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**Article** *in* International Journal of Plant & Soil Science · January 2017

DOI: 10.9734/IJPSS/2017/34710



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*International Journal of Plant & Soil Science*

***17(6): 1-13, 2017; Article no.IJPSS.34710***
***ISSN: 2320-7035***

# Indigenous Knowledge of Soil Health and Fertility Management in Garakahalli Micro Watershed of Ramanagar District, Karnataka

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author SCRK designed the study and performed socio-economic survey in Garakahalli micro watershed. Author BPB performed the statistical analysis and data interpretation. Author VR interpretation of indigenous knowledge of farmers through participatory resources appraisal. Authors SS and SPM did GIS analysis. Authors RH and SKS read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/IJPSS/2017/34710
*Editor(s):*
(1) Kofi Agyarko, College of Agricultural Education, University of Education, Winneba, Ghana.
*Reviewers:*
(1) Tássio Dresch Rech, Universidade do Planalto Catarinense, Brazil.
(2) Şeref Kiliç, Ardahan University, Turkey.
(3) Joseph Heckman, Rutgers University, USA.
Complete Peer review History: http://www.sciencedomain.org/review-history/20235

***Original Research Article***

***Received 6th June 2017***
***Accepted 19th July 2017***
***Published 27th July 2017***

## ABSTRACT

The comparative approach aims to establish differences and similarities between local knowledge and scientific information only to focus on the management of soil and land resources. The aim of the study at Garkahalli micro watershed in a part of Ramanagar district, Karnataka was to study farmers' perceptions about assessment of soil fertility and comparing them with the criteria of soil fertility used by researchers. To address this issue, semi-structured interviews were conducted in 251 households and major soil series with grid surface samples were collected for deriving thematic soil fertility map. The house hold interviews showed that the response of farmers in percentage against four sets of soil health indicators were listed as (1) soil organic carbon status (90%), colour (85%) and texture (80%), (2) 100% for yield under crop performance, (3) 100% for dry spells / rainfall distribution under environmental factors and (4) 100% for type and amount of farm yard

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manure and availability of irrigation (under agricultural management). The scoring of ten soil biophysical indicators used by farmers were found to be well in agreement with scientific method of soil fertility assessment and in designing integrated soil fertility management technologies at landscape level.

*Keywords: Traditional; biophysical indicators; visual assessment tools; southern dry zone; soil classification.*

## 1. INTRODUCTION

Indigenous knowledge (IK) is used to distinguish the knowledge developed by a given community from international knowledge systems or scientific knowledge [1,2]. Indigenous knowledge is unique knowledge that people in a given community (geographic area) have developed over time, and continue to develop [3,4,5]. IK is based on experience, often tested over centuries of use, adapted to local culture and environment, dynamic and changing [6]. It is generally recognized that IK plays an important role in sustainable management of natural resources and can also have impact on issues of global concern [2,7,8]. Visual soil assessment methodology is being developed for "use by farmers on-farm" [9]. The methodology would probably be limited to one or more transect walks conducted by the farmer(s) and the extension agent, a participatory field sketch [10].

In India, farmers have evolved land use systems and cropping patterns based not only on climate but also on soil types. Farmers generally consider edaphic factors for choosing crops and the level of management. In tribal region of Madhya Pradesh, farmers adopt soil texture based cropping system [11], in Yavatmal and Nagpur district, Maharashtra, farmers use soil depth for deciding crop suitability [12] and the level of production inputs for rain fed cotton and sorghum [13]; physiographic location for rice management in eastern parts [14]; slash and burn farming in North east India [15] and terrace based method of land and water management of Apatanis in Arunachal Pradesh [16]. In north Sikkim, rotten forest litter or organic matter-rich topsoil is put into grooves of rocks over potato seeds, or farmers use forest litter as a bedding material to generate a large quantity of compost for crop production [17]. Farmers from some parts of the mid-hills bury dead animals and use toilets as an integral part of soil fertility management [18].

Several studies have been undertaken to assess local knowledge about soils. Research in this area has predominantly focused on documenting how farmers classify their soils [19]. Less attention has been paid to studying and understanding how soil fertility is perceived and managed at farm level, and how various physical, economic and socio-cultural factors interact. Hence, the objectives of the present study were to (1) identify the dominant soil types and their vulnerability using elicitation of local soil knowledge, (2) characterise the physical and chemical properties of the soils and (3) link them to the relief position and land use in order to initiate sustainable soil use based on recommendations deduced from the elicitation of local knowledge.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

Garakahalli microwatershed is located in Garakahalli village of Ramanagar district, Karnataka. It is situated between 12°31′15″ to 12°31′36″ N latitude and 77°7′05″ to 77°7′54″ E longitude (Fig.1). The watershed is 527 ha with bimodal rainfall distribution from 13$^{th}$ week to 30$^{th}$ week where precipitation (P) exceeds potential evapotranspiration (PET).

In traditional agrocalendar the harvesting of millets is celebrated as *Sankranti* at the end of cropping season. The main agricultural activities associated during this period is burning of unwanted bushes and stumps (March - April — *mesura* (local name of month) threshing of millets and *besige hullime* (summer ploughing). The second spell of rainfall again starts from 37$^{th}$ week with short dry spells and extend up to December. Staggered planting of cereals (maize, ragi), pulses (red gram, field bean), and oil seeds (mustered, castor) is done starting from April and continued up to June. Generally maize, pulses and then followed by finger millet with a gap of about one month. Perhaps, this staggered planting creates high plant density leading to suppression of weeds besides making use of rainfall for long period. The agricultural season is closely associated with the rainfall pattern. An overview of the different seasons in the study area is given as below:

- March to June- (Dodda Jatharae and Adere): the rainfall during this period is 406 mm with Potential evaporation (PE) of 472 mm. The promising crops like maize and sorghum may be planted. The farmers mostly use this season to prepare their land,
- July to September (Kakata, Shravana, Teppa, Marlami) is the main rainy season with 532 mm of rainfall and 385 mm of PE. Crops are planted at the beginning of this period,
- October to February (Devalige, kiri devalegi and sankranti) is the dry season, when crops are harvested, threshed and stored. The ritual associated with this season is hosa ragi habba.

## 2.2 Farm Household Interviews

For evaluating the objectives of the study, primary data was collected from the sample respondents by personal interview with the help of questionnaire. Prior to the field survey, participatory rural appraisal tools were used namely; direct observation, formal and informal discussions, focus group discussions and key informants. Some limited field work was done to verify the facts of information, which was used as guide to interviews and discussions with selected farmers. Two hundred and fifty one

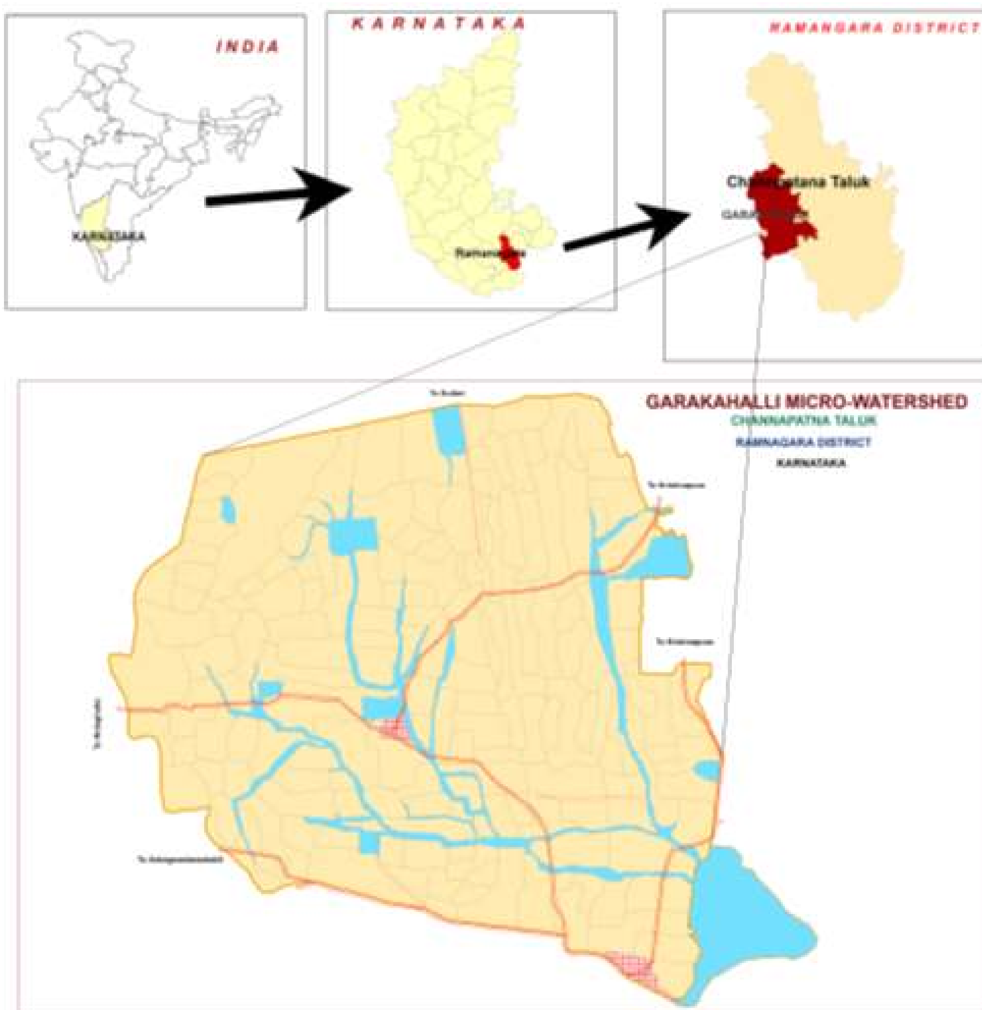



**Fig. 1. Location map of the study area**

(251) farm households at Garakahalli watershed were randomly selected from the representatives of each soil type mapped to gain insight into local methods of soil fertility management practices, and perceived trends in soil fertility. Many farmers expressed that the top layer (0-15 cm) is important for crop productivity therefore restricted soil analysis to this top layer only.

### 2.3 Field Survey

The land resource maps on 1:10000 scales were prepared and used to analyse the current land use practices and crop management practices at watershed level. The transect walks were made to record the variations between different types of soil, and analysed diversity in soil fertility management practices. The soils were defined and classified as USDA soil taxonomy up to soil series level and its phases as soil mapping units [20]. The traditional soil classification in Kannada language was made with consultation of local farmers, language experts and dictionary in defining equivalents terms in local language. The scheme of traditional names of soils in Kannada language is presented in Fig.2.

### 2.4 Soil Laboratory Analysis

The soil samples were air-dried, homogenized and sieved to pass a 2 mm mesh sieve for physical and chemical analyses. Particle-size distribution was determined using the pipette methods or hydrometer method. Soil pH was determined in water and 1 M KCl in a soil to solution ratio of 1: 2.5 soil water solution using glass electrodes after reciprocal shaking for 1 hour [21]. Total carbon in soil was determined by the wet digestion method of Walkley and Black [21]. Available phosphorus was determined by the Bray II method. Exchangeable cations (K, Ca, Mg and Na) were extracted with 1 M $NH_4OAc$ buffered at pH 7. The concentrations of K, Ca, Mg and Na in the solutions were measured by AAS (Perkin Elmer). Cation Exchange Capacity (CEC) was determined by distillation method using the soil for the basic exchangeable cation determination [21].

### 2.5 Photo Voice

In addition to personal interviews, we used a technique, photo voice, to elicit deeply held meanings. The assessment would generate a mixture of quantitative and qualitative data that would be recorded with the aid of the data sheets, supplemented by sketches and maps, annotated transect diagrams, and other relevant information from previous or ongoing studies in the local study area. The land resource inventory at Garakahalli watershed level aimed to provide a prototype database that could be readily adapted and made fast local assessment within the frame work of scoring the visual signs of soil health [9]. The information and indicators on the recording sheets were coded to simplify systematic collection, input and analysis of data

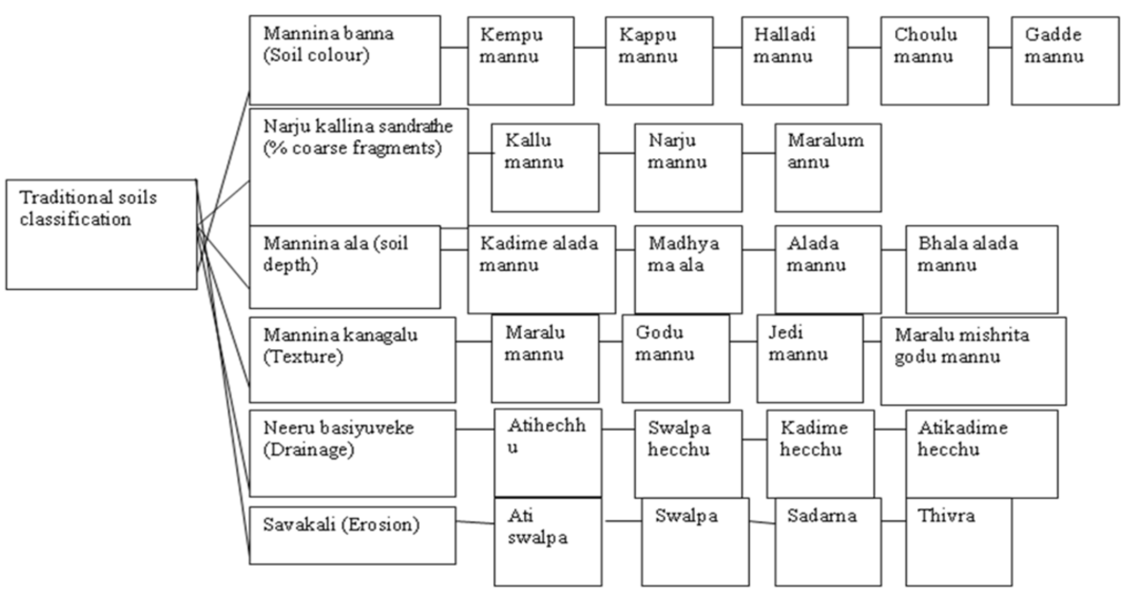
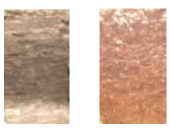
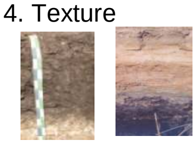
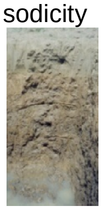



**Fig. 2. Traditional soil classification system in Garakahalli watershed**

(Table 1). We first compiled biophysical indicators enlisted in house hold interviews and synthesized them into four major domains with 10 biophysical indicators. The analysis of each soil type was performed using an iterative process and outcomes reported in this article. The visual scores of individual farmers for each biophysical indicator were rated individually as 0=poor, 1=moderate and 2= good. These ratings were multiplied with weighing factor to derive visual ranking and then added overall ranking so as to categorize as poor if score is <10, 10-25 as moderate and >25 as good [9].

**Table 1. Scoring of visual assessment of soil health**

| Soil property | Class/ range / Rating of soil constraints | | | |
|---|---|---|---|---|
| | **Severe** | **Moderate** | **Slight** | **None** |
| 1.Soil depth  | Very shallow(<25 cm) -0 | Shallow(25-50 cm)-1 | Moderately deep (50-100 cm)-2 | Deep(>100 cm)-3 |
| 2. Structure.  | None (Soil is single grain or massive)-0 | Weak(Poorly formed aggregates)-1 | Moderate(Well formed aggregates)-2 | Strong(Very well formed aggregates)-3 |
| 3.Tillage and pan compaction  | None (No tillage pan, friable consistence* (moist) and abundant pores/voids throughout)- 3 | Slight (Slightly developed tillage pan, friable to firm consistence (moist) and many fine pores throughout but with few large pores)- 2 | Moderate (Moderately developed tillage pan, firm consistence (moist) and moderate amount of pores but very few large pores)- 1 | Severe (Strongly developed tillage pan, with massive structure, very firm to extremely firm consistence (moist) and very few or no pores)- 0 |
| 4. Texture  | Sand, loamy sand (Low water and nutrient holding capacity*, good workability, high to very high infiltration rate)- 0 | Sandy loam, silt loam, heavy clay (Low to medium water and nutrient holding capacity; good workability) -1 | Medium clay, sandy clay loam, silty clay, sandy clay, silty clay loam (Medium to high available water holding capacity; high nutrient holding capacity;)- 2 | Loam, clay loam (Very high water holding capacity, high nutrient holding capacity, medium workability, moderate infiltration rate)- 3 |
| 5.Coarse fragments  | None to common (0 – 15% )- 3 | Common to many (15 – 40%)- 2 | Many to abundant (40 – 80%) 1 | Dominant (> 80%)- 0 |
| 6. Rooting condition  | Good condition (Unrestricted root development, many (<2 mm, 50/dm$^2$ ; > 2 mm, > 5/dm$^2$ ) - 3 | Moderate condition (Horizontal and vertical root development somewhat limited; more roots between | Poor condition Horizontal and vertical root development clearly limited; most roots concentrated in cracks between | Very poor condition Severe restriction of horizontal and vertical root development; presence of L-shaped roots, |

| Soil property | Class/ range / Rating of soil constraints | | | |
|---|---|---|---|---|
| | **Severe** | **Moderate** | **Slight** | **None** |
| | | coarse structural elements than inside; common roots (2 mm, > 5 - 20/dm$^2$ )- 2 | structural units, almost no roots inside units; few roots (2 mm, > 2 - 5/dm$^2$ )- 1 | over thickening of roots or roots squashed between coarse structural units or concentrated above dense layer, no roots inside units; none to very few roots (2 mm, 0 - 2/dm$^2$) - 0 |
| 7.organic matter/ colour  | Very low (White; value 8)- 1. | Low (Grey; value 5-7)-2 | Medium (Dark grey to black grey; value 3-4.5)- 2 | High (Black; value 2-2.5)- 3 |
| 8.Biological activity | None (No biological features, no earthworms)- 0 | Low (Few biological features or soil biota; 1- 4 earthworms counted in spadeful)-1 | Medium (Common biological features or biota; 4 – 8 earthworms counted in spadeful)-2 | High (Many biological features or biota; > 8 earthworms counted in spadeful)-3 |
| 9.surface crust / sealing | | | | |
| a. Physical  | None (No crust present)- 3 | Slight (Thin to medium crust (1 – 5 mm) on up to 20% of the surface)- 2 | Moderate (Thin to medium crust (1 – 5 mm) present on 20 - 50% of the surface, thick crust (> 5 mm) present in few patches) -1 | Severe (Thin, medium and thick crust present on more than 50% of the surface with common patches of thick crust)-3 |
| 10.salinity/ sodicity  | None (No signs of sodicity, also not in nearby areas, see below; depth of groundwater > 2 m)- 3 | Slight Sodicity: (in shallow pit soil structure is weak; in close-by areas some puddles of surface water are coloured black by dispersed organic colloids (slick spots); upon drying, black crusts are formed)-2 | Moderate Sodicity: (water logging is a common surface feature; some puddles of surface water are colored black by dispersed organic colloids (slick spots); upon drying, black crusts are formed; hard setting surface, but when worked soil becomes easily dusty when dry. -1 | Severe Sodicity: (in shallow pit the top of the B-horizon is visible in the form of well defined vertical columns or prisms, having a rounded top with lighter colour and smooth, shiny and well defined sides.)- 0 |

### 2.6 Data Analysis

Analysis of variance using the general linear model procedure of statistical analysis system was performed to detect soil physicochemical properties differences of three soil categories defined by 10 biophysical indicators. The data generated by structured questionnaires was analysed using descriptive statistics to describe and navigate farmers' perception.

## 3. RESULTS AND DISCUSSION

### 3.1 Traditional Classification and Terminology used in Defining Soils

The farmers of the study area used physical as well as perceptual characteristics of soils such as topography, soil colour and coarse fragments to classify soil in Kannada (Fig. 2). Their method is in concurrence with similar studies made in India [22] and in abroad [23,24]. Five topographic positions are recognised and named as bettada bhumi, ellijarina bhumi, tappalu, maidan bhumi and tari bhumi. The soil names are called on the basis of colour as kempu mannu (red soil), kappu mannu (black soil), halladi mannu (yellow soils) and gadde mannu (alluvial soil). Based on coarse fragments it is further defined as kallu bhumi (skeletal soils), savakali mannu (eroded soil), naraju mannu (gravelly soil) and marallu mannu (sandy soils). The soils are further grouped into four broad classes on the basis of depth as (i) kadime ala mannu (<25 cm), (ii) madhyam or sadarana ala mannu(25 to 50 cm) and (iii) ala mannu (50-100 cm) and (iv) bhala ala mannu (>100 cm). Four soil texture groups are recognised by local people and named as maralu mannu (sandy soil), godu mannu (loamy soil), jedi mannu (clayey soil) and maralu mishrita godu mannu (sandy loam soil). Similarly, drainage of soils classified into four classes viz., atihechhu (excessively drained), swalpa hechhu (well drained), kadime hechhu (moderately drained) and atikadime hechhu (poorly drained). Soil erosion is grouped into four categories like ati swalpa (very slight), swalpa (slight), sadarna (moderate) and thivra (sever).

The taxonomic relation between USDA soil classification and its equivalent soil terminologies used in Kannada are useful and easy to communicate to local farmers. The local terms like kalasu asthipanjarada (loamy skeletal) is used here to define for particle size class and lithic as Sileya. Similarly the matrix colour as gadha kandu (dark brown) and topographic position as madhyama dibbagala ilijāru (moderately sloping mounds) under the land use of podegalu aranya (scrub forest). This soil covers 2.08 ha with 0.39% of study area. The visista gadhakempu mannu (Typic Rhodustalfs ) where soil colour is considered as visual criteria to differentiate with other soils along with textural properties and covers 32.19% of total area. These soils have texture of marallu mannina tegedaddu (sandy clay loam) to marallu kalasumannu (sandy loam) and used for ona krisi bhūmi (dry land). Similarly the visista kadu kempu kandu (Typic Haplustalfs, 4.59% of total area) and hōda śilāyugada kempu gādha kandu (Rhodic / Kandic Paleustalfs, 36.98% of total area) are mostly used for dryland crops. Nadige vingadaneyāda kadu kempu kandu (Fluventic Haplustepts) cover 5.7% of total area with texture of kadumanninantha marallu (loamy sand) to gravelly sandy loam (Jalli marallu kalasumannu).In the present study, soil colour and texture with gravel content in the soils are considered in defining soil types [25,26].

### 3.2 Farmer's Approach to Assess Soil Health

From the group discussions it appeared that out of the 10 biophysical indicators named in the first individual interviews, only soil colour, soil organic matter and soil friability are unanimously considered by farmers as significant indicators of soil health. The results showed that the per cent of overall opinion of farmers in Garkahalli watershed about the principal indicators under three themes was expressed as 48.5% very important, 27.6% important, 10.6% undecided and 13.3 % not important. Among 10 biophysical indicators that influence crop productivity, the farmers expressed that organic matter/colour (15.5%) and rooting conditions (14.1%) are very important biophysical indicators for crop productivity (Table 2). The main deciding factors of soil fertility are biological activity (16% expressed as very important) and texture (15%) where tillage and pan compaction (20.4%, important) as major physical barrier in red soils and surface crust and sealing as problem for crops was undecided by 32.3% of farmers in the watershed. In socio-economic survey, 68.3% of farmers expressed that coarse fragments are not important and helpful for judging fertility of red soils in the region (Table 3). Similarly, the soil degradation as assessed by farmers is categorized to 16.4% expressed organic matter and colour as very important indicator

**Table 2. Assessment of farmer's perception about soil quality**

| Soil property | Number / per cent of Farmers' response | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Very important | % | Important | % | Undecided | % | Not Important | % |
| **Crop productivity** | | | | | | | | |
| 1.Soil depth | 165 | 11 | 75 | 16 | 10 | 8 | 1 | 0 |
| 2. Structure. | 165 | 11 | 40 | 8 | 25 | 20 | 21 | 5 |
| 3.Tillage and pan compaction | 135 | 9 | 85 | 18 | 30 | 24 | 1 | 0 |
| 4. Texture | 196 | 13 | 45 | 10 | 8 | 6 | 2 | 1 |
| 5.Coarse fragments | 0 | 0 | 20 | 4 | 31 | 25 | 200 | 47 |
| 6. Rooting condition | 210 | 14 | 30 | 6 | 10 | 8 | 1 | 0 |
| 7.Organic matter/ colour | 230 | 16 | 20 | 4 | 0 | 0 | 1 | 0 |
| 8.Biological activity | 198 | 13 | 50 | 11 | 1 | 1 | 2 | 1 |
| 9.Surface crust / sealing | 186 | 13 | 45 | 10 | 10 | 8 | 10 | 2 |
| 10.Salinity/ sodicity | 0 | 0 | 65 | 14 | 0 | 0 | 186 | 44 |
| Total Score | 1485 | 100 | 475 | 100 | 125 | 100 | 425 | 100 |
| Rank per centage | 59.2 | | 18.9 | | 5.0 | | 16.9 | |
| **Soil fertility** | | | | | | | | |
| 1.Soil depth | 175 | 11 | 65 | 16 | 10 | 4 | 1 | 0 |
| 2. Structure. | 165 | 11 | 40 | 10 | 25 | 9 | 21 | 7 |
| 3.Tillage and pan compaction | 135 | 9 | 85 | 20 | 30 | 11 | 1 | 0 |
| 4. Texture | 230 | 15 | 11 | 3 | 8 | 3 | 2 | 1 |
| 5.Coarse fragments | 0 | 0 | 20 | 5 | 31 | 12 | 200 | 68 |
| 6. Rooting condition | 190 | 12 | 50 | 12 | 10 | 4 | 1 | 0 |
| 7.Organic matter/ colour | 200 | 13 | 30 | 7 | 20 | 8 | 1 | 0 |
| 8.Biological activity | 245 | 16 | 5 | 1 | 1 | 0 | 0 | 0 |
| 9.Surface crust / sealing | 100 | 7 | 45 | 11 | 86 | 32 | 20 | 7 |
| 10.Salinity/ sodicity | 95 | 6 | 65 | 16 | 45 | 17 | 46 | 16 |
| Total Score | 1535 | 100 | 416 | 100 | 266 | 100 | 293 | 100 |
| Rank per centage | 61.2 | | 16.6 | | 10.6 | | 11.7 | |
| **Soil degradation** | | | | | | | | |
| 1.Soil depth | 140 | 12 | 85 | 12 | 20 | 8 | 6 | 2 |
| 2. Structure. | 90 | 7 | 75 | 11 | 53 | 20 | 33 | 10 |
| 3.Tillage and pan compaction | 135 | 11 | 85 | 12 | 30 | 11 | 1 | 0 |
| 4. Texture | 169 | 14 | 41 | 6 | 19 | 7 | 22 | 7 |
| 5.Coarse fragments | 0 | 0 | 20 | 3 | 31 | 12 | 200 | 60 |
| 6. Rooting condition | 139 | 11 | 76 | 11 | 24 | 9 | 12 | 4 |
| 7.Organic matter/ colour | 200 | 16 | 30 | 4 | 20 | 8 | 1 | 0 |
| 8.Biological activity | 134 | 11 | 87 | 13 | 16 | 6 | 14 | 4 |
| 9.Surface crust / sealing | 148 | 12 | 54 | 8 | 31 | 12 | 18 | 5 |
| 10.Salinity/ sodicity | 63 | 5 | 141 | 20 | 21 | 8 | 26 | 8 |
| Total Score | 1218 | 100 | 694 | 100 | 265 | 100 | 333 | 100 |
| Rank per cent age | 48.5 | | 27.6 | | 10.6 | | 13.3 | |

followed by salinity and sodicity (20.3% as important) and structural degradation (20% undecided). In most of the cases, farmers used and rated soil colour, texture and biological activity as important for soil fertility and crop productivity [27]. According to farmers' comments, if the soil is darker (black), it contains more clay, more organic matter, produces more abundant vegetation and consequently, have better friability and root development. The black soils are locally called as kappu mannu whereas soils on bettada bhumi are generally called as kempu mannu. For the farmers under conventional dry land production systems, the appearance of plants during the fallow period were the most important indicator of soil type, because the soil can get 'natural benefits' from the vegetation. More vegetation results in a reduced use of inorganic fertilizer because the biomass is considered a natural organic fertilizer. Besides, the farmers believe that the decomposing vegetation increases the 'fat' of the soil (organic matter), maintains soil friability and soil water content, promotes earthworms and micro-organisms, and provides protection against erosion. According to the farmers, the appearance of natural vegetation is a good indicator of soil conditions, for example, *Axonopus compressus* (Savannah grass) in sandy light texture indicates low fertile soils, *Cenchrus ciliaris* (kusa hullu) - well drained calcareous soils, *Chrysopogon fulvus* (Karehullu) - eroded shallow gravelly / stony soils, *Cynodon dactylon* (Garike hullu) – clay soils and *Vetiveria zizanioides* (Laavancha) - neutral to slightly alkaline soils.

### 3.3 Farmer's Perception and Its Relation with Soil Analysis

The top soils texture in the village is varied from sandy clay loam in all soils with more than 60 % sand and clay of >22% where as loamy sand texture in P3/P4 with sand content more than 70% and clay content <10% and sandy loam in P2 with clay content of 16.6% (Table 4). The soils defined in local as well as taxonomic terms are grouped into 4 classes based on pH such as slightly acid (P1), moderately acid (P4) and neutral to slightly alkaline (P2/P3). Generally, these soils have CEC values less than 20 cmol/kg indicating the influence of clay and fine silt fractions holding 70 to 80% of soil CEC in these soils. This observation is in agreement with results reported in highly weathered soils [28]. The exchange complex (exchangeable bases) is dominated by exchangeable Ca, followed by exchangeable Mg, and that exchangeable K and Na are minor components of the exchange complex. Thus, exchangeable Ca (<5cmol/kg in P1, P4) and Mg (<1.5 cmol/kg in P4) levels in soils are inadequate [29]. In addition, K level was also inadequate in comparison with the critical limit of 0.20 cmol/kg in P2/P3 [30]. The low levels of exchangeable bases in these soils are attributed to leaching of base cations but base saturation is > 60% to classify them at subgroup level as *Typic Rhodustalfs* (P2) / *Rhodic / Kandic Paleustalfs* (P4) / *Typic Haplustalfs* (P3). The general results showed substantial declined in the levels of exchangeable bases in soils. These soils have low organic carbon (<1%) except in P1 where organic carbon is 1.21%. The low organic carbon is due to low organic matter additions and other human factors such as crop removal. Hence, the application of organic residues is needed for optimum levels for sustained productivity [31,32].

The status of available nitrogen (N), phosphorus (P) and potassium (K) is presented in Table 4. All these soils are low in available nitrogen (272 kg/ha), medium $P_2O_5$ (28.75 to 51.75 kg/ha) and medium $K_2O$ content (135 to 335 kg/ha) [33]. Among the micronutrients, these soils are deficient in DTPA extractable zinc (<0.6 mg/kg). There was a strong correspondence between the farmers' assessment of soil fertility and the measured soil chemical characteristics. Fields that were described by farmers as fertile were found on average to have significantly higher values of percentage organic matter, total nitrogen, available phosphorus, and exchangeable potassium. Farmers of the study

**Table 3. Pooled ranking of soil indicators**

| Soil property | Ranking by Respondents | | | |
|---|---|---|---|---|
| | **Very important** | **Important (%)** | **Undecided** | **Not Important** |
| 1. Soil depth | 63.7 | 29.9 | 5.3 | 1.1 |
| 2. Structure. | 55.8 | 20.6 | 13.7 | 10.0 |
| 3. Tillage and pan compaction | 53.8 | 33.9 | 12.0 | 0.4 |
| 4. Texture | 79.0 | 12.9 | 4.6 | 3.5 |
| 5. Coarse fragments | 0.0 | 8.0 | 12.4 | 79.7 |
| 6. Rooting condition | 71.6 | 20.7 | 5.8 | 1.9 |
| 7. Organic matter/ colour | 83.7 | 10.6 | 5.3 | 0.4 |
| 8. Biological activity | 76.6 | 18.9 | 2.4 | 2.1 |
| 9. Surface crust / sealing | 57.6 | 19.1 | 16.9 | 6.4 |
| 10. Salinity/ sodicity | 21.0 | 36.0 | 8.8 | 34.3 |
| Total Score | 63.7 | 29.9 | 5.3 | 1.1 |
| Rank per cent age | 55.8 | 20.6 | 13.7 | 10.0 |

**Table 4. Selected physical and chemical characteristics of soils under study**

| Soil Series / local name | Major crops | Available ($kgha^{-1}$) | | | DTPA extractable($mgkg^{-1}$) | | | | pH | Organic carbon (%) | Exchangeable bases (cmol/kg) | | | | CEC (cmol/kg | Base saturation (%) | Particle size distribution (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | $P_20_5$ | $K_20$ | Fe | Mn | Cu | Zn | | | Ca | Mg | K | Na | | | Sand | Silt | clay |
| P1.*Typic Rhodustalfs* | Ragi | 184.8 | 19.9 | 352.7 | 5.2 | 21.2 | 0.6 | 0.3 | 6.3 | 1.2 | 2.9 | 2.5 | 0.6 | 0.6 | 7.0 | 59 | 64.7 | 13.1 | 22.2 |
| (Visista | Ragi | 203.6 | 38.1 | 253.7 | 3.0 | 11.0 | 0.8 | 0.4 | 6.6 | 0.8 | 3.1 | 2.3 | 0.5 | 0.5 | 7.6 | 84.6 | 65.3 | 21.5 | 13.2 |
| Gadhakempumannu) | Coconut | 159.4 | 35.2 | 140.6 | 11.5 | 33.7 | 1.0 | 0.5 | 7.3 | 0.7 | 3.7 | 2.1 | 0.4 | 0.4 | 8.6 | 76.8 | 70.4 | 16.7 | 22.9 |
| | Banana | 183.0 | 20.2 | 190.7 | 9.6 | 13.5 | 0.7 | 1.0 | 6.3 | 0.5 | 2.8 | 1.4 | 0.3 | 0.5 | 7.6 | 66.2 | 68.7 | 17.7 | 13.6 |
| | Horse gram | 201.0 | 24.7 | 240.1 | 8.9 | 26.7 | 0.8 | 0.5 | 6.4 | 0.7 | 3.5 | 1.9 | 0.4 | 0.5 | 9.5 | 66.0 | 72.9 | 15.4 | 11.7 |
| | Mulbery- | 218.4 | 70.8 | 229.7 | 8.4 | 13.4 | 0.6 | 0.9 | 6.6 | 0.7 | 3.9 | 2.1 | 0.4 | 0.6 | 10.1 | 69.5 | 63.4 | 21.7 | 14.9 |
| | Ragi | 176.7 | 54.0 | 190.8 | 9.7 | 22.1 | 0.6 | 0.4 | 7.4 | 0.5 | 4.1 | 1.6 | 0.3 | 0.4 | 10.3 | 62.6 | 66.4 | 19.9 | 23.7 |
| P2.*Typic Haplusalfs* | Coconut | 206.8 | 61.4 | 188.1 | 10.1 | 19.3 | 0.6 | 0.4 | 6.5 | 0.6 | 3.6 | 1.3 | 0.4 | 0.5 | 9.7 | 60.2 | 70.1 | 19.4 | 10.5 |
| (Visista Kadu kempu | Coconut | 182.9 | 29.6 | 318.6 | 9.7 | 25.4 | 0.8 | 0.8 | 6.8 | 0.5 | 6.5 | 1.7 | 0.1 | 0.1 | 10.4 | 81 | 70.3 | 13.1 | 16.6 |
| kandu) | Banana | 174.4 | 36.2 | 270.3 | 9.2 | 13.8 | 0.8 | 0.4 | 7.1 | 0.5 | 5.7 | 2.1 | 0.3 | 0.2 | 12.4 | 67.0 | 72.5 | 13.5 | 14.0 |
| P3. *Kandic / Rhodic* | Coconut | 196.7 | 20.9 | 137.2 | 6.5 | 11.0 | 0.6 | 0.5 | 6.6 | 0.4 | 5.3 | 1.8 | 0.4 | 0.1 | 7.7 | 99.0 | 73.6 | 13.5 | 12.9 |
| *paleustals* (Hōda śilāyugada-kempu gādha kandu) | Banana | 250.6 | 26.1 | 199.4 | 11.1 | 24.3 | 0.9 | 0.6 | 6.8 | 0.6 | 4.8 | 1.8 | 0.2 | 0.3 | 11.3 | 62.9 | 69.6 | 17.5 | 12.9 |
| P4. *Fluventic Haplustepts* (nadige vingadaneyāda-Kadu kempu kandu) | Banana | 166.4 | 25.7 | 124.8 | 9.2 | 18.3 | 0.9 | 0.5 | 7.5 | 0.4 | 5.5 | 0.6 | 0.5 | 0.4 | 10.6 | 61 | 79.1 | 7.4 | 13.5 |

**Table 5. Selected soil physical and chemical characteristics along with farmer's designated soil health indicators**

| Soil health indicator | Particle size distribution (<2 mm, ----%------) | | | Exchangeable bases (cmol/kg$^{-1}$) | | | | Organic carbon (%) | pH | CEC |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sand | silt | clay | Ca | Mg | K | Na | | 1:2.5 soil water ratio | cmol/kg |
| Poor | 74.5 | 14.2 | 11.3 | 3.01 | 1.31 | 0.34 | 0.46 | 0.51 | 6.8 | 4.97 |
| moderate | 68.3 | 11.9 | 19.8 | 4.76 | 1.85 | 0.24 | 0.28 | 0.48 | 7.2 | 8.23 |
| good | 70.6 | 11.8 | 17.6 | 3.23 | 1.27 | 0.21 | 0.23 | 0.44 | 6.5 | 6.96 |
| LSD(0.05) | 9.5 | 15.11 | 7.96 | 1.52 | 0.99 | 0.14 | 0.19 | 0.24 | 0.80 | 2.92 |
| SEM(+) | 1.84 | 2.86 | 1.56 | 0.29 | 0.19 | 0.027 | 0.04 | 0.046 | 0.16 | 0.55 |
| CV (%) | 12.6 | 53.9 | 45.96 | 42.26 | 63.23 | 52.42 | 60.22 | 46.9 | 11.3 | 47.0 |
| F calculated | 0.83 | 107.5* | 227.75* | 3.41 | 0.9 | 2.07 | 3.34 | 0.14 | 1.71 | 2.73 |

area are well aware of retaining crop residues in their field and crop rotation with leguminous crops (e.g. field bean, red gram, black and green gram). Despite the fact that farmers know the benefit of fallowing (keeping soil barren for eight months is a general practices in the study area) to restore soil fertility, the study also clearly showed that due to the ever increasing population pressure, long term fallowing was not practiced in the study area. Currently, the common practice in the area is seasonal fallowing i.e. leaving the land fallow for one or two seasons.

The soils of Garakahalli are neutral in reaction with low organic carbon (0.5%), low exchangeable K(0.4 cmol/kg), low in exchangeable Ca (<5 cmol/kg) and medium in exchangeable Mg (<0.5 to 1.5 cmol/kg). These soils have mean sand content of 70 per cent with clay less than 20% and low salt and sodium contents [34]. There was a significant differences in silt and clay particle size distribution between the soil groups (poor, moderate and good) but the mean values >70 per cent were observed in poor soils (Table 5).

It is apparent that the significant difference in silt and clay fractions as soil health indicators is true in this part of watershed because clay and silt particles have substantial exchange surface areas to adsorb and stabilize organic matter and nutrients [35]. The farmer's perception is poor regarding chemical characteristics of soils as there is no significant difference in exchangeable cations, organic carbon and cation exchange capacity (CEC). Considering the soil health indicators in three groups of soils, the moderate group of soils have mean of 4.76 cmol/kg for Ca, 1.85 cmol/kg Mg and 8.23 cmol/kg CEC where as poor soils have mean sand of 74.5 per cent, clay of 11.3%, pH of 6.8 and exchangeable bases viz., 3.0 cmol/kg Ca, 1.31 cmol/kg Mg and 0.46 cmol/kg Na (Table 5). Thus these results showed no significant difference between perceptions of researchers through laboratory analysis and farmer's visual assessment.

## 4. CONCLUSION

The results presented in this paper indicate that there are some similarities and anomalies in soil classification systems but shows potential synergism in solving problems related to soil management within the frame work of spatial scale responses. Naming and characterization of soil – land systems in combination of both scientific and ethnopedological means have revealed close agreement when mapped at landscape level and facilitate more accurate adaption of technical recommendations forwarded by extension specialists. In semi arid zone of Karnataka, the main issues related to agriculture are water scarcity and irregular distribution of rainfall where there is a need for fostering intimate coevolution of eco-socio systems. The results indicate that there is no significant agreement between visual assessment of soil health by farmers and scientific indicators of soil fertility such as exchangeable cations, cation exchange capacity, soil organic carbon content and pH. The classification of farmers does not necessarily correlate to the scientific classification because their classification and indicators rely on soil characteristics that they can practically experience.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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*The peer review history for this paper can be accessed here:*
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