH>=6.2 || pH <= 5.4) && (36 >=sand<=45) && (16 > silt <=29) && (26>=clay<=48) then Total Porosity=50

| Universe and Equivalent Classes | Objects |
|---|---|
| IND(B) | {1,85}, {86, 257} |
| IND(B)-ece | {1,85}, {86, 257} |
| IND(B)-caco | {1,85}, {86, 257} |
| IND(B)-gyps | {1,85}, {86, 257} |

Table 5: Sand Profile

| % Ranges | Sand | Clay | Silt | Total Porosity | pH |
|---|---|---|---|---|---|
| Low | 86 | 1 | 1 | 25 | 5.8 |
| Average | 92.5 | 3 | 3 | 37.5 | 6 |
| Large | 99 | 5 | 5 | 50 | 7 |

Table 6: Silt Profile

| % Ranges | Sand | Clay | Silt | Total Porosity | pH |
|---|---|---|---|---|---|
| Low | 1 | 40 | 40 | 42.5 | 6.1 |
| Average | 10.5 | 50 | 50 | 44.5 | 6.3 |
| Large | 20 | 60 | 60 | 46.5 | 6.5 |

Table 7: Clay Profile

| % Ranges | Sand | Clay | Silt | Total Porosity | pH |
|---|---|---|---|---|---|
| Low | 1 | 40 | 1 | 33 | 6 |
| Average | 22.5 | 69.5 | 20 | 20 | 46.5 |
| Large | 44 | 99 | 39 | 60 | 7 |

Table 8: Loamy Sand Profile

| % Ranges | Sand | Clay | Silt | Total Porosity | pH |
|---|---|---|---|---|---|
| Low | 70 | 1 | 1 | 25 | 5.8 |
| Average | 80 | 3 | 3 | 37.5 | 6 |
| Large | 90 | 5 | 5 | 50 | 7 |

Table 9: Silty Clay Profile

| % Ranges | Sand | Clay | Silt | Total Porosity | pH |
|---|---|---|---|---|---|
| Low | 1 | 40 | 40 | 42.5 | 6.1 |
| Average | 10.5 | 50 | 50 | 44.5 | 6.3 |
| Large | 20 | 60 | 60 | 46.5 | 6.5 |

Table 10: Sandy Clay Profile

| % Ranges | Sand | Clay | Silt | Total Porosity | pH |
|---|---|---|---|---|---|
| Low | 45 | 20 | 1 | 37.5 | 6 |
| Average | 62 | 27.5 | 14.5 | 42 | 6.3 |
| Large | 79 | 35 | 28 | 46.5 | 6.5 |

Table 11: Clay Loam Profile

| % Ranges | Sand | Clay | Silt | Total Porosity | pH |
|---|---|---|---|---|---|
| Low | 20 | 27 | 15 | 37.5 | 6 |
| Average | 32.5 | 33.5 | 36.5 | 42 | 6.3 |
| Large | 45 | 40 | 58 | 46.5 | 6.5 |

Table 12: Sandy Clay Loam Profile

| % Ranges | Sand | Clay | Silt | Total Porosity | pH |
|---|---|---|---|---|---|
| Low | 0 | 1 | 80 | 31 | 6 |
| Average | 6.5 | 6.5 | 89.5 | 42.5 | 6.5 |
| Large | 1 | 12 | 99 | 50 | 7 |

Table 13: Sandy Loam Profile

| % Ranges | Sand | Clay | Silt | Total Porosity | pH |
|---|---|---|---|---|---|
| Low | 43 | 7 | 1 | 25 | 5.8 |
| Average | 61.5 | 13.5 | 3 | 37.5 | 6 |
| Large | 80 | 20 | 5 | 50 | 7 |

Table 14: Loam Profile

| % Ranges | Sand | Clay | Silt | Total Porosity | pH |
|---|---|---|---|---|---|
| Low | 1 | 7 | 28 | 37.5 | 6 |
| Average | 26 | 17 | 39 | 42.15 | 6.3 |
| Large | 51 | 27 | 50 | 46.5 | 6.5 |

## 4.2 Fuzzy Classification for Soil Profile Data

Fuzzy Classification for Soil Profile Data (Algorithm 1) [12] with the following Fuzzy Fitness Rules for finding Soil suitability for minor millets, paddy, sugarcane, oilseeds, cotton, orchards and vegetables have been derived.

The Fuzzy Classification algorithm for soil profile data takes the soil major textural classes and relative percentage of total porosity as input in Fuzzy Inference System (FIS). The soil textural class includes sand, silt, and clay. The proposed system fuzzifies these values based on fuzzy membership functions. The fuzzified values are passed to the fuzzy inference engine where IF-THEN fuzzy rules are applied to get a fuzzy output. The output is passed through defuzzifer to get crisp value. A new surface is generated which provides us the pattern of the relative contaminated percentage of the soil area.

**Algorithm 1: Fuzzy Classification for Soil Profile Data**
**Input:** Create FIS, The training sample of Sand, Silt, Clay, pH and Total Porosity
**Output:** A FIS trained to classify the soil samples with Total Porosity

**Step 1.** FIS=Create Fuzzy Inference System
**Step 2.** TexturalClass=Read Soil texture with pH, Total Porosity
**Step 3.** TotPoro=Totper (TexturalClass)
**Step 4.** FuzzyPoro=Fuzzify (TotPoro)
**Step 5.** Call Fuzzy Fitness Rules
**Step 6.** FuzzyOutputPoro=FuzzyInferenceEngine (FuzzyPoro)
**Step 7.** CrispOutput=Defuzzify (FuzzyOutputPoro)
**Step 8.** TotPoro (TexturalClass) =CrispOutput
**Step 9.** Display TotPoro

**Fuzzy Fitness Rules:**

1. If (Sand is high) ^ (Clay is low) ^ (Silt is low) ^ (totpor is low) ^ (pH is low) → (SoilType is Sand) (Field is Sunflower)
2. If (Sand is high) ^ (Clay is low) ^ (Silt is low) ^ (totpor is medium) ^ (pH is low) → (SoilType is Sand) (Field is Potato)
3. If (Sand is high) ^ (Silt is low) ^ (Clay is low) ^ (totpor is medium) ^ (pH is medium) → (SoilType is Sand) (Field is Groundnut)
4. If (Sand is low) ^ (Silt is low) ^ (Clay is medium) ^ (totpor is low) ^ (pH is high) → (SoilType is Clay) (Field is Paddy) (Field is Sugarcane)
5. If (Sand is low) ^ (Silt is low) ^ (Clay is high) ^ (totpor is high) ^ (pH is high) →(SoilType is Clay) (Field is Paddy) (Field is Sugarcane)
6. If (Sand is medium) ^ (Silt is low) ^ (Clay is high) ^ (totpor is medium) ^ (pH is high) → (SoilType is Clay) (Field is Paddy) (Field is Sugarcane)
7. If (Sand is low) ^ (Silt is low) ^ (Clay is high) ^ (totpor is high) ^ (pH is medium) → (SoilType is Clay) (Field is Paddy) (Field is Sugarcane)
8. If (Sand is low) ^ (Silt is high) ^ (Clay is low) ^ (totpor is medium) ^ (pH is medium) → (SoilType is Silt) (Field is Wheat)
9. If (Sand is low) ^ (Silt is high) ^ (Clay is low) ^ (totpor is high) ^ (pH is high) → (SoilType is Silt) (Field is Wheat)
10. If (Sand is low) ^ (Silt is medium) ^ (Clay is low) ^ (totpor is medium) ^ (pH is medium) → (SoilType is Loam) (Field is Millets)
11. If (Sand is low) ^ (Silt is high) ^ (Clay is low) ^ (totpor is medium) ^ (pH is medium) → (SoilType is Loam) (Field is Wheat)
12. If (Sand is low) ^ (Silt is high) ^ (Clay is medium) ^ (totpor is medium) ^ (pH is medium) → (SoilType is Loam) (Field is Soyabean)
13. If (Sand is medium) ^ (Silt is low) ^ (Clay is medium) ^ (totpor is medium) ^ (pH is medium) → (SoilType is ClayLoam) (Field is Vegetables) (Field is Flower Plants)

14. If (Sand is medium) ^ (Silt is low) ^ (Clay is low) ^ (totpor is low) ^ (pH is medium) → (SoilType is SandyLoam) (Field is Cotton)
15. If (Sand is medium) ^ (Silt is low) ^ (Clay is low) ^ (totpor is medium) ^ (pH is medium) → (SoilType is andyLoam) (Field is Groundnut)
16. If (Sand is high) ^ (Silt is medium) ^ (Clay is low) ^ (totpor is medium) ^ (pH is medium) → (SoilType is andyLoam) (Field is Cotton)
17. If (Sand is high) ^ (Silt is low) ^ (Clay is low) ^ (totpor is low) ^ (pH is low) → (SoilType is LoamySand) (Field is Cotton)
18. If (Sand is high) ^ (Silt is low) ^ (Clay is low) ^ (totpor is low) ^ (pH is low) → (SoilType is Sand) (Field is Pigconpea)
19. If (Sand is high) ^ (Silt is low) ^ (Clay is low) ^ (totpor is medium) ^ (pH is medium) → (SoilType is Sand) (Field is Pigconpea)
20. If (Sand is high) ^ (Silt is low) ^ (Clay is low) ^ (totpor is high) ^ (pH is high) → (SoilType is Sand) (Field is Pigconpea)
21. If (Sand is low) ^ (Silt is low) ^ (Clay is high) ^ (totpor is high) ^ (pH is high) → (SoilType is Clay) (Field is Pigconpea)

### 4.3 Fuzzy-Genetic Hybrid Classification Algorithm

Hybrid Systems employ more than one technology to solve a problem. A Fuzzy-Genetic Algorithm is considered as a Genetic Algorithm that uses fuzzy logic based techniques. In combination of Fuzzy Inference System and Genetic algorithm, GA is used in the design of fuzzy system parameters, particularly for generating fuzzy rules and adjusting membership functions of fuzzy sets [3]. Genetic algorithm for Soil Profile data is named as GENSOIL (Algorithm 2) [12].

A Genetic Algorithm is a search technique used in computing to find true or approximate solutions to optimization and search problems. Genetic Algorithms are a particular class of Evolutionary Algorithms that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover also called recombination. The new population is used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached [5].

**Algorithm 2: GENSOIL (GENetic algorithm for SOIL Profile Data)**

**Step 1.** The percentage of Sand, Silt, Clay and Total Porosity (totpor) and pH are represented as the chromosome
**Step 2.** Under supervised mode the chromosome resembles a classifier structure
**Step 3.** Select the better individual with filter solutions which are more likely to be selected
**Step 4.** Apply selection method for selection
**Step 5.** Build the next generation that is yielded using crossover or mutation by making changes in the characteristics of the chromosome
**Step 6.** The Classifier classifies the chromosome on rule-based event with respect to sand, silt, clay, totpor and pH
**Step 7.** The new off string is tried with the Fuzzy Inference System and checks whether it yields Best Soil Solution
**Step 8.** Find the worst case that yields the population which newer should occur
**Step 9.** Terminate with Good Population Results

## 5. Experimental Results

With the use of Soil Profile Analysis Model suitability maps have been prepared for Puducherry Region and tabulated in Table 15. Based on a suitable criteria and the soil-site characteristics of the mapped soils, interpretative maps of land capability, irrigability, problem soils and potential soils have been prepared.

**Table 15 Abbreviations:**

LC - Land Capability Classification & Subclasses
LI - Land Irrigability Classification & Subclasses
M - Soil Suitability for Millets
GN - Soil Suitability for Groundnut
P - Soil Suitability for Paddy
SC - Soil Suitability for Sugarcane
V - Soil Suitability for Vegetables
F - Soil Suitability for Flower Plants

**Land Capability Classification & Sub classes:**

II - Good cultivable lands having minor problems of erosion and soil
III - Moderately good cultivable lands having moderate erosion and soil problems

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Table 15: Soil Profile Interpretations of Puducherry Region using Proposed Soil Profile Analysis Model

| Unit | Soil Series | LC | LI | M | GN | P | SC | V | F |
|---|---|---|---|---|---|---|---|---|---|
| 1. | Gorimedu<br>Kalapet | IIIe<br>IIIes | 2t<br>3t | S2<br>S1 | S1<br>S1 | S2<br>S2 | S2<br>S2 | S1<br>S1 | S1<br>S1 |
| 2. | Ayyankuttipalayam | IIIes | 4t | N2 | S1 | S1 | S1 | S1 | S1 |
| 3. | Sedarpet<br>Tuthipet | IIIes<br>VI | 4t<br>5s | S2<br>S2 | S2<br>N1 | S1<br>S2 | S2<br>N2 | S2<br>N2 | S2<br>N1 |
| 4. | Kuppam | IIIws | 3sd | N2 | S1 | S1 | S1 | N1 | N1 |
| 5. | Gingee<br>Penniar | IVes<br>IIIes | 4s<br>3sd | S1<br>S1 | S1<br>S1 | N2<br>N1 | N2<br>S2 | N1<br>S1 | N2<br>S1 |
| 6. | Sanyasikuppam<br>Puducherry | IIs<br>IIe | 2t<br>2t | S1<br>S1 | S1<br>S1 | S1<br>S2 | S1<br>S2 | S1<br>S1 | S1<br>S1 |
| 7. | Mannadipet | IIs | 3sd | S2 | N1 | S1 | S2 | S1 | S1 |
| 8. | Bahour<br>Mannadipet | IIs<br>IIIws | 3sd<br>3sd | S2<br>S1 | S2<br>N1 | S1<br>S1 | S1<br>S2 | S2<br>S1 | S1<br>S2 |
| 9. | Villianur | IIIws | 3sd | S2 | N2 | S1 | S2 | S2 | N2 |
| 10. | Palayam | IIIws | 3sd | S1 | S2 | S1 | S1 | S1 | S2 |
| 11. | Beaches | VI | 6 | N2 | N2 | N2 | N2 | N2 | N2 |
| 12. | Manapattu | IIIws | 3sd | N1 | N2 | S2 | N1 | N2 | N2 |
| 13. | Kottucherry | IVes | 4st | N2 | S1 | N2 | N2 | N2 | N2 |

IV - Fairly good cultivable lands having severe erosions and soil problems
VI - Lands well suited for grazing and forestry, having erosion and soil problems
VIII - Lands fairly well suited for grazing and forestry, having erosion, soil and drainage problems

**Sub classes:**

's' - rootzone limitations
'e' - erosions
'w'- excess of water

**Land Irrigability Classification & Sub classes:**

2 - Irrigable lands with slight limitations
3 - Irrigable lands with moderate limitations
4 - Marginally irrigable lands with severe limitations
5 - Lands not suitable for irrigation due to severe limitations
6 - Non irrigable lands

**Sub classes:**

't'- topography
's'- soil limitations
'd'- drainage

## 6. Conclusion and Future Directions

This research paper, proposes a complete Soil Profile Analysis Model, describes Knowledge Discovery in Databases of identifying valid, potentially useful and understandable structure in Soil Profile dataset. The long-felt need of the Union Territory to have a comprehensive, reliable and uniform database on soils has been fulfilled by the completion of this research work for Puducherry Region. This research paper is a valuable source of information on the occurrence of various kinds of soils, their distribution and extent, their problems and potentials, their capability for agriculture and other uses, and their suitability for growing different crops. This research work will be of immense value to planners, administrators, scientists, extension workers, Computer Science researchers and all others who are involved in the advancement of agriculture in the Puducherry Region.

In future, for preparing land-usage plans for village, watershed and block level, more detailed information on larger scales is needed, which can be achieved by carrying out further investigations as outlined below:

- Conducting detail surveys on priority of problem and potential areas identified through soil resource mapping work at detailed level or larger to quantify the nature of problems/potentials for formulating rational land-use plans for smaller areas at block, watershed and village level.

- Developing information kits for the soils identified for farm-level extension for the major crops.
- Designing multimedia tools about soil resources for teaching purposes and to develop awareness for preserving soil resources.
- Using Geographical Information System (GIS) for Regional/block/watershed/village level planning and implementation and for monitoring of soil resources.
- Extensive research is required to integrate Geology, Hydrology, Chemistry, GIS in preserving environmental contamination and Soft Computing approaches to develop scientific decision making systems to enable the farmers to make better decision to make them achieve maximum crop productivity, increase crop variety, improve irrigation facilities, use of suitable fertilizers and growing high yielding varieties.

## References

[1] Ashok Kumar D and Kannathasan N, A Survey on Data Mining and Pattern Recognition Techniques for Soil Data Mining, IJCSI International Journal of Computer Science Issues, Vol. 8 (3), pp. 422-428, May 2011.

[2] Soil Survey Staff, National Bureau of Soil Survey and Land Use Planning and Department of Agriculture, Government of Pondicherry, "Soils of Pondicherry and Karaikal for Land Use Planning-Executive Summary", 28B, Soil Resource Bull., NBSS Publication, Nagpur (India), December 1992.

[3] Zadeh L.A, Fuzzy sets, Information and Control, Vol.8 (3), pp. 338–353, 1965.

[4] Pawlak, Z, Rough Sets - Theoretical Aspects of Reasoning about Data, Kluwer Academic Publishers, Dordrecht, 1991.

[5] Goldberg D.E, Genetic Algorithms in Search, Optimization and Machine Learning, Addison Wesley Publishing Company, 1989.

[6] Jiawei Han, Micheline Kamber and Jian Pei, Data Mining: Concepts and Techniques, Third Edition, Morgan Kaufmann, 2011.

[7] S.Rajasekaran and G.A.Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, 1st Edition, PHI, 2003.

[8] Stepaniuk, Rough-Granular Computing in Knowledge Discovery and Data Mining, 2008.

[9] Ashok Kumar D and Kannathasan N, A Study and Characterization of Chemical Properties of Soil Surface Data Using k-Means Algorithm, IEEE Proceedings of the International Conference on Pattern Recognition, Informatics and Mobile Engineering (PRIME), pp. 264-270, doi: 10.1109/ICPRIME.2013.6496484, 2013.

[10] Ashok Kumar D and Kannathasan N, A Novel Artificial Neural Network Model for Prediction of Soil Total Porosity, Scopus Indexed - International Journal of Applied Engineering Research, Vol.10(14), pp. 34346-34352, September 2015.

[11] Ashok Kumar D and Kannathasan N, A Novel Soil Profile Feature Reduction Model using Principal Component Analysis, Scopus Indexed - Indian Journal of Science and Technology, Vol. 8(29), doi:10.17485/ijst/2015/v8i1/84111, November 2015.

[12] Ashok Kumar D and Kannathasan N, A Novel Fuzzy - Genetic Hybrid Classification Algorithm for Soil Profile Data, Scopus Indexed – Indian Journal of Science and Technology,Vol. 9(33), doi:10.17485/ijst/2016/v9i33/84153, September 2016.

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