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# Evaluation of Litho sequence soils for mapping units, Land capability and Land suitability classes in a selected area of Budhihal micro-watershed (4D7A312F) in Yadgir district of Karnataka using RS and GIS

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**Abstract**
The soils derived from diversified geological materials such as basalt, shale, schist, lime stone granite and sand stone under the same climate and vegetation in addition to almost the same topography in Budhihal Micro-watershed (4D7A312F) were characterized and evaluated for mapping units, land capability and soil suitability. Soils under study were grouped under three land capability classes such as III, IV and V. Irrespective of the parent materials soils under study were rated as marginally suitable (S3) for both cotton and pigeonpea. Schist derived soil was rated as moderately suitable (S2) while rest of the soils was rated as marginally suitable (S3) for groundnut crop. The basalt, schist and sandstone derived soils were rated as moderately suitable (S2) and rest of the soils were rated as marginally suitable (S3) for sorghum.

**Keywords:** diversified geology, mapping units, land capability, land suitability classes, RS and GIS

## 1. Introduction
Lithosequence is the function of formation of diversified soils differs in their properties due to the variation in lithology while rest of the soil forming factors remains constant. Soil properties namely depth, texture, structure, shrink and swell potential, clay mineralogy, CEC, nutrient status, sodicity, salinity, acidity *etc*., often varies with parent materials (Gray and Murphy, 2002) [4]. Response of soils to different management varies not only with the geomorphological features but also inherent soil properties and thus identification of different mapping units is utmost important for better management of soils. Land capability is ability of land surface to support natural or artificial vegetation growth or wildlife or human habitat. The land capability classification is based on the inherent soil characteristics as well as external land features and environmental factors that limit the land use. Soils with specific properties in addition to environmental factors are suitable for specific crops and thus rating the soil as highly, moderately or less suitable for specific crops is also important to obtain optimum returns from the land. Thus present investigation on evaluation of the soils developed from different parent materials in a selected area of about 137 ha in budihal micro-watershed for mapping units, land capability and crop suitability classes was taken up to conserve the soils for sustainable soil productivity.

## 2. Materials and Methods
Budhihal micro-watershed (4D7A312F) in Yadgir district of Karnataka is characterized by the predominant geological materials limestone, shale and granite and however diversified geological materials (Fig. 1) namely Intermediately siliceous (Pinkshale, greyshale, schist), highly siliceous (Granite and sandstone), low siliceous (Basalt) and calcareous (Limestone) rocks were observed in a small patch of 137 ha when the said micro-watershed area was traversed and this small patch of area was selected for study. This is situated in between 16021’49.898 and 16023’07.242 N and latitudes 76024’04.876 and 76023’55.015 E longitudes and is characterized by semiarid climate. Budhihal MWS was traversed with cadastral map and geology map of scale 1:50000 and in a patch of area diversified lithology namely pinkshale, greyshale, schist, granite, sandstone, limestone and basalt was observed.

The cadastral map was overlaid on LISS-IV merged Cartosat-I imagery. The coordinates of localized lithology collected using Juno SD (Trimble Make) handheld GPS locations were imported to ArcGIS and overlaid on the Budhihal MWS boundary and the spatial variation in lithology of selected area was delineated. In the study area, seven soil profile sampling sites, one from each geology were selected at randomly and these profile sampling sites were physiographically almost nearly leveled in order know the influence of lithology on soil properties. Geomorphological features such as surface stoniness, slope, drainage, erosion and soil depth classes of soil profile sites as well as the terminologies used to describe the same were as per the Anonymous (1951) [1] Geographical locations of the sampling spots and elevations above MSL were recorded using GPS. At these profile sampling spots, pits of one square meter size were excavated up to the depth of parent material. Horizon wise soil samples of one representative pedon for each geology were studied for morphological, physical and chemical properties following standard procedure. The spatial variability map of geology of Budhihal MWS was overlaid on various thematic layers of mapping units, LCC, and Land suitability to assess the influence of geology on the soil and crop for their potentials and limitations.

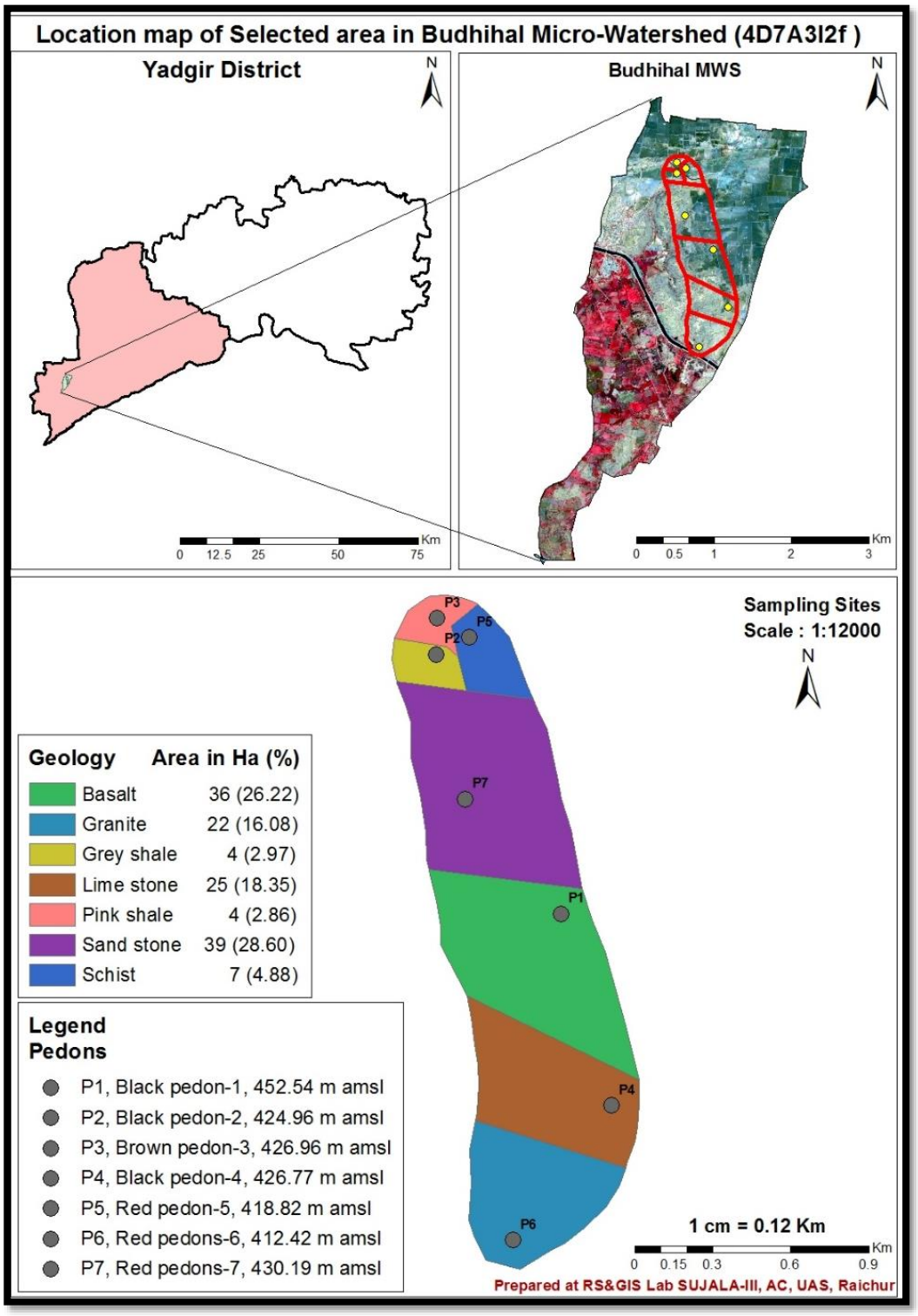


**Fig 1:** Diversified geology and profile sampling spots in a selected area of Budihal micro-watershed (4D7A312F)

## 3. Results and Discussion

### 3.1 Identification of soil series and mapping units

Soils derived from different parent materials were grouped into different soils series and mapping units based on the differentiating characteristics of soils (Table 1). Soils derived from different parent materials in a selected area of Budhihal MWS were grouped into four types of soil series and seven mapping units (Fig. 2) considering differentiating sub surface soil and surface soil characteristics as well as soil surface and geo morphological features (Table 1) of study sites. Classification of soils derived from diversified geology at the lowest category, soil series and at practical category, mapping units is as follow:

| Sl. No. | Pedons | Parent material | Soil series | Mapping unit |
|---|---|---|---|---|
| 1 | Black pedon-1 | Basalt | KAR (Karekal) | KARmB1g0 |
| 2 | Black pedon-2 | Greyshale | BLB (Bilebhavi) | BLBmB1g1 |
| 3 | Brown pedon-3 | Pinkshale | BLB (Bilebhavi) | BLBmB2g3 |
| 4 | Black pedon-4 | Limestone | NGB (Nagarbanda) | NGBhC2g0 |
| 5 | Red pedon-5 | Schist | BLB (Bilebhavi) | BLBhB1g0 |
| 6 | Red pedon-6 | Granite | RVN (Revunayak) | RVNhB2St2 |
| 7 | Red pedon-7 | Sandstone | NGB (Nagarbanda) | NGBcC2St3 |

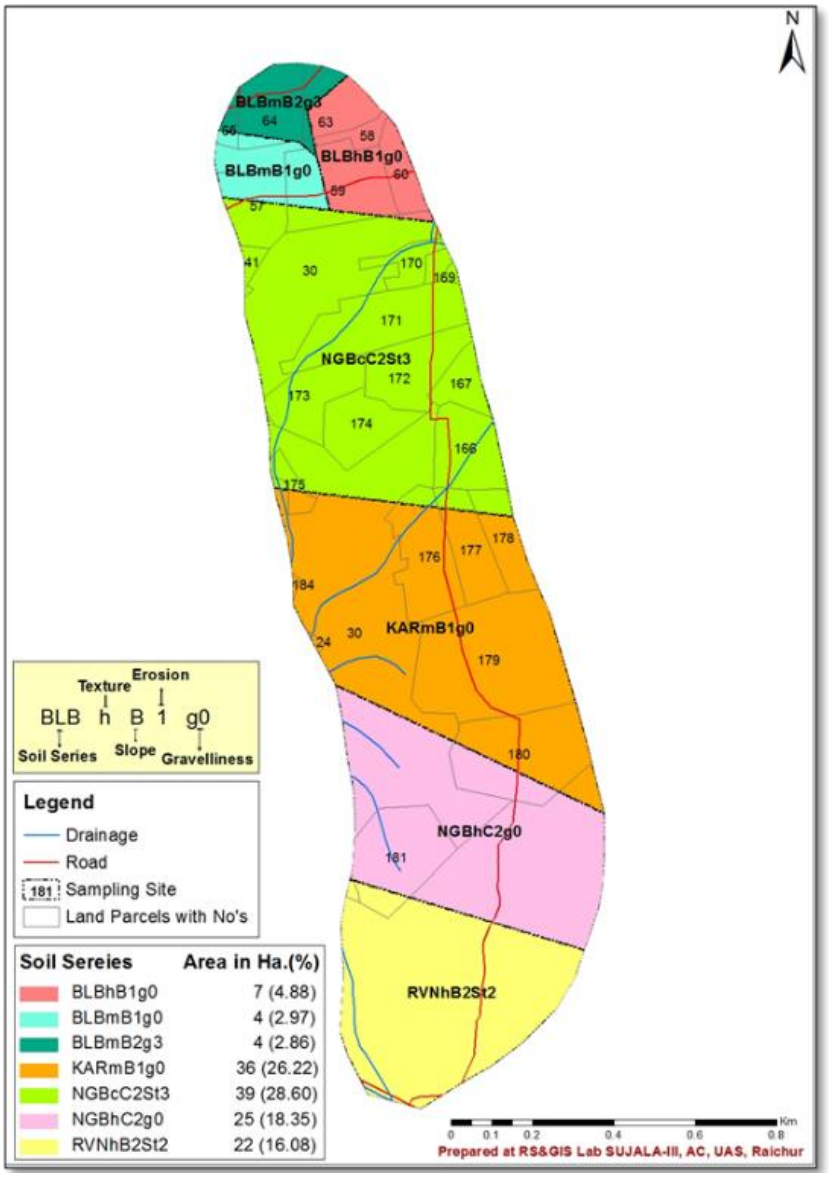


**Fig 2:** Spatial distribution of soil series and mapping units in selected area of Budhihal micro-watershed

### 3.2 Land evaluation studies

Land capability and soil suitability classification for major field procedures (Klingebiel and Montgomery, 1966) [5].

#### 3.2.1 Land capability classification (LCC)

Based on the crop production limiting soil factors as well as geo morphological features of soil-sites the study area was classified into different LCC (Table 2). The classification is based on the inherent soil characteristics, external land features and environmental factors that limit the land use. Based on the crop production limiting soil factors such as texture, depth, organic carbon, CEC, BSP, salinity *etc.*, as well as geo morphological features of soil-sites namely erosion, slope, drainage, surface coarse fragments and or

surface stoniness *etc*., the study area was classified into different land capability classes. The ultimate objective of allocating different LCC over a land area is to achieve complete soil conservation and thus soil health for its sustainable productivity. Land capability classes I to IV are arable while V to VIII are nonarable. The LCC are further divided into land capability sub classes based on the erosion risk, wetness problem and soil root zone limitations.

Land capability is the capacity of land to produce crops, raise forestry or yield any other benefits on a sustained basis. Soils were grouped under III, IV and V land capability classes (Fig. 3). Basalt and greyshale derived black soils were classified under land capability class III and the most limiting wetness factor was drainage, soil factor was profile development and fertility factor was organic carbon in basalt derived black soil and in greyshale derived black soils the most limiting soil factors were soil depth, surface texture coarse fragments and profile development.

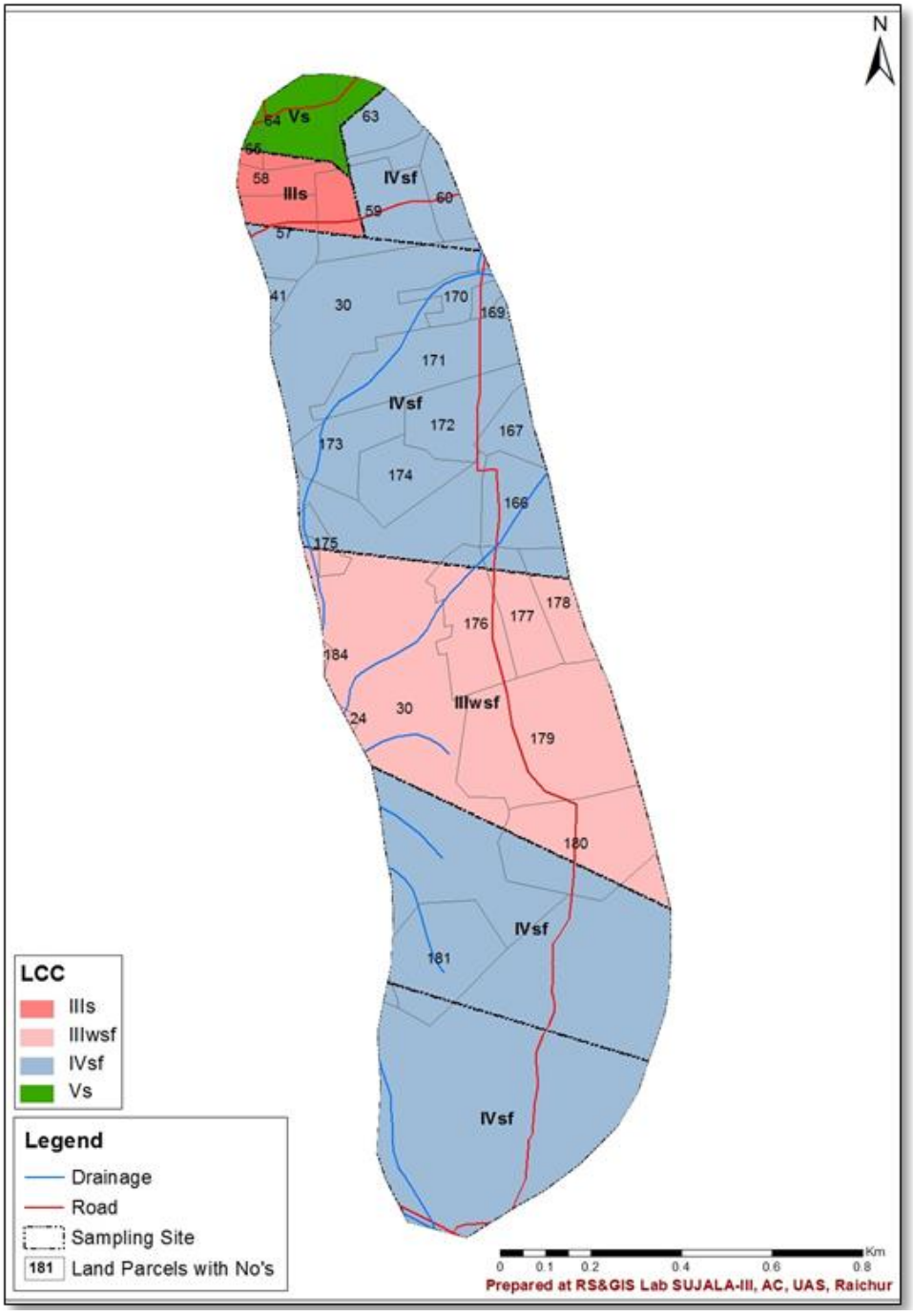


**Fig 3:** Spatial distribution of land capability classes and subclasses in selected area of Budhihal micro-watershed

Limestone derived black soil and schist, granite and sandstone derived red soils were classified under land capability class IV and the most limiting soil factors were surface texture, solum depth and profile development in limestone derived black soil and in both schist and granite derived red soils the most limiting soil factor was surface texture while solum depth was the most limiting soil factor in sandstone derived red soils. The most limiting fertility factor in the limestone schist, granite and sandstone derived soils was organic carbon content. Pinkshale derived brown soil was qualified for land capability class V because of the most limiting soil factor sub surface coarse fragments content and as per this land capability classification pinkshale derived brown soil belonged to non-arable class while rest of the soils belonged to arable classes Sharma *et al.* (1996) [7].

**Table 1:** Differentiating characteristics of soils derived from different geological materials to identify soil series and mapping units

| Pedons | Geological material | Soil series | Mapping units | Soil colour | | Soil texture | | Geomorphological features | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Surface | Sub surface | Surface | Sub surface | Solum depth (cm) | Slope | Erosion | Surface fragments (Gravells/stones) |
| Black pedon-1 | Basalt | KAR(Karekal) | KARmB1g0 | 10YR3/2 | 10YR3/2 | cl | c | 120 | B | e1 | Non gravelly |
| Black pedon-2 | Greyshale | BLB(Bilebhavi) | BLBmB1g1 | 10YR3/3 | 10YR4/3 | c | c | 88 | B | e1 | Gravelly |
| Brown pedon-3 | Pinkshale | BLB(Bilebhavi) | BLBmB2g3 | 7.5YR3/4 | 7.5YR4/3.5 | c | c | 98 | B | e2 | Extremely gravelly |
| Black pedon-4 | Limestone | NGB(Nagarbanda) | NGBhC2g0 | 10YR4/3 | 10YR4/3 | scl | scl | 28 | C | e2 | Non gravelly |
| Red pedon-5 | Schist | BLB(Bilebhavi) | BLBhB1g0 | 5YR5/4 | 5YR5/4 | scl | cl | 90 | B | e1 | Non gravelly |
| Red pedon-6 | Granite | RVN(Revunayak) | RVNhB2St2 | 5YR4/6 | 5YR5/6 | scl | scl | 50 | B | e2 | Very stony |
| Red pedon-7 | Sandstone | NGB(Nagarbanda) | NGBcC2St3 | 5YR5/6 | 5YR4/6 | sl | sl | 35 | C | e2 | Extremely stony |

**Erosion classes**
1 Slight - e1
2 Moderate - e2

**Slope classes**
A 0-1% - Nearly level
B 1-3% - Very gently sloping
C3-5% - Gently sloping

**Gravelly class Stony class**
g0 - Non gravelly (<15%)
g1 - Gravelly (15-35%)
g3 - Extremely gravelly (60-80%)

St2 - Very stony
St3 - Extremely stony

**Table 2:** Land capability classes of selected study area of Budhihal micro-watershed

| Topography (t) | | | | Wetness (w) | Physical properties (s) | | | | | | Fertility (f) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pedons | Geology | Slope (%) | Erosion | Drainage | Surface texture | Surface coarse fragments (% by vol) | Surface stoniness (%) | Sub Sur face coarse fragments (%) | Soil depth (cm) | Profile development | CEC (cmol (p+) $kg^{-1}$) | BS (%) | OC (0-15 cm) (%) | EC $dSm^{-1}$ | Overall LCC |
| Black pedon-1 | Basalt | 1-3 (II) | Slight (II) | Somewhat poor (III) | Clay loam (II) | 2.90 (I) | - | 2.71 (I) | 120 (II) | A-AC (III) | 33.77 (I) | 91.58 (II) | 0.67 (III) | 0.21 (I) | IIIwsf |
| Black pedon-2 | Grey shale | 1-3 (II) | Slight (II) | Somewhat poor-Moderately well (II) | Gravelly clay (III) | 15.9 (III) | - | 12.26 (II) | 88 (III) | A-B-BC-C (III) | 29.33 (I) | 80 (II) | 1.2 (I) | 0.14 (I) | IIIs |
| Brown pedon-3 | Pink shale | 1-3 (II) | Moderate (II) | Moderately well-Well (II) | Extremely gravelly clay (III) | 72.82 (IV) | - | 71.43 (V) | 98 (III) | A-B-C (III) | 23.39 (I) | 75 (III) | 0.95 (II) | 0.19 (I) | Vs |
| Balck pedon-4 | Lime stone | 3-5 (III) | Moderate (II) | Moderately well (II) | Sandy clay loam (IV) | 3.45 (II) | - | 1.74 (I) | 25 (IV) | A-AC-C (IV) | 14.54 (II) | 93 (II) | 0.2 (IV) | 0.13 (I) | IVsf |
| Red pedon-5 | Schist | 1-3 (II) | Slight (II) | Moderately well-Well (II) | Very gravelly sandy clay loam (IV) | 38.86 (III) | - | 26.82 (III) | 90 (III) | A-B-BC (III) | 17.89 (I) | 83 (II) | 0.46 (IV) | 0.76 (I) | IVsf |
| Red pedon-6 | Granite | 1-3 (II) | Moderate (II) | Well (I) | Gravelly Sandy clay loam (IV) | 25.95 (III) | 0.1-3 (II) | 22.95 (III) | 50 (III) | A-B-BC-C (III) | 11.31 (II) | 70 (III) | 0.38 (IV) | 0.15 (I) | IVsf |
| Red pedon-7 | Sand stone | 3-5 (III) | Moderate (III) | Somewhat excessive (I) | Sandy loam (III) | 7.99 (II) | 3-5 (III) | 7.07 (I) | 35 (IV) | A-B-BC-C (II) | 4.65 (III) | 69 (III) | 0.32 (IV) | 0.13 (I) | IVsf |

**Table 3:** Soil suitability classes of selected study area of Budhihal micro-watershed for Cotton

| Pedons | Geology | Climate (c) | | Topographic | | Physico - chemical characteristics (f) | | | | | | | | | Overall limitation | Suitability sub class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rain fall mm | Mean temp $^0C$ | Slope (t) | Drainage (w) | Effective soil depth cm | Coarse fragments % | Texture | $CaCO_3$ % | pH 1:2.5 | OC % | CEC $cmolkg^{-1}$ | BS % | ESP % | | |
| Black pedon-1 | Basalt | 1 | 1 | 2 | 2 | 1 | 1 | 1 | N | 3 | N | 3 | 1 | 1 | 3x2 | S3f |
| Black pedon-2 | Greyshale | 1 | 1 | 2 | 1 | 2 | N | 1 | N | 3 | 2 | 3 | 1 | 1 | 3x2 | S3f |
| Brown pedon-3 | Pinkshale | 1 | 1 | 2 | 1 | 2 | N | 1 | N | 3 | 3 | N | 2 | 1 | 3x2 | S3f |
| Black pedon-4 | Limestone | 1 | 1 | 3 | 1 | N | 1 | 3 | N | 3 | N | N | 1 | 1 | 3x3 | S3tf |
| Red pedon-5 | Schist | 1 | 1 | 2 | 1 | 2 | N | 2 | N | 3 | N | N | 1 | 1 | 3x1 | S3f |
| Red pedon-6 | Granite | 1 | 1 | 2 | 1 | 3 | N | 3 | 3 | 3 | N | N | 2 | 2 | 3x4 | S3f |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Red pedon-7 | Sandstone | 1 | 1 | 3 | 3 | 3 | 2 | N | 1 | 2 | N | N | 2 | 2 | 3x3 | S3twf |

**Table 4:** Soil suitability classes of selected study area of Budhihal micro-watershed for Pigeonpea

| Pedons | Geology | Climate (c) | | Topographic | | Physico - chemical characteristics (f) | | | | | | Overall limitation | Suitability sub class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rain-fall mm | Mean temp $^{o}C$ | Slope (t) | Drainage (w) | Effective soil depth cm | Coarse fragments % | Texture | pH 1:2.5 | EC $dSm^{-1}$ | ESP % | | |
| Black pedon-1 | Basalt | 0 | 1 | 1 | 2 | 1 | 1 | 2 | 3 | 1 | 1 | 3x1 | S3f |
| Black pedon-2 | Greyshale | 0 | 1 | 1 | 2 | 2 | 1 | 2 | 3 | 1 | 1 | 3x1 | S3f |
| Brown pedon-3 | Pinkshale | 0 | 1 | 1 | 1 | 2 | 3 | 2 | 3 | 1 | 1 | 3x1 | S3f |
| Black pedon-4 | Limestone | 0 | 1 | 2 | 2 | N | 1 | 1 | 3 | 1 | 1 | 3x1 | S3f |
| Red pedon-5 | Schist | 0 | 1 | 1 | 1 | 2 | 3 | 1 | 3 | 1 | 1 | 3x2 | S3f |
| Red pedon-6 | Granite | 0 | 1 | 1 | 1 | 3 | 2 | 1 | 3 | 1 | 2 | 3x2 | S3f |
| Red pedon-7 | Sandstone | 0 | 1 | 2 | 3 | N | 1 | 1 | 2 | 1 | 2 | 3x1 | S3w |

**Table 5:** Soil suitability classes of selected study area of Budhihal micro-watershed for Groundnut

| Pedons | Geology | Climate (c) | | Topographic | | Physico - chemical characteristics (f) | | | | | | Overall limitation | Suitability sub class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rain fall mm | Mean temp $^{0}C$ | Slope (t) | Drainage (w) | Effective soil depth cm | Coarse fragments % | Texture | $CaCO_3$ % | pH 1:2.5 | ESP % | | |
| Black pedon-1 | Basalt | 1 | 1 | 1 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 3x1 | S3w |
| Black pedon-2 | Greyshale | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 3 | 2 | 3x1 | S3f |
| Brown pedon-3 | Pinkshale | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 | 2 | 2 | 3x1 | S3f |
| Black pedon-4 | Limestone | 1 | 1 | 2 | 2 | N | 1 | 1 | 2 | 2 | 2 | 3x1 | S3f |
| Red pedon-5 | Schist | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 2x3 | S2f |
| Red pedon-6 | Granite | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 2 | 3 | 3x2 | S3f |
| Red pedon-7 | Sandstone | 1 | 1 | 2 | 0 | 3 | 1 | 3 | 0 | 1 | 3 | 3x3 | S3f |

**Table 6:** Soil suitability classes of selected study area of Budhihal micro-watershed for Sorghum

| Pedons | Geology | Climate (c) | | Topographic | | Physico - chemical characteristics (f) | | | | | | | | | Overall limitation | Suitability sub class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rain fall mm | Mean temp $^{0}C$ | Slope (t) | Drainage (w) | Effective soil depth cm | $CaCO_3$ % | Coarse fragments % | Texture | pH 1:2.5 | OC% | CEC $cmolkg^{-1}$ | BS % | ESP% | | |
| Black pedon-1 | Basalt | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 2x4 | S2wf |
| Black pedon-2 | Greyshale | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 3 | 3 | 0 | 1 | 2 | 3x1 | S3f |
| Brown pedon-3 | Pinkshale | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 2 | 1 | 1 | 1 | 2 | 3x1 | S3f |
| Black pedon-4 | Limestone | 1 | 1 | 2 | 1 | N | 2 | 1 | N | 2 | 3 | 2 | 1 | 1 | 3x1 | S3f |
| Red pedon-5 | Schist | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2x4 | S2f |
| Red pedon-6 | Granite | 1 | 1 | 1 | 1 | 2 | 1 | 2 | N | 2 | 2 | 2 | 1 | 3 | 3x1 | S3f |

### 3.2.2 Land suitability classification for crops

Land/soil suitability for raising various crops was evaluated following FAO guidelines (Anonymous, 2009) [2]. Considering climate and soil requirements of the major field crops namely sorghum, cotton, groundnut and pigeon pea, the soils of study area were rated as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N) for specific field crops. Suitability of soils derived from different parent materials for raising major field crops namely sorghum, cotton, groundnut and pigeon pea were evaluated considering climate and soil requirements of the above said crops and these soils were rated as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N) for above said field crops (Tables 3, 4, 5, 6). Land/soil suitability of study area for the major field crops namely sorghum, cotton, groundnut and pigeon pea was evaluated and the selected study area irrespective of the parent materials was rated as marginally suitable (S3) for both cotton (Table 3) and pigeon pea (Table 4). The most limiting factor in determining the suitability of selected study area derived from diversified geological materials for cotton and pigeon pea was physico-chemical characteristics of soils with exception to the soils derived from sandstone where topographic factor slope and drainage factor wetness in addition to physico-chemical characteristics of soil were the limiting factors in determining land suitability for cotton while drainage factor wetness was the limiting factor in determining suitability of soils derived from sandstone for pigeon pea and these findings are in agreement with Gabhane *et al.* (2006) [3].

The soils derived from schist was rated as moderately suitable (S2) while rest of the soils derived from other geological materials were rated as marginally suitable (S3) for groundnut crop (Table 5). The most limiting factor in rating suitability of the soil derived from basalt for groundnut was drainage factor wetness and in rest of the soils derived from other parent materials were the physico-chemical properties of soils and these findings are in agreement with Ravikumar (2004) [6]. The soils derived from basalt, schist and sandstone were rated as moderately suitable (S2) and that of pinkshale, limestone and granite were rated as marginally suitable (S3) for sorghum. In the soils derived from both basalt and sandstone parent materials the drainage factor wetness as well as physico-chemical properties of soil were the most limiting factors and in rest of the soils the physico-chemical properties of soils were the most limiting factors in rating the soil suitability for sorghum (Table 6) and these findings are in agreement with Vadivelu and Sys (1993) [8].

## 4. Conclusion

The soils were grouped under four soil series namely Karekal (Pedon-1), Bilebhavi (Pedons-2, 3 and 5), Nagarbanda (Pedons-4 and 7) and Revunayak (Pedon-6) and seven mapping units. Soils were grouped under three land capability classes such as III, IV and V. Irrespective of the parent materials soils under study were rated as marginally suitable (S3) for both cotton and pigeonpea. Schist derived soil was rated as moderately suitable (S2) while the soils derived from rest of the parent materials were rated as marginally suitable (S3) for groundnut crop. The basalt, schist and sandstone derived soils were rated as moderately suitable (S2) and the soils derived from the rest of the parent materials were rated as marginally suitable (S3) for sorghum.

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2. WDD, GoK, Bangalore; Sujala-Project Implementing Agency and
3. NBSSLUP, RC, Bangalore: Lead Consortium Partner of Sujala-III, Project.

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