Plant Archives Vol. 26, No. 2, 2026 pp. 2047-2052 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.2.281

LAND CAPABILITY CLASSIFICATION OF THE MADAPUR SUB-WATERSHED IN THE NORTHERN TRANSITION ZONE OF KARNATAKA INDIA

Mahalaxmi Shrishail Devarnavadgi[1]*, S.S. Gundlur[1], B. R. Jagadeesh[1], Milind P. Potdar[2], M.S. Shirahatti[3], Meti Ranjitha[1], Adithya kunal[4] and Chaya G.B.[5]

[1]Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India.

[2]Department of Agricultural Meteorology, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India.

[3]Department of Agricultural Engineering, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India.

[4]Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, GKVK, Bengaluru-560065, Karnataka, India.

[1]Department of Crop Physiology, University of Agricultural Sciences, Dharwad-580 005, Karnataka, India

*Corresponding author E-mail: devarnavadgimahalaxmi@gmail.com

(Date of Receiving-01-08-2026; Date of Revision-02-10-2026; Date of Acceptance-07-10-2026)

ABSTRACT

Land capability classification provides a scientific basis for matching land use with inherent soil and terrain limitations and for identifying appropriate conservation measures. The present study was conducted during 2024-2026 in the Madapur sub-watershed (4D4F2m) of Shiggaon taluk, Haveri district, Karnataka, covering a total geographical area of 6869.05 ha. A detailed soil survey was carried out using high-resolution World View-2 satellite imagery, cadastral maps and field traversing at a scale of 1:7,920. Twenty-nine soil profiles were studied, and the resulting soil resource inventory comprised 29 soil series delineated into 166 mapping units. The mapping units were grouped into land capability classes following Sehgal (1996). The evaluated area covered 6415 ha, accounting for 93.39 per cent of the total geographical area. Land capability classes II, III and IV were identified. Class II occupied the largest area of 3112 ha, comprising IIs (1665 ha; 24.25 %) and IIes (1447 ha; 21.06 %). Class III covered 2194 ha (31.95 %), represented by IIIs (630 ha; 9.18 %) and IIIes (1564 ha; 22.77 %), whereas Class IV occupied 1109 ha (16.14 %), comprising IVs (194 ha; 2.82 %) and IVes (915 ha; 13.32 %). Soil depth, gravelliness and texture were the major inherent limitations, while erosion constituted an additional constraint in the IIes, IIIes and IVes subclasses. The predominance of Class II land indicates that a substantial portion of the Madapur sub-watershed is suitable for sustained cultivation with moderate management interventions. Class III and IV lands require progressively greater soil and water conservation measures, including erosion control, moisture conservation and appropriate land-use practices. The study provides a spatial basis for conservation-oriented land-use planning and sustainable management of soil resources in the sub-watershed.

***Key words*:** Land capability classification, soil resource inventory, soil limitations, erosion, land-use planning, Madapur sub-watershed.

Introduction

Land is a finite and valuable natural resource that should be managed in accordance with its inherent potential. Rapid population growth, excessive exploitation and improper management of natural resources have intensified land degradation and increased competition for available land. Land performs several important functions, including supporting plant growth and storing water and nutrients required by living organisms. Its capability is controlled by attributes such as soil type, soil

depth, texture, geology, topography and hydrological conditions, which together influence the extent to which land can be used for different purposes (Panhalkar, 2011). Sustainable management of land resources is essential for maintaining agricultural productivity, food security and environmental quality. Increasing pressure on land, coupled with soil erosion, declining soil fertility and inappropriate land use, has increased the need for systematic assessment of land according to its inherent potential and limitations.

Land capability classification provides a practical basis for such assessment by grouping land units according to their characteristics and their capacity for sustained use. A land classification according to its capabilities for use may be defined as one in which bodies of land are classified on the basis of their physical characteristics, with or without economic considerations, according to their capability for human use (USDA, 1938). This concept continues to be useful in land-use planning because it provides a broad indication of land potential while emphasizing conservation requirements. Land capability classification remains useful for broad-level planning because of its simplicity and ease of interpretation, although more specific evaluations may be required for crop-level recommendations (Yadav and Patil, 2024). This classification gives a general idea about the capability of the soils but does not explain specific crop performance unless supplemented by additional information (Ramamurthy *et al.*, 2020).

The United States Department of Agriculture developed a land capability classification system consisting of eight classes designated by Roman numerals I to VIII. Classes I to IV are generally suitable for cultivation, although the severity of limitations and the need for conservation measures increase progressively from Class I to Class IV. In contrast, Classes V to VIII are generally unsuitable for regular cultivation and are better suited to pasture, grazing, woodland, range and wildlife uses (USDA, 1973). The assignment of land to a particular capability class depends on important soil-site characteristics such as landscape position, slope, soil depth and texture (Tideman, 1990). Thus, land capability classification provides a useful basis for identifying land units with similar limitations and management requirements and supports scientific land-use planning at the watershed scale.

Material and Methods

The study was conducted during 2024–2026 in the Madapur sub-watershed (4D4F2m), located in Shiggaon taluk of Haveri district, Karnataka, India. The sub-watershed lies between 15°05’ 56” and 15°06’ 05” N latitude and 75°18’ 41” and 75°21’ 18’ E longitude. The elevation of the study area ranges from 500 to 634 m above mean sea level, and the total geographical area of the sub-watershed is 6869.05 ha. The study area experiences mean maximum temperatures ranging from 28 to 38 °C and mean minimum temperatures ranging from 16 to 23 °C. The average annual rainfall of the sub-watershed is about 717.0 mm. Geologically, the area is characterized by formations belonging to the Archaean Dharwar Supergroup. The soils of the sub-watershed predominantly consist of shallow to deep black clay soils and red sandy loam soils, occurring approximately in equal proportions. Agriculture is the major land use in the sub-watershed, with *kharif* (June–September) being the principal cropping season. The major crops cultivated in the area include maize, sugarcane, sorghum, pulses, groundnut, cotton, wheat and soybean, along with horticultural crops.

A detailed soil survey of the study area was conducted using high-resolution WorldView-2 satellite imagery and cadastral maps. The satellite image and scanned topographic sheets were georeferenced and subdivided using ArcGIS 10.4.1 to prepare subsets at a scale of 1:7,920. During the detailed soil survey, landforms were identified based on geology, drainage pattern, surface characteristics, slope features and existing land use. After delineating the landforms on the satellite image, representative areas were selected by traversing the landscape. Transects were laid perpendicular to the contours so as to capture the major variations occurring within each landform. Along each transect, soil profiles were opened at relatively close intervals wherever changes in slope, erosion status, gravelliness, stoniness or soil depth were observed. Accordingly, a total of 29 soil profiles were studied.

At each pedon location, a fresh soil profile was exposed and detailed morphological characteristics, including colour, texture, structure and consistency, were recorded following Soil Survey Staff (2022). Soil samples collected from different horizons were air-dried, ground, passed through a 2 mm sieve and analysed for selected physical, physicochemical and chemical properties. Particle-size distribution was determined by the international pipette method (Piper, 2010). Soil pH and electrical conductivity (EC) were measured in a 1:2.5 soil suspension following Jackson (1973). Organic carbon (OC) was estimated by the Walkley and Black (1934) method, while calcium carbonate equivalent ($CaCO_3$) was determined as described by Piper (2010). Cation exchange capacity (CEC) was determined using 1 N

Table 1: Soil phases under different Land Capability Classes (LCC).

Soil phases	Land Capability Class	Description	Area (ha)	TGA (%)
ATTfA1g2, ATTiA1g2, ATTmA1, ATTmA1g1, ATTmA1g2, ATTmA1g2St1, BVPfA1g2St2, BVPiA1g2, BVPiA1g3St2, BVPmA1g1, JLGmA1, MKRmA1g1, SKBfA1, SKBfB2, SKBiA1g3St3, LDKmA1, LDKmA1g1, BTPmB1, GPHmA1	Class IIs	Good cultivable lands for sustainable agriculture with moderate limitations of soil	1665	24.25
ATTfB2g1St1, ATTfC3g2, ATTmB2, ATTmB2g1, ATTmB2g1St1, ATTmB2g2, ATTmB2g2Ca, ATTmB2g2St1, BVPfB2, BVPfB2g2, BVPfC3, BVPiB2g2, BVPiB2g2St1, BVPiB2g2St2, BVPiC3g3St1, BVPmB2, BVPmB2g1, BVPmB2g2, BVPmB2g2St2, BVPmC3g2, BVPmC3g2St1, SGBfC3g2St1, SGBhC3g3, SGBmB2, SGBmC3g1, SGBmC3g2, VKPmB2g1, VKPmB2g2St2, VKPmC2g1, JLGmB2, JLGmB2g2, KPRmB2, LDKfB2, LDKmB2, MVDmB2g2Ca, BTPfB2g2, BTPmB2, BTPmB2g1Ca, BTPmB2g2, GDAfB2g2, GPHmB2, MGDmB2, MKRmC3g3St3	Class IIes	Good cultivable lands for sustainable agriculture with moderate limitations of erosion, soil depth, gravelliness and texture	1447	21.06
AKTiA1g2, AKTiA1g2St1, AKTmA1, AKTmA1g1, AKTmA1g2, BDTmA1g1St1, CKRfA1g1, CKRfA1g2, BTKmA1g1, MDTmA1, MDTmA1g1, MDTmA1g2, GDMfA1, GDMfA1g2, GDMiA1g3St3, GDMmA1g1, GDMmA1g2, RNRmA1, RNRmA1g1, GDAfA1, GDAmA1, GDAmA1g1, GDAmA1g2	Class IIIs	Moderately good cultivable lands for sustainable agriculture with severe limitations of soil depth, gravelliness and texture	630	9.18
AKTfB2g3St3, AKTmB2g1St2, AKTmB2g2, MUKmA1, MUKmA1g1, MUKfB2, MUKfA1g1, MUKfB2g1, MUKfB2g2St1, MUKfC3g2St1, MUKmB2, MUKmB2g2, YSJfB2g2St1, YSJfC3g2St1, YSJfC3g3St1, YSJmA1, YSJmA1g1Ca, YSJmB2g1Ca, YSJmB2g2, BDThC3g3, BDThC3g3St1, BDTiB2g2, BDTmB2, BDTmB2g1, CKRfB2g2St1, CKRfC3g2, CKRfC3g3, CKRhC3g2, CKRiB2g2, CKRiC3g3, CKRmB2, CKRmB2g1, CKRmC3g2St1, DRThC3g3St2, MDTmB2g1, SKBmB2g2, SKBmC3g3, GDMiC3g2St1, GDMmB2, GDMmB2g2St1, GDMmC3g3St3, RNRfB2g2St1, RNRmB2g2St1, GDAfC3g2, GDAhC3g3St2, GDAmC3g2	Class IIIes	Moderately good cultivable lands for sustainable agriculture with severe limitations of erosion, soil depth, gravelliness and texture.	1564	22.77
HLGmA1g1, HLGmB2, MLPiC3g2St3, MLPmA1, MLPmA1g1, MLPmA1g2, ADGmA1g1, NBPmA1g1	Class IVs	Fairly good cultivable lands with severe limitations of soil depth, gravelliness and texture.	194	2.82
HLGfB2g1Ca, SRLfB2g1, SRLfB2g2, SRLfB2g2St1, SRLfB2g2St2, SRLiB2g2St2, SRLiC3g3St2, SRLmB2, ADGfC3g3, ADGiB2, ADGiB2g1St2, ADGiB2g2St1, ADGiC3g2St1, ADGiC3g3St2, ADGiC3g3St3, ADGmB2, ADGmB2g1, ADGmB2g2St1, AKTiC4g3St4, AKTmB2g2St1, NBPfA1g1, NBPfC3g3, NBPfC3g3St3, NBPiB2g3St1, NBPiB2g3St3, NBPiC3g3St2	Class IVes	Fairly good cultivable lands with severe limitations of erosion, soil depth, gravelliness and texture.	915	13.32

sodium acetate at pH 8.2 as described by Bower (1952). Base saturation was calculated as the sum of exchangeable bases divided by CEC and expressed as a percentage, whereas exchangeable sodium percentage (ESP) was calculated as the proportion of exchangeable sodium to CEC. Based on the detailed soil resource inventory, 29 soil series were identified and delineated into 166 mapping units as phases of soil series (Fig. 1 and Table 1). These mapping units were subsequently grouped into different land capability classes following the guidelines of Sehgal (1996).

Results

The land capability classification of the Madapur sub-watershed grouped the evaluated soil phases into Classes II, III and IV, with soil-related limitations occurring either individually or in combination with erosion hazards (Table 1 and Fig. 6). The evaluated area covered 6415 ha,

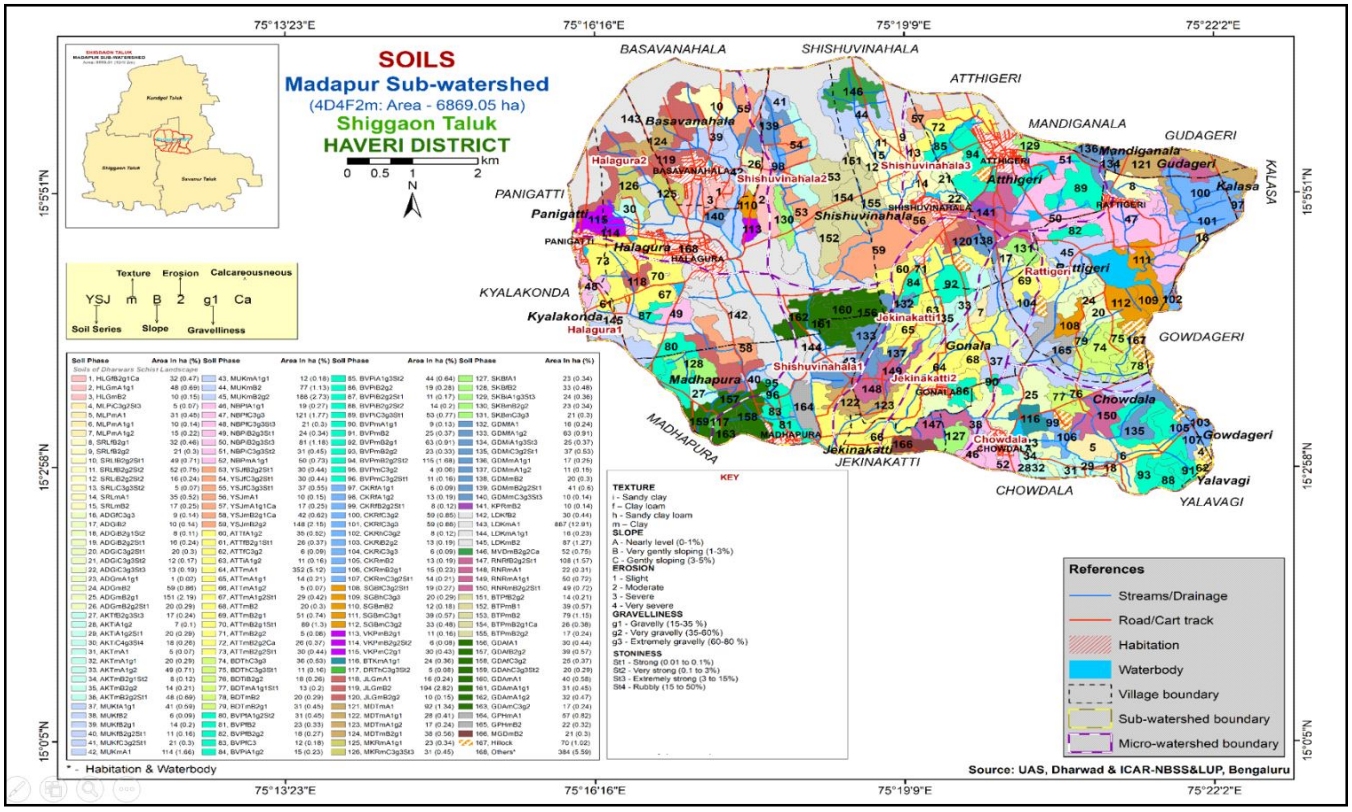


Fig. 1: Soil phase map of Madapur Sub-watersh.

representing approximately 93.39 per cent of the total geographical area.

Class II lands were the most extensive, comprising subclasses IIs and IIes. Subclass IIs occupied 1665 ha (24.25%) and represented good cultivable lands with moderate soil limitations, primarily associated with soil depth, gravelliness and texture. Subclass IIes covered 1447 ha (21.06%) and consisted of good cultivable lands affected by moderate erosion in addition to soil-related constraints. Together, Class II lands accounted for 3112 ha of the sub-watershed. Class III lands occupied 2194 ha (31.95%) and were represented by subclasses IIIs and IIIes. Subclass IIIs covered 630 ha (9.18%) and comprised moderately good cultivable lands with severe limitations related mainly to soil depth, gravelliness and texture. Subclass IIIes extended over 1564 ha (22.77%) and represented moderately good cultivable lands affected by severe erosion in combination with soil-related constraints. The relatively large extent of IIIes indicated that erosion, together with inherent soil limitations, considerably restricted the agricultural potential of these lands.

Class IV lands accounted for 1109 ha (16.14%) of the total geographical area. Of this, subclass IVs occupied 194 ha (2.82%) and included fairly good cultivable lands with severe soil limitations, particularly shallow soil depth, gravelliness and unfavourable texture. Subclass IVes covered 915 ha (13.32%) and consisted of fairly good cultivable lands subjected to severe erosion along with soil-related limitations. Overall, Class II lands were dominant in the Madapur sub-watershed, followed by Classes III and IV. Among the individual subclasses, IIs occupied the largest area, followed by IIIes, IIes, IVes, IIIs and IVs. Soil depth, gravelliness and texture were the major inherent limitations governing land capability, while erosion constituted an additional constraint in the IIes, IIIes and IVes subclasses. These findings indicate that a substantial proportion of the sub-watershed remains suitable for cultivation, although appropriate soil and water conservation measures are essential for sustaining

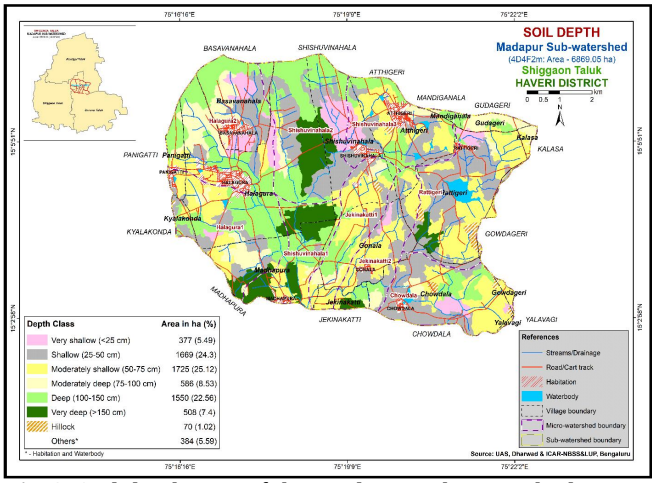


Fig. 2: Soil depth map of the Madapur sub-watershed.

productivity in areas affected by erosion and severe soil limitations.

Discussion

Land capability classification is a conservation-oriented system that groups land according to the degree and nature of permanent or semi-permanent limitations influencing its agricultural use. Soil depth, texture, gravelliness, stoniness, slope, erosion and drainage are among the major factors considered in differentiating capability classes. The dominance of Class II lands in the Madapur sub-watershed indicated that a substantial portion of the area was suitable for sustained cultivation, although moderate management interventions were required. Previous studies have also demonstrated that land capability is largely governed by soil properties, topography and erosion, with Classes I–IV generally regarded as cultivable lands having progressively greater limitations and conservation requirements (Panhalkar, 2011; Upadhayaya *et al*., 2013; Yadav and Patil, 2024).

The IIs lands were characterized by moderate soil-related limitations and could be managed for sustainable crop production through balanced fertilization, addition of organic amendments, crop residue recycling and adoption of suitable crop rotations. In contrast, the IIes lands were additionally affected by erosion, suggesting their occurrence on gently sloping to undulating terrain where surface runoff may result in the loss of fertile topsoil. Such areas require appropriate conservation practices such as contour cultivation, graded or

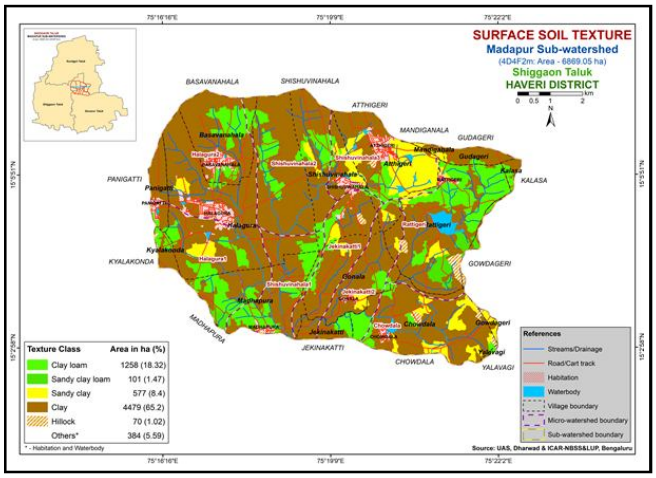


Fig. 3: Surface soil texture map of the Madapur sub-watershed.

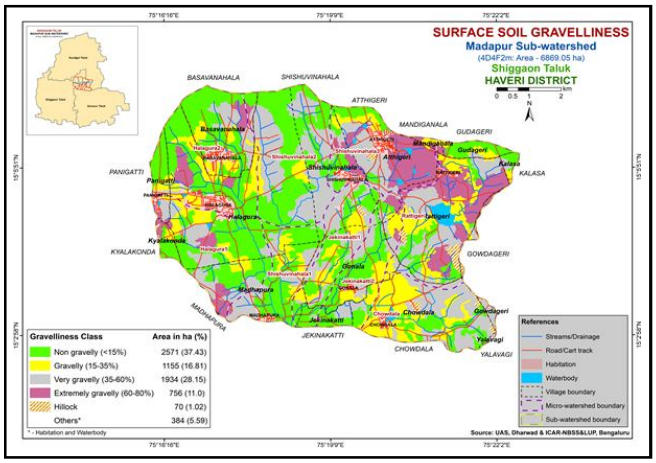


Fig. 4: Surface soil gravellliness map of the Madapur sub-watershed.

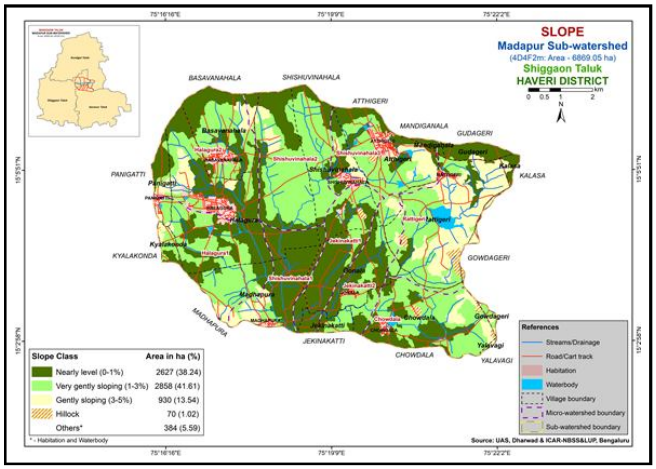


Fig. 5: Slope map of the Madapur sub-watershed.

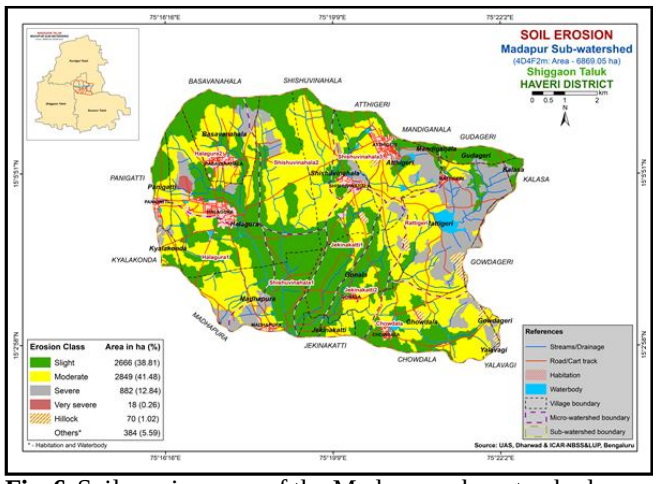


Fig. 6: Soil erosion map of the Madapur sub-watershed.

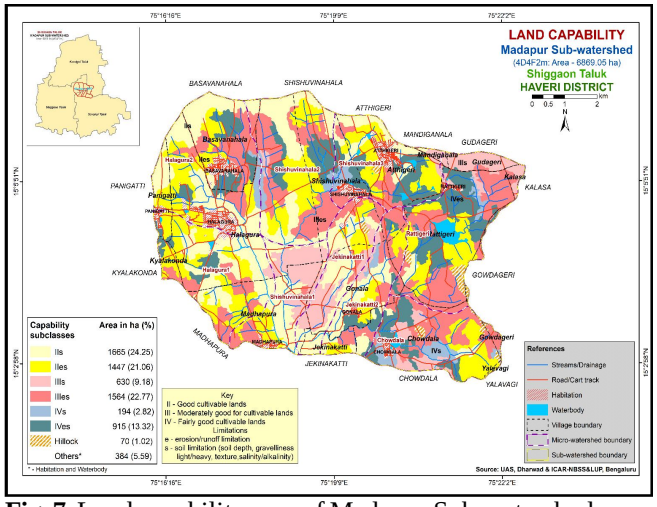


Fig. 7: Land capability map of Madapur Sub-watershed.

compartment bunding, vegetative barriers and maintenance of adequate soil cover. Ramesh Kumar *et al*., (2018) reported that slope, erosion, soil depth and stoniness were important determinants of land capability classes in a Karnataka micro-watershed, while Rajesh *et al*., (2018) similarly grouped moderately cultivable lands under IIes where soil depth, slope, texture and erosion imposed moderate constraints.

Class III lands were moderately suitable for cultivation but were associated with severe limitations related to soil depth, gravelliness and texture, with erosion constituting an additional constraint in the IIIes subclass. Shallow soil depth restricts effective rooting volume and reduces available water storage and nutrient uptake, whereas higher gravel content decreases the proportion of fine soil available for root growth. Unfavourable soil texture may further limit crop performance through poor moisture retention in coarse-textured soils or restricted infiltration and aeration in fine-textured soils. Similar limitations involving soil depth, texture, slope and erosion were responsible for the occurrence of substantial areas under Classes III and IV in the Ganjigatti sub-watershed (Yadav and Patil, 2024). Rajesh *et al*., (2018) also classified marginally cultivable soils under IIIes due to severe limitations associated with erosion, slope, texture and soil depth.

Class IV lands represented the most restricted cultivable lands in the Madapur sub-watershed. Their shallow depth, high gravelliness, unfavourable texture and susceptibility to erosion considerably reduced the range of crops and intensity of cultivation that could be supported. These lands are therefore better suited to restricted cultivation, drought-tolerant crops, perennial horticulture, fodder production, agroforestry or silvipasture, along with intensive soil and water conservation measures. Comparable Class IV lands affected by limitations of slope, texture, erosion and rooting conditions were reported by Rajesh *et al*., (2018), while Ram *et al*., (2013) observed that shallow, gravelly and erosion-prone upland soils were generally placed in the more restricted capability classes. Overall, the land capability pattern of the Madapur sub-watershed highlights the need to utilize each land unit according to its inherent potential and to integrate soil fertility management with erosion control and moisture conservation practices (Table 1 and Fig. 6).

References

Bower, C.A., Reitemeier R.F. and Fireman M. (1952). Exchangeable cations analysis of saline and alkali soils. *Soil Science*, **73**, 251-261.

Jackson M.L. (1973). *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi, India.

Panhalkar, S. (2011). Land capability classification for integrated watershed development by applying remote sensing and GIS techniques. *ARPN Journal of Agricultural and Biological Science*, **6(4)**, 46-55.

Piper, C.S. (2010). *Soil and Plant Analysis: A Laboratory Manual of Methods for the Examination of Soils and the Determination of the Inorganic Constituents of Plants*. Reprint for Asia, Scientific Publishers, Jodhpur, India.

Ramamurthy, V., Challa O., Naidu L.G.K., Anil Kumar K.S., Singh S.K., Mamatha D., Ranjitha K. and Mishra B.B. (2020). Land evaluation and land use planning. In: *The Soils of India*, World Soils Book Series, Mishra B B (Ed.), Springer Nature, Switzerland, 191-214.

Ramesh Kumar, S.C., Bhaskar B.P., Chandrakala M., Niranjana K.V., Hegde R. and Singh S.K. (2018). Land capability and land irrigability classification in Garakahalli micro-watershed of Karnataka. *Agropedology*, **28(1)**, 60-70.

Rajesh, N.L., Bai R.M., Rajesh V., Sathishkumar U., Bhat S.N. and Rudramurthy H.V. (2018). Land resource inventory of Kalmali North-2 micro-watershed for assessment of land capability class and land suitability for horticulture crops using geospatial technology. *Journal of Pharmacognosy and Phytochemistry*, **7(6)**, 2709-2716.

Ram, R.L., Jha P., Sharma P.K., Ahmed N., Kumar R., Sharanappa, Vasudeo Rao D.A.L. and Singh V. (2013). Mapping and assessment of soils in Nagarjunasagar catchment, Lingasugur Taluk of Karnataka. *International Journal of Agricultural Science*, **5(1)**, 347-353.

Sehgal, J.L. (1996). *Pedology: Concepts and Applications*. Kalyani Publishers, New Delhi, 176-185.

Soil Survey Staff (2022). *Keys to Soil Taxonomy*. USDA Natural Resources Conservation Service, United States Department of Agriculture, Washington, D.C., USA, 410.

Tideman, E.M. (1990). *Watershed Management: Guidelines for Indian Conditions*. Omega Scientific Publishers, New Delhi.

Upadhayaya, V.K., Gupta R.D. and Arora S. (2013). Land capability classification in relation to soil properties representing bio-sequences in foothills of North India. *Journal of Soil and Water Conservation*, **12(1)**, 3-9.

USDA (1938). *Soils and Men: Yearbook of Agriculture*. United States Government Printing Office, Washington, D.C., USA, 1232.

USDA (1973). *Land Capability Classification*. Agriculture Handbook No. 210, Soil Conservation Service, United States Department of Agriculture, Washington, D.C., USA.

Walkley, A. and Black I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, **37**, 29-38.

Yadav, M.B.N. and Patil P.L. (2024). Land capability and irrigability classification of the Ganjigatti sub-watershed in the Hilly zone of Karnataka. *Journal of Soil and Water Conservation*, **23(1)**, 7-21.