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SOIL-SITE SUITABILITY EVALUATION FOR MAJOR HORTICULTURAL CROPS IN THE MADAPUR SUB-WATERSHED OF KARNATAKA, INDIA, USING REMOTE SENSING AND GIS

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ABSTRACT

The present study was undertaken to evaluate the soil-site suitability of the Madapur sub-watershed, Karnataka, India, for major horticultural crops using soil survey, remote sensing and GIS techniques. The Madapur sub-watershed, located in Shiggaon taluk of Haveri district, covers an area of 6869.05 ha and falls under the northern transitional zone of Karnataka. A detailed soil resource inventory was carried out using a 1:7,920 scale base map, satellite imagery and field survey. Twenty-four representative soil profiles were studied for morphological, physical and chemical properties, and 29 soil series were identified and grouped into 166 soil mapping units. Soil-phase-level suitability assessment was carried out for mango, sapota, guava and banana following the limitation approach of FAO using ArcGIS 10.8. The results revealed considerable spatial variability in soil-site characteristics and crop suitability across the watershed. For mango, the land was mainly classified as moderately suitable, marginally suitable and currently not suitable, with rooting depth, gravelliness, texture and nutrient availability as major limitations. Sapota and guava showed comparatively wider adaptability, although shallow depth, poor drainage, excessive gravelliness and unfavorable texture restricted their suitability in several mapping units. Banana exhibited the highest potential among the evaluated crops, with 1030 ha (14.99%) classified as highly suitable, mainly in deep, well-drained soils of KPR and LDK soil phases. However, 2046 ha (29.79%) of the watershed was currently not suitable for banana due to severe rooting, drainage and gravel limitations. Overall, deep, well-drained soils with favorable texture, better moisture retention and adequate fertility were more suitable for horticultural development, whereas shallow, gravelly and poorly drained soils showed poor suitability. The study demonstrates the usefulness of RS-GIS-based soil-site evaluation for scientific crop selection, land use planning and sustainable horticultural development in the Madapur sub-watershed under semi-arid tropical conditions of Karnataka, India region.

***Keywords* :** Soil-site suitability, Horticultural crops, Remote sensing, Land evaluation.

Introduction

Sustainable agricultural production in the coming years depends largely on the careful use and conservation of natural resources. With the world population expected to increase substantially by 2050, food production systems must become more efficient without causing further degradation of land and water resources (FAO, 2017). Although intensive agriculture has played an important role in increasing crop yields, continuous and unscientific use of land has led to several problems such as soil erosion, compaction, nutrient exhaustion, salinity, alkalinity, waterlogging and decline in soil organic matter. These changes reduce the productive capacity of soils and create serious challenges for long-term food security (Anilkumar *et al.*, 2017).

In India, pressure on land resources is increasing due to population growth, expansion of cultivation and inappropriate management practices. Therefore, scientific planning of land use has become essential for maintaining soil productivity and preventing further degradation. Sustainable land management requires proper knowledge of soil characteristics, land capability, existing limitations and crop requirements. Such information helps in identifying the most suitable use of each land unit and supports better decision-making for crop production and resource conservation (Sehgal, 1995; Prabhavati *et al.*, 2017).

Land evaluation provides a systematic basis for assessing the potential of land for different agricultural uses. According to FAO (1976), land suitability assessment compares the characteristics of a land unit with the requirements of a particular land use or crop. This approach helps to determine whether a soil can support a crop successfully under existing conditions. It also identifies the major constraints that may reduce crop growth and yield, such as shallow soil depth, steep slope, poor drainage, erosion, coarse fragments, unsuitable texture, salinity, alkalinity and low nutrient availability (Naidu *et al.*, 2006; Sehgal, 2005).

Soil-site suitability evaluation is especially useful for selecting crops according to the inherent capacity of the land. Each crop has a specific requirement for soil depth, texture, moisture, drainage, slope, nutrient status and climatic conditions. When crops are grown without considering these requirements, productivity may decline and land degradation may increase. Hence, matching crop needs with soil and site characteristics is necessary for achieving higher yield, better profitability and sustainable use of land resources. This concept forms the foundation for scientific land use planning and crop diversification (Singh *et al.*, 1981; Vyas *et al.*, 2024).

Watersheds are considered suitable units for natural resource assessment and management because they represent an integrated system of land, soil, water, vegetation and human activity. Watershed-based planning helps in understanding the spatial variability of land resources and in suggesting location-specific management practices. This information is essential for preparing soil maps, identifying constraints and planning suitable cropping systems (Prabhavati *et al.*, 2017; Surya *et al.*, 2025). Remote sensing and Geographic Information System technologies have greatly improved the process of land resource evaluation. Remote sensing data are useful for identifying landforms, drainage patterns, land use, vegetation cover, slope and other surface features. GIS helps in storing, analysing and integrating spatial and non-spatial information to generate thematic maps. These maps are useful for researchers, planners and farmers to make scientific and site-specific decisions for sustainable agriculture (Aronoff, 1991; Walke *et al.*, 2012; Gangopadhyay *et al.*, 2018).

Several studies have shown that the integration of soil survey data with RS and GIS is effective for evaluating land capability and crop suitability in different watersheds. Soil and site parameters such as depth, slope, texture, gravelliness, erosion, drainage and nutrient status have been identified as major factors influencing the suitability of land for field and horticultural crops (Anilkumar *et al.*, 2017; Vyas *et al.*, 2024; Vemula *et al.*, 2026). Therefore, soil-site suitability assessment not only helps in identifying suitable crops but also indicates the management practices required to overcome specific limitations.

Keeping these considerations in view, the present study was undertaken to evaluate the soil resources of the Madapur sub-watershed using soil survey, remote sensing and GIS techniques. The study focuses on characterizing soil properties, assessing land capability, identifying major soil and site limitations, and evaluating the suitability of different soil mapping units for important crops. The outcome of the study will provide a scientific basis for sustainable land use planning, crop selection and improved management of soil and water resources in the watershed.

Material and Methods

The Madapur sub-watershed (4D4F2m) the designated study area, is situated in Shiggaon taluk of Haveri district. (Fig. 1), within the northern transitional zone of Karnataka. It is geographically positioned at $15^0 6'5''$ North latitudes and $75^0 18'41''$ East longitude covering an area of about 6869.05 hectares. The region experiences a hot semi-arid climate, with average maximum temperatures ranging between 26°C and 38°C, and minimum temperatures between 16°C and 22°C. The average annual rainfall typically varies from 620 to 1025 mm.

Methodology

A comprehensive survey of the Madapur sub watershed was undertaken using a 1:7,920 scale base map and satellite imagery to analyze geology, drainage patterns, surface features, slope gradients, land use, landforms and physiographic divisions. Based on these observations, twenty-four representative soil profiles were selected for morphometric analysis, with their physical and chemical properties determined using standard laboratory procedures. The detailed soil resource inventory identified 29 soil series, further subdivided into 166 mapping units according to surface characteristics. Soil-phase-level suitability maps were prepared for major fruit crops grown in the region Mango, Sapota, Guava and Banana using ArcGIS 10.8. Suitability assessment followed the limitation method outlined by Naidu *et al.* (2006), taking into account both the type and severity of land constraints. The evaluation was conducted in three phases. Phase I involved collecting land and soil characteristics (Table 1) in accordance with FAO (1976) guidelines. Phase II utilized landscape and soil requirements for the four crops, as specified by Naidu *et al.* (2006) and described by Sehgal (2005). Phase III applied a four-tier classification system, comprising orders, classes, subclasses and units. Two orders were defined: S (Suitable) and N (Not suitable). Order S included three classes S1 (Highly suitable), with negligible or minor limitations; S2 (Moderately suitable), with up to three moderate limitations that could slightly reduce productivity; and S3 (Marginally suitable), where severe limitations substantially affect yield yet allow marginally viable cultivation. Order N contained two classes N1 or N (Currently not suitable), where existing constraints hinder profitable use under present technology and economic conditions and N2 (Permanently not suitable), where limitations are too severe for sustainable use in the future. Subclasses denoted the nature of limitations or required improvements using lowercase letters after the class numeral, while units shown as numerals in parentheses indicated the relative priority for land improvement measures. The final suitability classification for each soil series was determined by comparing observed land characteristics with crop-specific limitation thresholds provided by Naidu *et al.* (2006), as described by Sehgal (2005), in line with FAO (1976) guidelines.

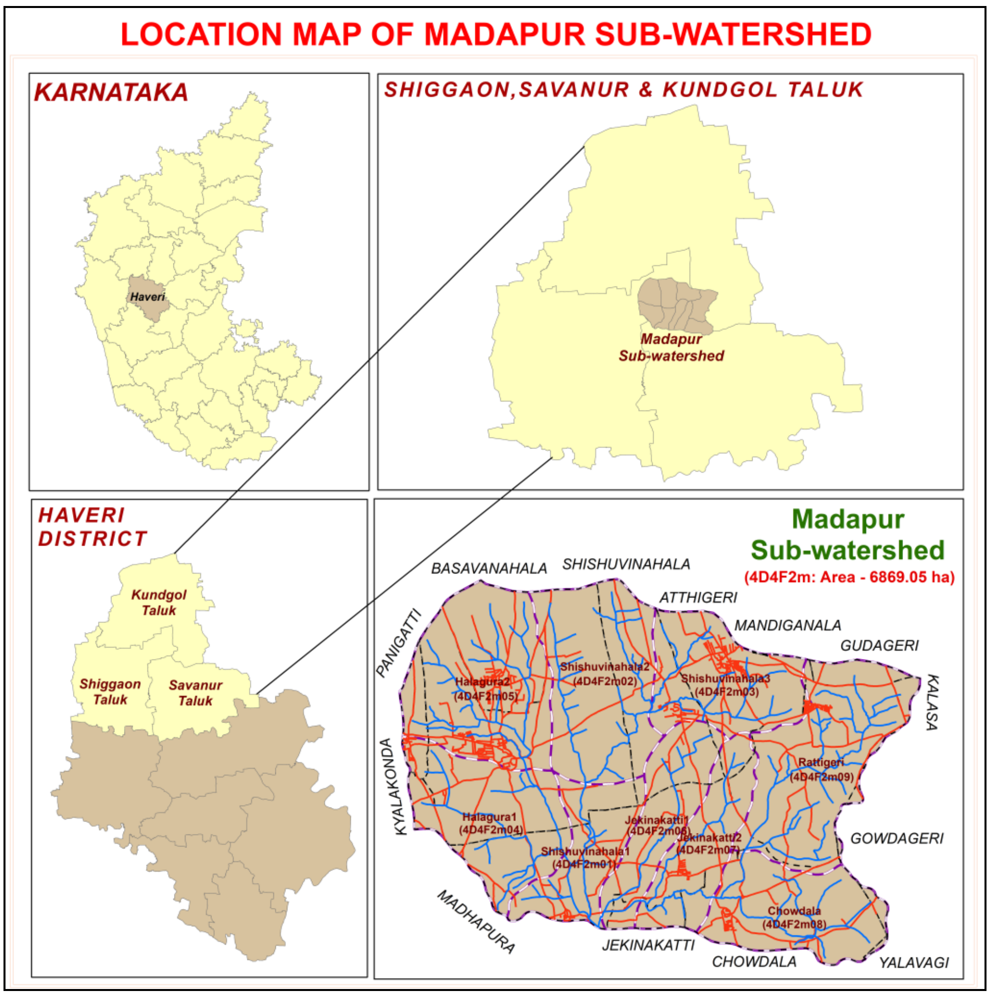

Fig. 1 : Location Map of Study area

Results and Discussion

The soil characteristics of the study area were evaluated using established soil-site suitability criteria for major fruit crops commonly cultivated in northern Karnataka. The resulting land suitability assessment is presented in Table 2 and Fig. 1-4.

Soil-site suitability evaluation for mango

Mango (*Mangifera indica* L.) is one of the most important tropical fruit crops cultivated in India owing to its high economic value and adaptability to diverse agro-climatic conditions. The crop performs best in deep (>100 cm), well-drained, fertile soils with clay loam to loam texture, moderate moisture-holding capacity and unrestricted rooting conditions. Mango is highly sensitive to prolonged waterlogging and shallow soils because these conditions restrict root development, nutrient uptake and tree vigour. Excessive gravelliness, coarse texture, poor drainage and shallow effective soil depth adversely affect orchard establishment and long-term productivity. According to the soil-site suitability criteria of Naidu *et al.* (2006), and FAO (1976), effective soil depth, drainage, texture, gravelliness and fertility constitute the major land qualities influencing mango cultivation. Soil-site evaluation at the soil-phase level in the Madapur sub-watershed revealed suitability classes ranging from moderately suitable (S2) and marginally suitable (S3) to currently not suitable (N) (Table 2 and Fig. 2). The dominant limitations identified were rooting depth, gravelliness, texture and nutrient availability.

Within the moderately suitable (S2) category, the S2gt subclass occupied 702 ha (10.22%) and comprised the soil phases GDMfA1, GDMfA1g2, GDMiA1g3St3, GDMiC3g2St1, GDMmA1g1, GDMmA1g2, GDMmB2, GDMmB2g2St1, GDMmC3g3St3, RNRfB2g2St1, RNRmA1, RNRmA1g1, RNRmB2g2St1, GDAfA1, GDAfB2g2, GDAfC3g2, GDAhC3g3St2, GDAmA1, GDAmA1g1, GDAmA1g2 and GDAmC3g2, where moderate gravelliness and texture constituted the principal limitations. The S2nt subclass covered 237 ha (3.44%) and included KPRmB2, MVDmB2g2Ca, BTPfB2g2, BTPmB1, BTPmB2, BTPmB2g1Ca and BTPmB2g2, in which moderate nutrient availability together with unfavorable texture restricted suitability. The S2rt subclass occupied 1020 ha (14.85%) and consisted of LDKfB2, LDKmA1, LDKmA1g1 and LDKmB2, where rooting depth and texture were the dominant limitations. The S2t subclass covered 99 ha (1.45%), represented by GPHmA1, GPHmB2 and MGDmB2, where texture alone moderately influenced crop performance. These soil phases possess deep effective soil profiles (>110 cm), moderately well-drained conditions, favourable cation exchange capacity and comparatively better moisture retention, making them suitable for commercial mango cultivation with appropriate nutrient and water management practices.

The marginally suitable (S3) category occupied 604 ha (8.79%) and included five suitability subclasses. The S3gn subclass, represented by BTKmA1g1 and DRThC3g3St2, occupied 125 ha (1.82%), where gravelliness and nutrient availability moderately restricted crop growth. The S3gnt subclass comprising MDTmA1, MDTmA1g1, MDTmA1g2 and MDTmB2g1 covered 175 ha (2.55%), where combined limitations of gravelliness, nutrient availability and unfavorable texture reduced suitability. The S3nt subclass, represented by JLGmA1, JLGmB2 and JLGmB2g2, occupied 220 ha (3.20%), where nutrient availability and clayey texture constituted the major constraints. The S3r subclass included MKRmA1g1 and MKRmC3g3St3, covering 54 ha (0.79%), while the S3rn subclass represented by SKBfA1, SKBfB2, SKBiA1g3St3, SKBmB2g2 and SKBmC3g3 occupied 30 ha (0.43%), were restricted rooting conditions together with nutrient limitations adversely affected crop suitability. Although these soils possess comparatively deeper profiles than the unsuitable lands, moderate gravelliness, heavy texture and rooting restrictions are expected to reduce water availability and root proliferation during prolonged dry periods. Therefore, successful mango cultivation in these mapping units requires adoption of integrated nutrient management, deep pit planting, organic matter incorporation, mulching and efficient soil and water conservation measures to minimize the effect of these inherent limitations.

The currently not suitable (N) class constituted the largest proportion of the watershed, covering 3753 ha (54.63%), which comprised of soil series in HLG, MLP, SRL, ADG, AKT, MUK, NBP, YSJ, ATT, BDT, BVP, CKR, SGB, VKP.These mapping units are predominantly characterized by shallow effective soil depth, somewhat poorly drained to moderately well-drained conditions, excessive gravelliness (35–80%), sandy clay to clay textures and restricted rooting conditions. The combined effect of these permanent soil limitations considerably lowers the productive potential of mango and renders these mapping units unsuitable for sustainable orchard establishment. Similar findings were also reported by Manjunatha *et al.* (2017), Vyas *et al.* (2024) and Vemula *et al.* (2026), who observed that shallow soil depth, gravelliness, poor drainage and unfavorable texture were the major factors responsible for the occurrence of unsuitable lands for mango cultivation in the semi-arid regions of Karnataka.

Soil-site suitability evaluation for sapota

Sapota (*Manilkara zapota* L.) is a hardy tropical fruit crop that performs well under warm and humid climatic conditions. The crop grows best in deep, well-drained soils with clay loam to clay texture, adequate moisture-holding capacity and moderate fertility. Although sapota is comparatively tolerant to drought and slightly alkaline soils, shallow soil depth, excessive gravelliness, poor drainage and unfavorable soil texture considerably restrict root development and fruit production. According to the soil-site suitability criteria of Naidu et al. (2006), sapota requires deep (>100 cm), well-drained soils with moderate texture and unrestricted rooting conditions for optimum productivity. In the Madapur sub-watershed, soil-site evaluation at the soil-phase level revealed suitability classes ranging from moderately suitable (S2) and marginally suitable (S3) to currently not suitable (N) (Table 2 and Fig. 3). The major limitations influencing suitability were rooting depth, texture, nutrient availability and gravelliness.

Within the moderately suitable (S2) category, the S2gn subclass occupied 30 ha and was represented by the BTKmA1g1 and DRThC3g3St2 soil phases, where moderate gravelliness and nutrient availability limited crop performance. The S2gnt subclass comprising MDTmA1, MDTmA1g1, MDTmA1g2 and MDTmB2g1 occupied 175 ha, where moderate gravelliness, nutrient availability and texture collectively influenced suitability. The S2rn subclass included SKBfA1, SKBfB2, SKBiA1g3St3, SKBmB2g2 and SKBmC3g3 (125 ha), where rooting depth and nutrient status constituted the principal limitations. The S2r subclass represented by MKRmA1g1 and MKRmC3g3St3 covered 54 ha, while the S2gt subclass consisting of GDM, RNR and GDA soil phases occupied 702 ha, where moderate gravelliness and texture were the dominant constraints. The S2nt subclass, represented by KPRmB2, MVDmB2g2Ca, BTPfB2g2, BTPmB1, BTPmB2, BTPmB2g1Ca and BTPmB2g2, occupied 535 ha, whereas the S2t subclass comprising LDKfB2, LDKmA1, LDKmA1g1, LDKmB2, GPHmA1, GPHmB2 and MGDmB2 covered 1041 ha, where texture alone imposed moderate limitations. These soil phases generally possess deep effective soil depth, good drainage and favorable moisture retention, making them suitable for profitable sapota cultivation with appropriate nutrient management.

The marginally suitable (S3) category occupied 1708 ha and included five suitability subclasses. The S3rt subclass, represented by ATTfA1g2, ATTfB2g1St1, ATTfC3g2, ATTiA1g2, ATTmA1, ATTmA1g1, ATTmA1g2, ATTmA1g2St1, ATTmB2, ATTmB2g1, ATTmB2g1St1, ATTmB2g2, ATTmB2g2Ca and ATTmB2g2St1, was mainly limited by rooting depth and texture. The S3gn subclass comprising BDThC3g3, BDThC3g3St1, BDTiB2g2, BDTmA1g1St1, BDTmB2 and BDTmB2g1 exhibited gravelliness and nutrient limitations. The S3r subclass included the BVP soil phases, where restricted rooting depth constituted the dominant limitation, while the S3gnt subclass represented by the CKR soil phases was affected by combined gravelliness, nutrient deficiency and unfavorable texture. The S3nt subclass consisted of SGBfC3g2St1, SGBhC3g3, SGBmB2, SGBmC3g1, SGBmC3g2, VKPmB2g1, VKPmB2g2St2 and VKPmC2g1, where nutrient availability and texture moderately restricted crop suitability. Although these mapping units possess moderate fertility, the combined influence of rooting restrictions, gravelliness and texture reduced their productive potential.

The currently not suitable (N) class occupied 2046 ha (29.79%) and was primarily associated with shallow effective soil depth, poor rooting conditions and unfavorable soil physical characteristics. This category included the HLG, MLP, SRL, ADG, AKT, MUK, NBP and YSJ soil phases. The HLG and MLP soil phases were characterized by shallow effective soil depth and poor drainage, whereas the SRL, ADG and AKT phases exhibited excessive gravelliness and coarse texture. Likewise, the MUK and YSJ soil phases were affected by moderately alkaline reaction and calcareousness in addition to restricted rooting depth. Although some of these soils possessed moderate chemical fertility, severe physical limitations outweighed the favorable fertility characteristics, making them unsuitable for sustainable sapota cultivation. Similar findings were reported by Madhusudan (2019), Mahesh et al. (2019), Vyas et al. (2024) and Vemula et al. (2026), who identified soil depth, texture and gravelliness as the principal factors governing soil-site suitability for perennial fruit crops.

Soil-site suitability evaluation for guava

Guava (*Psidium guajava* L.) is one of the most adaptable tropical fruit crops and is capable of growing under a wide range of agro-climatic and soil conditions. Nevertheless, optimum growth and higher fruit yield are obtained in deep, well-drained soils with clay loam to loam texture, good moisture-holding capacity and moderate fertility. The crop is comparatively tolerant to drought and slightly alkaline soils; however, shallow soil depth, excessive gravelliness, poor drainage and heavy clay texture adversely affect root growth, aeration and nutrient uptake, thereby reducing fruit yield and quality. According to the soil-site suitability criteria proposed by Naidu et al. (2006), Sys et al. (1993) and FAO (1976), effective soil depth, drainage, texture, gravelliness and nutrient status are the principal land qualities governing guava cultivation. The soil-site suitability evaluation carried out at the soil-phase level in the Madapur sub-watershed revealed suitability classes ranging from moderately suitable (S2) and marginally suitable (S3) to currently not suitable (N) (Table 2 and Fig. 4). The major limitations identified were rooting depth, texture, gravelliness and nutrient availability.

Within the moderately suitable (S2) category, the S2gn subclass occupied 30 ha (0.43%) and was represented by the BTKmA1g1 and DRThC3g3St2 soil phases, where moderate gravelliness and nutrient availability constituted the principal limitations. The S2gnt subclass comprising MDTmA1, MDTmA1g1, MDTmA1g2 and MDTmB2g1 occupied 175 ha (2.55%), where moderate gravelliness, nutrient availability and clayey texture collectively influenced crop suitability. The S2rn subclass covered 125 ha (1.82%) and included SKBfA1, SKBfB2, SKBiA1g3St3, SKBmB2g2 and SKBmC3g3, where moderate rooting depth together with nutrient availability limited crop performance. The S2r subclass represented by MKRmA1g1 and MKRmC3g3St3 occupied 54 ha (0.79%), whereas the S2gt subclass consisting of GDMfA1, GDMfA1g2, GDMiA1g3St3, GDMiC3g2St1, GDMmA1g1, GDMmA1g2, GDMmB2, GDMmB2g2St1, GDMmC3g3St3, RNRfB 2g2St1, RNRmA1, RNRmA1g1, RNRm B2g2St1, GDAfA1, GDAfB2g2, GDAfC3g2, GDAhC3 g3St2, GDAmA1, GDAmA1g1, GDAmA1g2 and GDAmC3g2 occupied 702 ha (10.22%), where gravelliness and texture moderately influenced suitability. The S2nt subclass covered 457 ha (6.65%) and comprised KPRmB2, MVDmB2g2Ca, BTPfB2g2, BTPmB1, BTPmB2, BTPmB2g1Ca and BTPmB2g2, while the S2t subclass represented by LDKfB2, LDKmA1, LDKmA1g1, LDKmB2 and GPHmA1, GPHmB2 and MGDmB2 occupied 1119 ha (16.30%), where moderate textural limitation was the major constraint. These soil phases are characterized by deep effective profiles (>100 cm), favorable drainage, comparatively higher moisture-holding capacity and satisfactory fertility status, making them suitable for sustainable guava cultivation with appropriate nutrient and irrigation management.

The marginally suitable (S3) category occupied 1707 ha (24.86%) and included five suitability subclasses. The S3rt subclass occupied 824 ha (12.00%) and was represented by the ATTfA1g2, ATTfB2g1St1, ATTfC3g2, ATTiA1g2, ATTmA1, ATTmA1g1, ATTmA1g2, ATTmA1g2St1, ATTmB2, ATTmB2g1, ATTmB2g1St1, ATTmB2g2, ATTmB2g2Ca and ATTmB2g2St1, SGBfC3g2St1, SGBhC3g3, SGBmB2, SGBmC3g1, SGBmC3g2 soil phases, where rooting depth together with unfavorable texture constituted the principal limitations. The S3gn subclass comprising BDThC3g3, BDThC3g3St1, BDTiB2g2, BDTmA1g1St1, BDTmB2 and BDTmB2g1 occupied 130 ha (1.89%), where gravelliness and nutrient availability moderately restricted crop performance. The S3r subclass represented by all BVP soil phases covered 492 ha (7.16%), where restricted rooting conditions were primarily responsible for reduced suitability. Likewise, the S3gnt subclass consisting of CKRfA1g1, CKRfA1g2, CKRfB2g2St1, CKRfC3g2, CKRfC3g3, CKRhC3g2, CKRiB2g2, CKRiC3g3, CKRmB2, CKRmB2g1 and CKRmC3g2St1 occupied 215 ha (3.13%), where gravelliness, nutrient deficiency and texture collectively limited crop productivity. The S3nt subclass represented by, VKPmB2g1, VKPmB2g2St2 and VKPmC2g1 occupied 46 ha (0.68%), where nutrient availability and texture were the dominant limitations. Although these mapping units possess moderate soil fertility, their physical limitations reduce rooting volume and available soil moisture, thereby lowering orchard productivity. Adoption of integrated nutrient management, mulching and soil-moisture conservation practices may improve productivity; however, the inherent physical constraints cannot be completely eliminated.

The currently not suitable (N) class occupied 2046 ha (29.79%), representing nearly one-third of the Madapur sub-watershed. The HLG and MLP soil phases are predominantly limited by shallow depth and poor drainage, whereas the SRL, ADG and AKT soil phases exhibit excessive gravelliness and coarse-textured subsoil. Likewise, the MUK and YSJ soil phases are moderately alkaline and calcareous, reducing micronutrient availability and root activity. The combined influence of these permanent physical limitations outweighs their relatively favorable fertility status, making these mapping units unsuitable for sustainable guava cultivation.

Overall, the soil-site suitability evaluation indicated that guava is comparatively more adaptable than mango because of its greater tolerance to moderate soil alkalinity and moisture stress. Nevertheless, effective soil depth, rooting conditions, gravelliness and soil texture remain the dominant factors governing crop suitability in the Madapur sub-watershed. The GDM, GDA, RNR, KPR, BTP, MVD, LDK, GPH and MGD soil phases offer the greatest potential for commercial guava cultivation, whereas the extensive HLG, MLP, SRL, ADG, AKT, MUK, NBP and YSJ soil phases are constrained by severe inherent soil limitations. These findings corroborate earlier reports by Anilkumar *et al.* (2019), Vyas *et al.* (2024), Vemula *et al.* (2026), who identified soil depth, texture and gravelliness as the principal determinants of guava suitability under semi-arid tropical conditions.

Soil-site suitability evaluation for banana

Banana (*Musa paradisiaca* L.) is one of the most important commercial fruit crops cultivated under tropical and subtropical climates because of its high productivity and year-round demand. The crop requires deep (>100 cm), well-drained, fertile soils with clay loam to clay texture, high moisture-holding capacity and adequate nutrient availability for optimum growth and yield. Banana is highly responsive to soil fertility and irrigation and performs best in soils free from salinity, excessive gravelliness and rooting restrictions. Shallow soils, poor drainage, coarse fragments and heavy textural limitations adversely affect root proliferation, moisture storage and nutrient uptake, thereby reducing bunch weight and fruit quality. According to the soil-site suitability criteria of Naidu *et al.* (2006), and FAO (1976), effective soil depth, drainage, texture, gravelliness and nutrient status constitute the major land qualities governing banana cultivation. The soil-site suitability evaluation at the soil-phase level in the Madapur sub-watershed revealed four suitability classes, namely highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and currently not suitable (N) (Table 2 and Fig. 5). The principal limitations identified were gravelliness, nutrient availability, rooting depth and soil texture.

The highly suitable (S1) class occupied 1030 ha (14.99%) and was represented by the KPRmB2, LDKfB2, LDKmA1, LDKmA1g1 and LDKmB2 soil phases. These mapping units possess deep effective soil depth (>118 cm), moderately well-drained conditions, favorable clay to clay loam texture, high moisture-holding capacity and satisfactory fertility status with comparatively higher cation exchange capacity and base saturation. The absence of severe physical limitations and the availability of adequate rooting volume provide ideal conditions for vigorous root development, efficient nutrient uptake and sustained moisture supply throughout the crop growth period. Consequently, these soil phases were classified as highly suitable for banana cultivation and are considered the most promising areas for commercial banana production in the Madapur sub-watershed.

The moderately suitable (S2) category occupied a substantial proportion of the watershed and comprised five suitability subclasses. The S2g subclass covered 723 ha (10.52%) and included the GDMfA1, GDMfA1g2, GDMiA1g3St3, GDMiC3g2St1, GDMmA1g1, GDMmA1g2, GDMmB2, GDMmB2g2St1, GDMmC3g3St3, RNRfB2g2St1, RNRmA1, RNRmA1g1, RNRmB2g2St1, GDAfA1, GDAfB2g2, GDAfC3g2, GDAhC3g3St2, GDAmA1, GDAmA1g1, GDAmA1g2, GDAmC3g2 and MGDmB2 soil phases, where moderate gravelliness constituted the principal limitation. The S2n subclass occupied 305 ha (4.44%) and comprised MVDmB2g2Ca, BTPfB2g2, BTPmB1, BTPmB2 and BTPmB2g1Ca, where nutrient availability moderately influenced crop suitability. The S2gn subclass represented by BTKmA1g1, DRThC3g3St2 and SKBfA1, SKBfB2, SKBiA1g3St3, SKBmB2g2 and SKBmC3g3, MDTmA1, MDTmA1g1, MDTmA1g2, MDTmB2g1, occupied 330 ha (4.81%), where moderate gravelliness together with nutrient availability restricted crop performance. The S2gr subclass included MKRmA1g1 and MKRmC3g3St3, occupying 54 ha (0.79%), where gravelliness and rooting depth were the dominant limitations. The S2rn subclass represented by JLGmA1, JLGmB2 and JLGmB2g2 covered 220 ha (3.20%), where moderate rooting depth together with nutrient limitations influenced crop productivity. These mapping units generally possess deep profiles, favorable drainage and comparatively good fertility; therefore, banana cultivation can be successfully undertaken with balanced fertilization, efficient irrigation and organic matter management.

The marginally suitable (S3) category occupied 1707 ha (24.85%) and included three suitability subclasses. The S3r subclass occupied 701 ha (10.20%) and consisted of the ATTfA1g2, ATTfB2g1St1, ATTfC3g2, ATTiA1g2, ATTmA1, ATTmA1g1, ATTmA1g2, ATTmA1g2St1, ATTmB2, ATTmB2g1, ATTmB2g1St1, ATTmB2g2, ATTmB2g2Ca and ATTmB2g2St1 soil phases, where restricted rooting depth was the principal limitation. The S3gn subclass, represented by BDThC3g3, BDThC3g3St1, BDTiB2g2, BDTmA1g1St1, BDTmB2, BDTmB2g1, CKRfA1g1, CKRfA1g2, CKRfB2g2St1, CKRfC3g2, CKRfC3g3, CKRhC3g2, CKRiB2g2, CKRiC3g3, CKRmB2, CKRmB2g1, CKRmC3g2St1, SGBfC3g2St1, SGBhC3g3, SGBmB2, SGBmC3g1, SGBmC3g2, VKPmB2g1, VKPmB2g2St2 and VKPmC2g1 occupied 514 ha (7.49%), where gravelliness and nutrient availability constituted the major limitations. The S3gr subclass included all BVP soil phases and occupied 492 ha (7.16%), where excessive gravelliness together with restricted rooting conditions reduced crop suitability. Although these soils can support banana cultivation under intensive management, their inherent physical limitations reduce moisture storage and nutrient uptake, thereby affecting bunch development and overall yield.

The currently not suitable (N) class occupied 2046 ha (29.79%), representing nearly one-third of the Madapur sub-watershed. The HLG and MLP soil phases are mainly limited by shallow profiles and poor drainage, whereas the SRL, ADG and AKT phases exhibit coarse texture and excessive gravel content. Similarly, the MUK and YSJ soil phases possess moderately alkaline and calcareous conditions that may reduce micronutrient availability. These severe inherent physical limitations restrict root development, reduce moisture availability and ultimately make these soil phases unsuitable for sustainable banana cultivation despite their moderate fertility status.

Overall, the soil-site suitability evaluation demonstrated that banana exhibited the highest adaptability among the four fruit crops evaluated in the Madapur sub-watershed, with 14.99 per cent of the area classified as highly suitable (S1). Deep, well-drained soils of the KPR and LDK soil phases were identified as the most suitable for commercial banana cultivation, whereas the GDM, GDA, RNR, BTP and MVD soil phases were moderately suitable with manageable limitations. In contrast, the extensive HLG, MLP, SRL, ADG, AKT, MUK, NBP and YSJ soil phases remain unsuitable because of severe rooting depth, drainage and gravelliness constraints. These findings are in close agreement with the studies of kumar et al. (2017), who reported that effective soil depth, drainage, gravelliness and soil texture are the primary determinants governing banana suitability under tropical and semi-arid conditions. a recent biophysical land evaluation study by Bhaskar et al.(2024) in Andhra Pradesh emphasized that soil depth, texture, drainage, alkalinity, and organic carbon are critical constraints affecting banana suitability.

Conclusion

The soil-site suitability evaluation of the Madapur sub-watershed using soil survey, remote sensing and GIS techniques revealed marked spatial variability in the suitability of land for major fruit crops. Among the evaluated crops, banana showed the highest potential, with a portion of the area classified as highly suitable, whereas mango, sapota and guava were mostly grouped under moderately to marginally suitable classes. The major soil and site limitations influencing crop suitability were shallow effective soil depth, excessive gravelliness, restricted rooting conditions, poor drainage, unfavorable texture and nutrient constraints. Soil phases with deep, well-drained profiles and better moisture retention showed greater potential for fruit crop cultivation, while shallow, gravelly and poorly drained soils were found unsuitable for sustainable orchard development. The study highlights the usefulness of RS-GIS-based soil-site suitability assessment in identifying crop-specific potential areas and supporting scientific land use planning, crop selection and site-specific management for sustainable horticultural development in the watershed.

Table 1 : Soil-site characteristics of soil mapping units of Madapur sub-watershed for evaluation of crop suitability.

SI. No.	Soil phases	Wetness (w)	Soil physical conditions (s)					Soil fertility (f)				Salinity/ Alkalinity (n)		Erosion (e)
		Drainage	Depth (cm)	Texture	Stoniness (%)	Gravel (%)	$CaCO_3$ (%)	pH (1:2.5)	OC (g kg^{-1})	CEC [cmol (p+) kg^{-1}]	BS (%)	EC (1:2.5) dSm^{-1}	ESP	Slope (%)
1.	HLGfB2g1Ca	Somewhat poor drained	25	Clay loam	NIL	15-35	2.34	7.72	8.7	32.56	90.29	0.14	3.43	1-3
2.	HLGmA1g1	Somewhat poor drained	25	Clay	NIL	15-35	2.34	7.72	8.7	32.56	90.29	0.14	3.43	0-1
3.	HLGmB2	Somewhat poor drained	25	Clay	NIL	<15	2.34	7.72	8.7	32.56	90.29	0.14	3.43	1-3
4.	MLPiC3g2St3	Moderately well drained	12	Sandy clay	3-15	60-80	3.81	7.58	3.7	37.91	90.19	0.18	1.27	3-5
5.	MLPmA1	Moderately well drained	12	Clay	NIL	<15	3.81	7.58	3.7	37.91	90.19	0.18	1.27	0-1
6.	MLPmA1g1	Moderately well drained	12	clay	NIL	15-35	3.81	7.58	3.7	37.91	90.19	0.18	1.27	0-1
7.	MLPmA1g2	Moderately well drained	12	clay	NIL	35-60	3.81	7.58	3.7	37.91	90.19	0.18	1.27	0-1
8.	SRLfB2g1	Moderately well drained	25	Clay loam	NIL	15-35	2.42	6.61	5.6	25.33	88.91	0.15	1.34	1-3

9.	SRLfB2g2	Moderately well drained	25	Clay loam	NIL	35-60	2.42	6.61	5.6	25.33	88.91	0.15	1.34	1-3
10.	SRLfB2g2St1	Moderately well drained	25	Clay loam	0.01-0.1	35-60	2.42	6.61	5.6	25.33	88.91	0.15	1.34	1-3
11.	SRLfB2g2St2	Moderately well drained	25	Clay loam	0.1-3	35-60	2.42	6.61	5.6	25.33	88.91	0.15	1.34	1-3
12.	SRLiB2g2St2	Moderately well drained	25	Sandy clay	0.1-3	35-60	2.42	6.61	5.6	25.33	88.91	0.15	1.34	1-3
13.	SRLiC3g3St2	Moderately well drained	25	Sandy clay	0.1-3	35-60	2.42	6.61	5.6	25.33	88.91	0.15	1.34	3-5
14.	SRLmA1	Moderately well drained	25	Clay	NIL	<15	2.42	6.61	5.6	25.33	88.91	0.15	1.34	0-1
15.	SRLmB2	Moderately well drained	25	Clay	NIL	<15	2.42	6.61	5.6	25.33	88.91	0.15	1.34	1-3
16.	ADGfC3g3	Moderately well drained	45	Clay loam	NIL	60-80	2.12	7.12	4.5	27.41	89.46	0.28	0.88	3-5
17.	ADGiB2	Moderately well drained	45	Sandy clay	NIL	<15	2.12	7.12	4.5	27.41	89.46	0.28	0.88	1-3
18.	ADGiB2g1St2	Moderately well drained	45	Sandy clay	0.1-3	15-35	2.12	7.12	4.5	27.41	89.46	0.28	0.88	1-3
19.	ADGiB2g2St1	Moderately well drained	45	Sandy clay	0.01-0.1	35-60	2.12	7.12	4.5	27.41	89.46	0.28	0.88	1-3
20.	ADGiC3g2St1	Moderately well drained	45	Sandy clay	0.01-0.1	35-60	2.12	7.12	4.5	27.41	89.46	0.28	0.88	3-5
21.	ADGiC3g3St2	Moderately well drained	45	Sandy clay	0.1-3	60-80	2.12	7.12	4.5	27.41	89.46	0.28	0.88	3-5
22.	ADGiC3g3St3	Moderately well drained	45	Sandy clay	3-15	60-80	2.12	7.12	4.5	27.41	89.46	0.28	0.88	3-5
23.	ADGmA1g1	Moderately well drained	45	Clay	NIL	15-35	2.12	7.12	4.5	27.41	89.46	0.28	0.88	0-1
24.	ADGmB2	Moderately well drained	45	Clay	NIL	<15	2.12	7.12	4.5	27.41	89.46	0.28	0.88	1-3
25.	ADGmB2g1	Moderately well drained	45	Clay	NIL	15-35	2.12	7.12	4.5	27.41	89.46	0.28	0.88	1-3
26.	ADGmB2g2St1	Moderately well drained	45	Clay	0.01-0.1	35-60	2.12	7.12	4.5	27.41	89.46	0.28	0.88	1-3
27.	AKTfB2g3St3	Moderately well drained	43	Clay loam	3-15	60-80	1.62	7.55	7.5	31.82	89.94	0.13	2.33	1-3
28.	AKTiA1g2	Moderately well drained	43	Sandy clay	NIL	35-60	1.62	7.55	7.5	31.82	89.94	0.13	2.33	0-1
29.	AKTiA1g2St1	Moderately well drained	43	Sandy clay	0.01-0.1	35-60	1.62	7.55	7.5	31.82	89.94	0.13	2.33	0-1
30.	AKTiC4g3St4	Moderately well drained	43	Sandy clay	15-50	60-80	1.62	7.55	7.5	31.82	89.94	0.13	2.33	3-5
31.	AKTmA1	Moderately well drained	43	Clay	NIL	<15	1.62	7.55	7.5	31.82	89.94	0.13	2.33	0-1
32.	AKTmA1g1	Moderately well drained	43	Clay	NIL	15-35	1.62	7.55	7.5	31.82	89.94	0.13	2.33	0-1
33.	AKTmA1g2	Moderately well drained	43	Clay	NIL	35-60	1.62	7.55	7.5	31.82	89.94	0.13	2.33	0-1
34.	AKTmB2g1St2	Moderately well drained	43	Clay	0.1-3	15-35	1.62	7.55	7.5	31.82	89.94	0.13	2.33	1-3
35.	AKTmB2g2	Moderately well drained	43	Clay	NIL	35-60	1.62	7.55	7.5	31.82	89.94	0.13	2.33	1-3
36.	AKTmB2g2St1	Moderately well drained	43	Clay	0.01-0.1	35-60	1.62	7.55	7.5	31.82	89.94	0.13	2.33	1-3
37.	MUKfA1g1	Moderately well drained	32	Clay loam	NIL	15-35	3.21	8.12	8.6	22.52	83.08	0.27	2.22	0-1
38.	MUKfB2	Moderately well drained	32	Clay loam	NIL	<15	3.21	8.12	8.6	22.52	83.08	0.27	2.22	1-3
39.	MUKfB2g1	Moderately well drained	32	Clay loam	NIL	15-35	3.21	8.12	8.6	22.52	83.08	0.27	2.22	1-3
40.	MUKfB2g2St1	Moderately well drained	32	Clay loam	0.01-0.1	35-60	3.21	8.12	8.6	22.52	83.08	0.27	2.22	1-3
41.	MUKfC3g2St1	Moderately well drained	32	Clay loam	0.01-0.1	35-60	3.21	8.12	8.6	22.52	83.08	0.27	2.22	3-5
42.	MUKmA1	Moderately well drained	32	Clay	NIL	<15	3.21	8.12	8.6	22.52	83.08	0.27	2.22	0-1

43.	MUKmA1g1	Moderately well drained	32	Clay	NIL	15-35	3.21	8.12	8.6	22.52	83.08	0.27	2.22	0-1
44.	MUKmB2	Moderately well drained	32	Clay	NIL	<15	3.21	8.12	8.6	22.52	83.08	0.27	2.22	1-3
45.	MUKmB2g2	Moderately well drained	32	Clay	NIL	35-60	3.21	8.12	8.6	22.52	83.08	0.27	2.22	1-3
46.	NBPfA1g1	Moderately well drained	45	Clay loam	NIL	15-35	1.81	7.38	6.0	25.41	92.37	0.14	4.41	0-1
47.	NBPfC3g3	Moderately well drained	45	Clay loam	NIL	60-80	1.81	7.38	6.0	25.41	92.37	0.14	4.41	3-5
48.	NBPfC3g3St3	Moderately well drained	45	Clay loam	3-15	60-80	1.81	7.38	6.0	25.41	92.37	0.14	4.41	3-5
49.	NBPiB2g3St1	Moderately well drained	45	Sandy clay	0.01-0.1	60-80	1.81	7.38	6.0	25.41	92.37	0.14	4.41	1-3
50.	NBPiB2g3St3	Moderately well drained	45	Sandy clay	3-15	60-80	1.81	7.38	6.0	25.41	92.37	0.14	4.41	1-3
51.	NBPiC3g3St2	Moderately well drained	45	Sandy clay	0.1-3	60-80	1.81	7.38	6.0	25.41	92.37	0.14	4.41	3-5
52.	NBPmA1g1	Moderately well drained	45	Clay	NIL	15-35	1.81	7.38	6.0	25.41	92.37	0.14	4.41	0-1
53.	YSJfB2g2St1	Moderately well drained	38	Clay loam	0.01-0.1	35-60	1.72	8.16	5.8	45.81	94.04	0.12	3.80	1-3
54.	YSJfC3g2St1	Moderately well drained	38	Clay loam	0.01-0.1	35-60	1.72	8.16	5.8	45.81	94.04	0.12	3.80	3-5
55.	YSJfC3g3St1	Moderately well drained	38	Clay loam	0.01-0.1	60-80	1.72	8.16	5.8	45.81	94.04	0.12	3.80	3-5
56.	YSJmA1	Moderately well drained	38	Clay	NIL	<15	1.72	8.16	5.8	45.81	94.04	0.12	3.80	0-1
57.	YSJmA1g1Ca	Moderately well drained	38	Clay	NIL	15-35	1.72	8.16	5.8	45.81	94.04	0.12	3.80	0-1
58.	YSJmB2g1Ca	Moderately well drained	38	Clay	NIL	15-35	1.72	8.16	5.8	45.81	94.04	0.12	3.80	1-3
59.	YSJmB2g2	Moderately well drained	38	Clay	NIL	35-60	1.72	8.16	5.8	45.81	94.04	0.12	3.80	1-3
60.	ATTfA1g2	Moderately well drained	65	Clay loam	NIL	35-60	3.61	7.82	5.8	35.64	94.00	0.24	1.63	0-1
61.	ATTfB2g1St1	Moderately well drained	65	Clay loam	0.01-0.1	15-35	3.61	7.82	5.8	35.64	94.00	0.24	1.63	1-3
62.	ATTfC3g2	Moderately well drained	65	Clay loam	NIL	35-60	3.61	7.82	5.8	35.64	94.00	0.24	1.63	3-5
63.	ATTiA1g2	Moderately well drained	65	Sandy clay	NIL	35-60	3.61	7.82	5.8	35.64	94.00	0.24	1.63	0-1
64.	ATTmA1	Moderately well drained	65	Clay	NIL	<15	3.61	7.82	5.8	35.64	94.00	0.24	1.63	0-1
65.	ATTmA1g1	Moderately well drained	65	Clay	NIL	15-35	3.61	7.82	5.8	35.64	94.00	0.24	1.63	0-1
66.	ATTmA1g2	Moderately well drained	65	Clay	NIL	35-60	3.61	7.82	5.8	35.64	94.00	0.24	1.63	0-1
67.	ATTmA1g2St1	Moderately well drained	65	Clay	0.01-0.1	35-60	3.61	7.82	5.8	35.64	94.00	0.24	1.63	0-1
68.	ATTmB2	Moderately well drained	65	Clay	NIL	<15	3.61	7.82	5.8	35.64	94.00	0.24	1.63	1-3
69.	ATTmB2g1	Moderately well drained	65	Clay	NIL	15-35	3.61	7.82	5.8	35.64	94.00	0.24	1.63	1-3
70.	ATTmB2g1St1	Moderately well drained	65	Clay	0.01-0.1	15-35	3.61	7.82	5.8	35.64	94.00	0.24	1.63	1-3
71.	ATTmB2g2	Moderately well drained	65	Clay	NIL	35-60	3.61	7.82	5.8	35.64	94.00	0.24	1.63	1-3
72.	ATTmB2g2Ca	Moderately well drained	65	Clay	NIL	35-60	3.61	7.82	5.8	35.64	94.00	0.24	1.63	1-3
73.	ATTmB2g2St1	Moderately well drained	65	Clay	0.01-0.1	35-60	3.61	7.82	5.8	35.64	94.00	0.24	1.63	1-3
74.	BDThC3g3	Moderately well drained	65	Sandy clay loam	NIL	60-80	2.17	6.46	8.1	26.44	83.66	0.23	1.74	3-5
75.	BDThC3g3St1	Moderately well drained	65	Sandy clay loam	0.01-0.1	60-80	2.17	6.46	8.1	26.44	83.66	0.23	1.74	3-5
76.	BDTiB2g2	Moderately well drained	65	Sandy clay	NIL	35-60	2.17	6.46	8.1	26.44	83.66	0.23	1.74	1-3

77.	BDTmA1g1St1	Moderately well drained	65	Clay	0.01-0.1	15-35	2.17	6.46	8.1	26.44	83.66	0.23	1.74	0-1
78.	BDTmB2	Moderately well drained	65	Clay	NIL	<15	2.17	6.46	8.1	26.44	83.66	0.23	1.74	1-3
79.	BDTmB2g1	Moderately well drained	65	clay	NIL	15-35	2.17	6.46	8.1	26.44	83.66	0.23	1.74	1-3
80.	BVPfA1g2St2	Moderately well drained	73	Clay loam	0.1-3	35-60	3.14	6.71	4.1	22.42	85.01	0.27	0.80	0-1
81.	BVPfB2	Moderately well drained	73	Clay loam	NIL	<15	3.14	6.71	4.1	22.42	85.01	0.27	0.80	1-3
82.	BVPfB2g2	Moderately well drained	73	Clay loam	NIL	35-60	3.14	6.71	4.1	22.42	85.01	0.27	0.80	1-3
83.	BVPfC3	Moderately well drained	73	Clay loam	NIL	<15	3.14	6.71	4.1	22.42	85.01	0.27	0.80	3-5
84.	BVPiA1g2	Moderately well drained	73	Sandy clay	NIL	35-60	3.14	6.71	4.1	22.42	85.01	0.27	0.80	0-1
85.	BVPiA1g3St2	Moderately well drained	73	Sandy clay	0.1-3	60-80	3.14	6.71	4.1	22.42	85.01	0.27	0.80	0-1
86.	BVPiB2g2	Moderately well drained	73	Sandy clay	NIL	35-60	3.14	6.71	4.1	22.42	85.01	0.27	0.80	1-3
87.	BVPiB2g2St1	Moderately well drained	73	Sandy clay	0.01-0.1	35-60	3.14	6.71	4.1	22.42	85.01	0.27	0.80	1-3
88.	BVPiB2g2St2	Moderately well drained	73	Sandy clay	0.1-3	35-60	3.14	6.71	4.1	22.42	85.01	0.27	0.80	1-3
89.	BVPiC3g3St1	Moderately well drained	73	Sandy clay	0.01-0.1	60-80	3.14	6.71	4.1	22.42	85.01	0.27	0.80	3-5
90.	BVPmA1g1	Moderately well drained	73	Clay	NIL	15-35	3.14	6.71	4.1	22.42	85.01	0.27	0.80	0-1
91.	BVPmB2	Moderately well drained	73	Clay	NIL	<15	3.14	6.71	4.1	22.42	85.01	0.27	0.80	1-3
92.	BVPmB2g1	Moderately well drained	73	Clay	NIL	15-35	3.14	6.71	4.1	22.42	85.01	0.27	0.80	1-3
93.	BVPmB2g2	Moderately well drained	73	Clay	NIL	35-60	3.14	6.71	4.1	22.42	85.01	0.27	0.80	1-3
94.	BVPmB2g2St2	Moderately well drained	73	Clay	0.1-3	35-60	3.14	6.71	4.1	22.42	85.01	0.27	0.80	1-3
95.	BVPmC3g2	Moderately well drained	73	Clay	NIL	35-60	3.14	6.71	4.1	22.42	85.01	0.27	0.80	3-5
96.	BVPmC3g2St1	Moderately well drained	73	Clay	0.01-0.1	35-60	3.14	6.71	4.1	22.42	85.01	0.27	0.80	3-5
97.	CKRfA1g1	Moderately well drained	65	Clay loam	NIL	15-35	1.62	6.32	5.4	20.84	80.52	0.32	1.54	0-1
98.	CKRfA1g2	Moderately well drained	65	Clay loam	NIL	35-60	1.62	6.32	5.4	20.84	80.52	0.32	1.54	0-1
99.	CKRfB2g2St1	Moderately well drained	65	Clay loam	0.01-0.1	35-60	1.62	6.32	5.4	20.84	80.52	0.32	1.54	1-3
100.	CKRfC3g2	Moderately well drained	65	Clay loam	NIL	35-60	1.62	6.32	5.4	20.84	80.52	0.32	1.54	3-5
101.	CKRfC3g3	Moderately well drained	65	Clay loam	NIL	60-80	1.62	6.32	5.4	20.84	80.52	0.32	1.54	3-5
102.	CKRhC3g2	Moderately well drained	65	Sandy clay loam	NIL	35-60	1.62	6.32	5.4	20.84	80.52	0.32	1.54	3-5
103.	CKRiB2g2	Moderately well drained	65	Sandy clay	NIL	35-60	1.62	6.32	5.4	20.84	80.52	0.32	1.54	1-3
104.	CKRiC3g3	Moderately well drained	65	Sandy clay	NIL	60-80	1.62	6.32	5.4	20.84	80.52	0.32	1.54	3-5
105.	CKRmB2	Moderately well drained	65	Clay	NIL	<15	1.62	6.32	5.4	20.84	80.52	0.32	1.54	1-3
106.	CKRmB2g1	Moderately well drained	65	Clay	NIL	15-35	1.62	6.32	5.4	20.84	80.52	0.32	1.54	1-3
107.	CKRmC3g2St1	Moderately well drained	65	Clay	0.01-0.1	35-60	1.62	6.32	5.4	20.84	80.52	0.32	1.54	3-5
108.	SGBfC3g2St1	Moderately well drained	59	Clay loam	0.01-0.1	35-60	1.86	7.18	4.7	27.46	87.04	0.23	2.62	3-5
109.	SGBhC3g3	Moderately well drained	59	Sandy clay loam	NIL	60-80	1.86	7.18	4.7	27.46	87.04	0.23	2.62	3-5
110.	SGBmB2	Moderately well drained	59	Clay	NIL	<15	1.86	7.18	4.7	27.46	87.04	0.23	2.62	1-3

111.	SGBmC3g1	Moderately well drained	59	Clay	NIL	15-35	1.86	7.18	4.7	27.46	87.04	0.23	2.62	3-5
112.	SGBmC3g2	Moderately well drained	59	Clay	NIL	35-60	1.86	7.18	4.7	27.46	87.04	0.23	2.62	3-5
113.	VKPmB2g1	Moderately well drained	70	Clay	NIL	15-35	2.16	7.62	7.1	47.21	94.01	0.16	0.47	1-3
114.	VKPmB2g2St2	Moderately well drained	70	Clay	0.1-3	35-60	2.16	7.62	7.1	47.21	94.01	0.16	0.47	1-3
115.	VKPmC2g1	Moderately well drained	70	Clay	NIL	15-35	2.16	7.62	7.1	47.21	94.01	0.16	0.47	3-5
116.	BTKmA1g1	Well drained	82	Clay	NIL	15-35	2.48	6.42	7.7	23.14	87.99	0.21	3.20	0-1
117.	DRThC3g3St2	Moderately well drained	81	Sandy clay loam	0.1-3	60-80	1.24	8.10	6.1	28.92	81.85	0.28	3.87	3-5
118.	JLGmA1	Moderately well drained	98	Clay	NIL	<15	1.24	7.92	6.0	36.42	90.06	0.41	1.32	0-1
119.	JLGmB2	Moderately well drained	98	Clay	NIL	<15	1.24	7.92	6.0	36.42	90.06	0.41	1.32	1-3
120.	JLGmB2g2	Moderately well drained	98	Clay	NIL	35-60	1.24	7.92	6.0	36.42	90.06	0.41	1.32	1-3
121.	MDTmA1	Moderately well drained	98	Clay	NIL	<15	3.15	8.33	7.1	30.84	92.87	0.51	4.60	0-1
122.	MDTmA1g1	Moderately well drained	98	Clay	NIL	15-35	3.15	8.33	7.1	30.84	92.87	0.51	4.60	0-1
123.	MDTmA1g2	Moderately well drained	98	Clay	NIL	35-60	3.15	8.33	7.1	30.84	92.87	0.51	4.60	0-1
124.	MDTmB2g1	Moderately well drained	98	Clay	NIL	15-35	3.15	8.33	7.1	30.84	92.87	0.51	4.60	1-3
125.	MKRmA1g1	Moderately well drained	79	Clay	NIL	15-35	4.21	6.90	6.8	21.45	92.31	0.21	1.68	0-1
126.	MKRmC3g3St3	Moderately well drained	79	Clay		60-80	4.21	6.90	6.8	21.45	92.31	0.21	1.68	3-5
127.	SKBfA1	Moderately well drained	98	Clay loam	NIL	<15	1.45	6.15	4.7	23.12	80.36	0.18	0.65	0-1
128.	SKBfB2	Moderately well drained	98	Clay loam	NIL	<15	1.45	6.15	4.7	23.12	80.36	0.18	0.65	1-3
129.	SKBiA1g3St3	Moderately well drained	98	Sandy clay	3-15	60-80	1.45	6.15	4.7	23.12	80.36	0.18	0.65	0-1
130.	SKBmB2g2	Moderately well drained	98	Clay	NIL	35-60	1.45	6.15	4.7	23.12	80.36	0.18	0.65	1-3
131.	SKBmC3g3	Moderately well drained	98	Clay	NIL	60-80	1.45	6.15	4.7	23.12	80.36	0.18	0.65	3-5
132.	GDMfA1	Moderately well drained	118	Clay loam	NIL	<15	4.24	6.18	6.8	33.21	93.35	0.24	2.89	0-1
133.	GDMfA1g2	Moderately well drained	118	Clay loam	NIL	35-60	4.24	6.18	6.8	33.21	93.35	0.24	2.89	0-1
134.	GDMiA1g3St3	Moderately well drained	118	Sandy clay	3-15	60-80	4.24	6.18	6.8	33.21	93.35	0.24	2.89	0-1
135.	GDMiC3g2St1	Moderately well drained	118	Sandy clay	0.01-0.1	35-60	4.24	6.18	6.8	33.21	93.35	0.24	2.89	3-5
136.	GDMmA1g1	Moderately well drained	118	Clay	NIL	15-35	4.24	6.18	6.8	33.21	93.35	0.24	2.89	0-1
137.	GDMmA1g2	Moderately well drained	118	Clay	NIL	35-60	4.24	6.18	6.8	33.21	93.35	0.24	2.89	0-1
138.	GDMmB2	Moderately well drained	118	Clay	NIL	<15	4.24	6.18	6.8	33.21	93.35	0.24	2.89	1-3
139.	GDMmB2g2St1	Moderately well drained	118	Clay	0.01-0.1	35-60	4.24	6.18	6.8	33.21	93.35	0.24	2.89	1-3
140.	GDMmC3g3St3	Moderately well drained	118	Clay	3-15	60-80	4.24	6.18	6.8	33.21	93.35	0.24	2.89	3-5
141.	KPRmB2	Moderately well drained	150	Clay	NIL	<15	2.32	7.34	4.1	48.82	91.97	0.16	1.68	1-3
142.	LDKfB2	Moderately well drained	118	Clay loam	NIL	<15	3.61	7.12	4.8	34.21	92.78	0.24	2.51	1-3
143.	LDKmA1	Moderately well drained	118	Clay	NIL	<15	3.61	7.12	4.8	34.21	92.78	0.24	2.51	0-1
144.	LDKmA1g1	Moderately well drained	118	Clay	NIL	15-35	3.61	7.12	4.8	34.21	92.78	0.24	2.51	0-1

145.	LDKmB2	Moderately well drained	118	Clay	NIL	<15	3.61	7.12	4.8	34.21	92.78	0.24	2.51	1-3
146.	MVDmB2g2Ca	Moderately well drained	150	Clay	NIL	35-60	3.40	8.17	7.2	42.53	89.58	0.31	2.77	1-3
147.	RNRfB2g2St1	Moderately well drained	112	Clay loam	0.01-0.1	35-60	1.02	7.32	7.6	23.21	91.17	0.16	4.48	1-3
148.	RNRmA1	Moderately well drained	112	Clay	NIL	<15	1.02	7.32	7.6	23.21	91.17	0.16	4.48	0-1
149.	RNRmA1g1	Moderately well drained	112	Clay	NIL	15-35	1.02	7.32	7.6	23.21	91.17	0.16	4.48	0-1
150.	RNRmB2g2St1	Moderately well drained	112	clay	0.01-0.1	35-60	1.02	7.32	7.6	23.21	91.17	0.16	4.48	1-3
151.	BTPfB2g2	Moderately well drained	172	Clay loam	NIL	35-60	3.63	7.82	5.8	47.23	91.46	0.24	3.43	1-3
152.	BTPmB1	Moderately well drained	172	Clay	NIL	<15	3.63	7.82	5.8	47.23	91.46	0.24	3.43	1-3
153.	BTPmB2	Moderately well drained	172	Clay	NIL	<15	3.63	7.82	5.8	47.23	91.46	0.24	3.43	1-3
154.	BTPmB2g1Ca	Moderately well drained	172	Clay	NIL	15-35	3.63	7.82	5.8	47.23	91.46	0.24	3.43	1-3
155.	BTPmB2g2	Moderately well drained	172	Clay	NIL	35-60	3.63	7.82	5.8	47.23	91.46	0.24	3.43	1-3
156.	GDAfA1	Moderately well drained	130	Clay loam	NIL	<15	2.71	7.19	7.5	33.21	93.35	0.24	2.89	0-1
157.	GDAfB2g2	Moderately well drained	130	Clay loam	NIL	35-60	2.71	7.19	7.5	33.21	93.35	0.24	2.89	1-3
158.	GDAfC3g2	Moderately well drained	130	Clay loam	NIL	35-60	2.71	7.19	7.5	33.21	93.35	0.24	2.89	0-1
159.	GDAhC3g3St2	Moderately well drained	130	Sandy clay loam	0.1-3	35-60	2.71	7.19	7.5	33.21	93.35	0.24	2.89	0-1
160.	GDAmA1	Moderately well drained	130	Clay	NIL	<15	2.71	7.19	7.5	33.21	93.35	0.24	2.89	0-1
161.	GDAmA1g1	Moderately well drained	130	Clay	NIL	15-35	2.71	7.19	7.5	33.21	93.35	0.24	2.89	0-1
162.	GDAmA1g2	Moderately well drained	130	Clay	NIL	35-60	2.71	7.19	7.5	33.21	93.35	0.24	2.89	0-1
163.	GDAmC3g2	Moderately well drained	130	Clay	NIL	35-60	2.71	7.19	7.5	33.21	93.35	0.24	2.89	0-1
164.	GPHmA1	Moderately well drained	130	Clay	NIL	<15	1.82	8.30	7.9	50.81	93.64	0.13	3.58	0-1
165.	GPHmB2	Moderately well drained	130	Clay	NIL	<15	1.82	8.30	7.9	50.81	93.64	0.13	3.58	1-3
166.	MGDmB2	Moderately well drained	160	Clay	NIL	<15	5.41	8.00	4.6	52.81	92.77	0.16	2.05	1-3

Table 2 : Soil-site suitability classification of soil mapping units of Madapur sub-watershed for major horticultural crops

SI. No.	Soil phases	Mango	Sapota	Guava	Banana
1.	HLGfB2g1Ca	N	N	N	N
2.	HLGmA1g1	N	N	N	N
3.	HLGmB2	N	N	N	N
4.	MLPiC3g2St3	N	N	N	N
5.	MLPmA1	N	N	N	N
6.	MLPmA1g1	N	N	N	N
7.	MLPmA1g2	N	N	N	N
8.	SRLfB2g1	N	N	N	N
9.	SRLfB2g2	N	N	N	N
10.	SRLfB2g2St1	N	N	N	N
11.	SRLfB2g2St2	N	N	N	N
12.	SRLiB2g2St2	N	N	N	N
13.	SRLiC3g3St2	N	N	N	N
14.	SRLmA1	N	N	N	N
15.	SRLmB2	N	N	N	N
16.	ADGfC3g3	N	N	N	N
17.	ADGiB2	N	N	N	N
18.	ADGiB2g1St2	N	N	N	N
19.	ADGiB2g2St1	N	N	N	N
20.	ADGiC3g2St1	N	N	N	N
21.	ADGiC3g3St2	N	N	N	N
22.	ADGiC3g3St3	N	N	N	N
23.	ADGmA1g1	N	N	N	N
24.	ADGmB2	N	N	N	N
25.	ADGmB2g1	N	N	N	N
26.	ADGmB2g2St1	N	N	N	N
27.	AKTfB2g3St3	N	N	N	N
28.	AKTiA1g2	N	N	N	N
29.	AKTiA1g2St1	N	N	N	N
30.	AKTiC4g3St4	N	N	N	N
31.	AKTmA1	N	N	N	N
32.	AKTmA1g1	N	N	N	N
33.	AKTmA1g2	N	N	N	N
34.	AKTmB2g1St2	N	N	N	N
35.	AKTmB2g2	N	N	N	N
36.	AKTmB2g2St1	N	N	N	N

37.	MUKfA1g1	N	N	N	N
38.	MUKfB2	N	N	N	N
39.	MUKfB2g1	N	N	N	N
40.	MUKfB2g2St1	N	N	N	N
41.	MUKfC3g2St1	N	N	N	N
42.	MUKmA1	N	N	N	N
43.	MUKmA1g1	N	N	N	N
44.	MUKmB2	N	N	N	N
45.	MUKmB2g2	N	N	N	N
46.	NBPfA1g1	N	N	N	N
47.	NBPfC3g3	N	N	N	N
48.	NBPfC3g3St3	N	N	N	N
49.	NBPiB2g3St1	N	N	N	N
50.	NBPiB2g3St3	N	N	N	N
51.	NBPiC3g3St2	N	N	N	N
52.	NBPmA1g1	N	N	N	N
53.	YSJfB2g2St1	N	N	N	N
54.	YSJfC3g2St1	N	N	N	N
55.	YSJfC3g3St1	N	N	N	N
56.	YSJmA1	N	N	N	N
57.	YSJmA1g1Ca	N	N	N	N
58.	YSJmB2g1Ca	N	N	N	N
59.	YSJmB2g2	N	N	N	N
60.	ATTfA1g2	N	S3rt	S3rt	S3r
61.	ATTfB2g1St1	N	S3rt	S3rt	S3r
62.	ATTfC3g2	N	S3rt	S3rt	S3r
63.	ATTiA1g2	N	S3rt	S3rt	S3r
64.	ATTmA1	N	S3rt	S3rt	S3r
65.	ATTmA1g1	N	S3rt	S3rt	S3r
66.	ATTmA1g2	N	S3rt	S3rt	S3r
67.	ATTmA1g2St1	N	S3rt	S3rt	S3r
68.	ATTmB2	N	S3rt	S3rt	S3r
69.	ATTmB2g1	N	S3rt	S3rt	S3r
70.	ATTmB2g1St1	N	S3rt	S3rt	S3r
71.	ATTmB2g2	N	S3rt	S3rt	S3r
72.	ATTmB2g2Ca	N	S3rt	S3rt	S3r
73.	ATTmB2g2St1	N	S3rt	S3rt	S3r
74.	BDThC3g3	N	S3gn	S3gn	S3gn
75.	BDThC3g3St1	N	S3gn	S3gn	S3gn
76.	BDTiB2g2	N	S3gn	S3gn	S3gn
77.	BDTmA1g1St1	N	S3gn	S3gn	S3gn
78.	BDTmB2	N	S3gn	S3gn	S3gn
79.	BDTmB2g1	N	S3gn	S3gn	S3gn
80.	BVPfA1g2St2	N	S3r	S3r	S3gr
81.	BVPfB2	N	S3r	S3r	S3gr
82.	BVPfB2g2	N	S3r	S3r	S3gr
83.	BVPfC3	N	S3r	S3r	S3gr
84.	BVPiA1g2	N	S3r	S3r	S3gr
85.	BVPiA1g3St2	N	S3r	S3r	S3gr
86.	BVPiB2g2	N	S3r	S3r	S3gr
87.	BVPiB2g2St1	N	S3r	S3r	S3gr
88.	BVPiB2g2St2	N	S3r	S3r	S3gr
89.	BVPiC3g3St1	N	S3r	S3r	S3gr
90.	BVPmA1g1	N	S3r	S3r	S3gr
91.	BVPmB2	N	S3r	S3r	S3gr
92.	BVPmB2g1	N	S3r	S3r	S3gr
93.	BVPmB2g2	N	S3r	S3r	S3gr
94.	BVPmB2g2St2	N	S3r	S3r	S3gr
95.	BVPmC3g2	N	S3r	S3r	S3gr
96.	BVPmC3g2St1	N	S3r	S3r	S3gr
97.	CKRfA1g1	N	S3gnt	S3gnt	S3gn
98.	CKRfA1g2	N	S3gnt	S3gnt	S3gn
99.	CKRfB2g2St1	N	S3gnt	S3gnt	S3gn
100.	CKRfC3g2	N	S3gnt	S3gnt	S3gn
101.	CKRfC3g3	N	S3gnt	S3gnt	S3gn
102.	CKRhC3g2	N	S3gnt	S3gnt	S3gn
103.	CKRiB2g2	N	S3gnt	S3gnt	S3gn
104.	CKRiC3g3	N	S3gnt	S3gnt	S3gn
105.	CKRmB2	N	S3gnt	S3gnt	S3gn
106.	CKRmB2g1	N	S3gnt	S3gnt	S3gn
107.	CKRmC3g2St1	N	S3gnt	S3gnt	S3gn
108.	SGBfC3g2St1	N	S3nt	S3rt	S3gn
109.	SGBhC3g3	N	S3nt	S3rt	S3gn
110.	SGBmB2	N	S3nt	S3rt	S3gn
111.	SGBmC3g1	N	S3nt	S3rt	S3gn
112.	SGBmC3g2	N	S3nt	S3rt	S3gn
113.	VKPmB2g1	N	S3nt	S3nt	S3gn
114.	VKPmB2g2St2	N	S3nt	S3nt	S3gn
115.	VKPmC2g1	N	S3nt	S3nt	S3gn
116.	BTKmA1g1	S3gn	S2gn	S2gn	S2gn
117.	DRThC3g3St2	S3gn	S2gn	S2gn	S2gn
118.	JLGmA1	S3nt	S2nt	S2nt	S2rn
119.	JLGmB2	S3nt	S2nt	S2nt	S2rn
120.	JLGmB2g2	S3nt	S2nt	S2nt	S2rn
121.	MDTmA1	S3gnt	S2gnt	S2gnt	S2gn
122.	MDTmA1g1	S3gnt	S2gnt	S2gnt	S2gn
123.	MDTmA1g2	S3gnt	S2gnt	S2gnt	S2gn
124.	MDTmB2g1	S3gnt	S2gnt	S2gnt	S2gn
125.	MKRmA1g1	S3r	S2r	S2r	S2gr
126.	MKRmC3g3St3	S3r	S2r	S2r	S2gr
127.	SKBfA1	S3rn	S2rn	S2rn	S2gn
128.	SKBfB2	S3rn	S2rn	S2rn	S2gn
129.	SKBiA1g3St3	S3rn	S2rn	S2rn	S2gn
130.	SKBmB2g2	S3rn	S2rn	S2rn	S2gn
131.	SKBmC3g3	S3rn	S2rn	S2rn	S2gn
132.	GDMfA1	S2gt	S2gt	S2gt	S2g
133.	GDMfA1g2	S2gt	S2gt	S2gt	S2g
134.	GDMiA1g3St3	S2gt	S2gt	S2gt	S2g
135.	GDMiC3g2St1	S2gt	S2gt	S2gt	S2g
136.	GDMmA1g1	S2gt	S2gt	S2gt	S2g
137.	GDMmA1g2	S2gt	S2gt	S2gt	S2g
138.	GDMmB2	S2gt	S2gt	S2gt	S2g
139.	GDMmB2g2St1	S2gt	S2gt	S2gt	S2g
140.	GDMmC3g3St3	S2gt	S2gt	S2gt	S2g
141.	KPRmB2	S2nt	S2nt	S2nt	S1
142.	LDKfB2	S2rt	S2t	S2t	S1
143.	LDKmA1	S2rt	S2t	S2t	S1
144.	LDKmA1g1	S2rt	S2t	S2t	S1
145.	LDKmB2	S2rt	S2t	S2t	S1
146.	MVDmB2g2Ca	S2nt	S2nt	S2nt	S2n
147.	RNRfB2g2St1	S2gt	S2gt	S2gt	S2g
148.	RNRmA1	S2gt	S2gt	S2gt	S2g
149.	RNRmA1g1	S2gt	S2gt	S2gt	S2g
150.	RNRmB2g2St1	S2gt	S2gt	S2gt	S2g
151.	BTPfB2g2	S2nt	S2nt	S2nt	S2n
152.	BTPmB1	S2nt	S2nt	S2nt	S2n
153.	BTPmB2	S2nt	S2nt	S2nt	S2n
154.	BTPmB2g1Ca	S2nt	S2nt	S2nt	S2n
155.	BTPmB2g2	S2nt	S2nt	S2nt	S2n
156.	GDAfA1	S2gt	S2gt	S2gt	S2g

157.	GDAfB2g2	S2gt	S2gt	S2gt	S2g
158.	GDAfC3g2	S2gt	S2gt	S2gt	S2g
159.	GDAhC3g3St2	S2gt	S2gt	S2gt	S2g
160.	GDAmA1	S2gt	S2gt	S2gt	S2g
161.	GDAmA1g1	S2gt	S2gt	S2gt	S2g
162.	GDAmA1g2	S2gt	S2gt	S2gt	S2g
163.	GDAmC3g2	S2gt	S2gt	S2gt	S2g
164.	GPHmA1	S2t	S2nt	S2t	S2n
165.	GPHmB2	S2t	S2nt	S2t	S2n
166.	MGDmB2	S2t	S2t	S2t	S2g

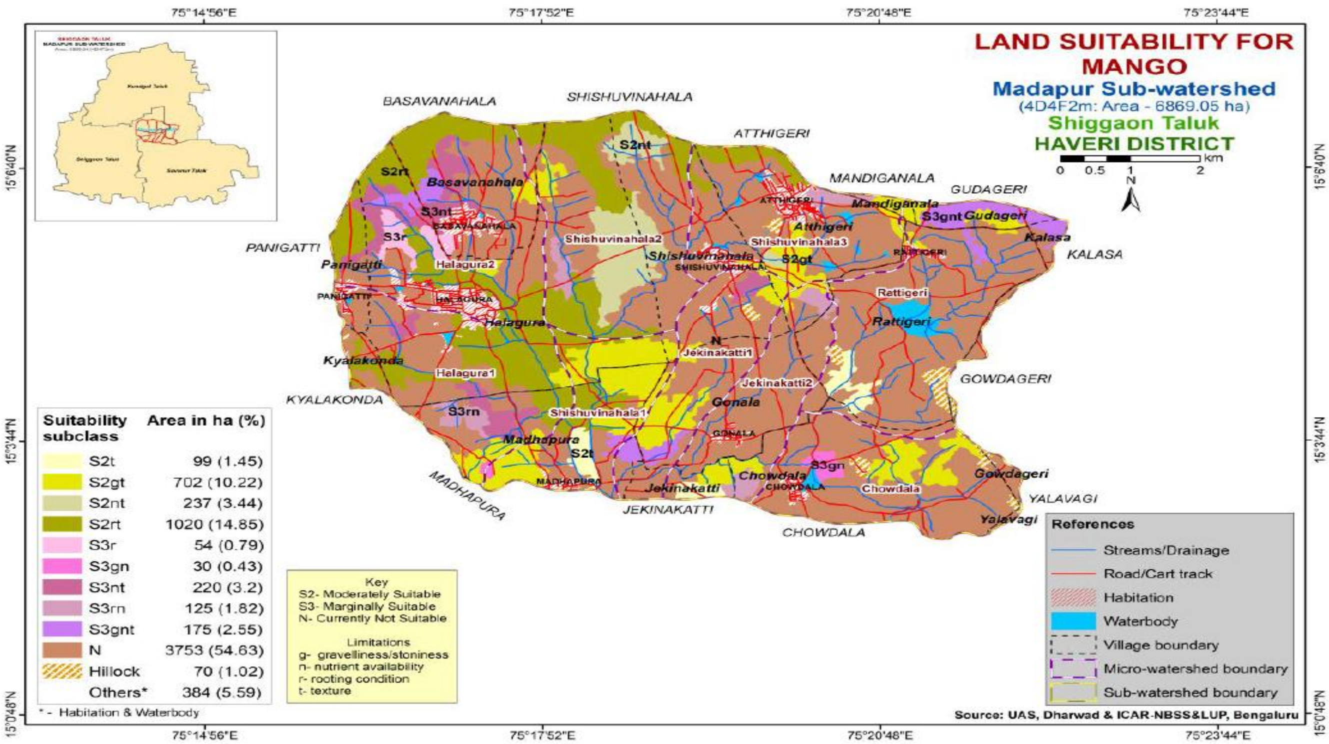

Fig. 2 : Soil site suitability map for Mango crop in Madapur Sub-watershed

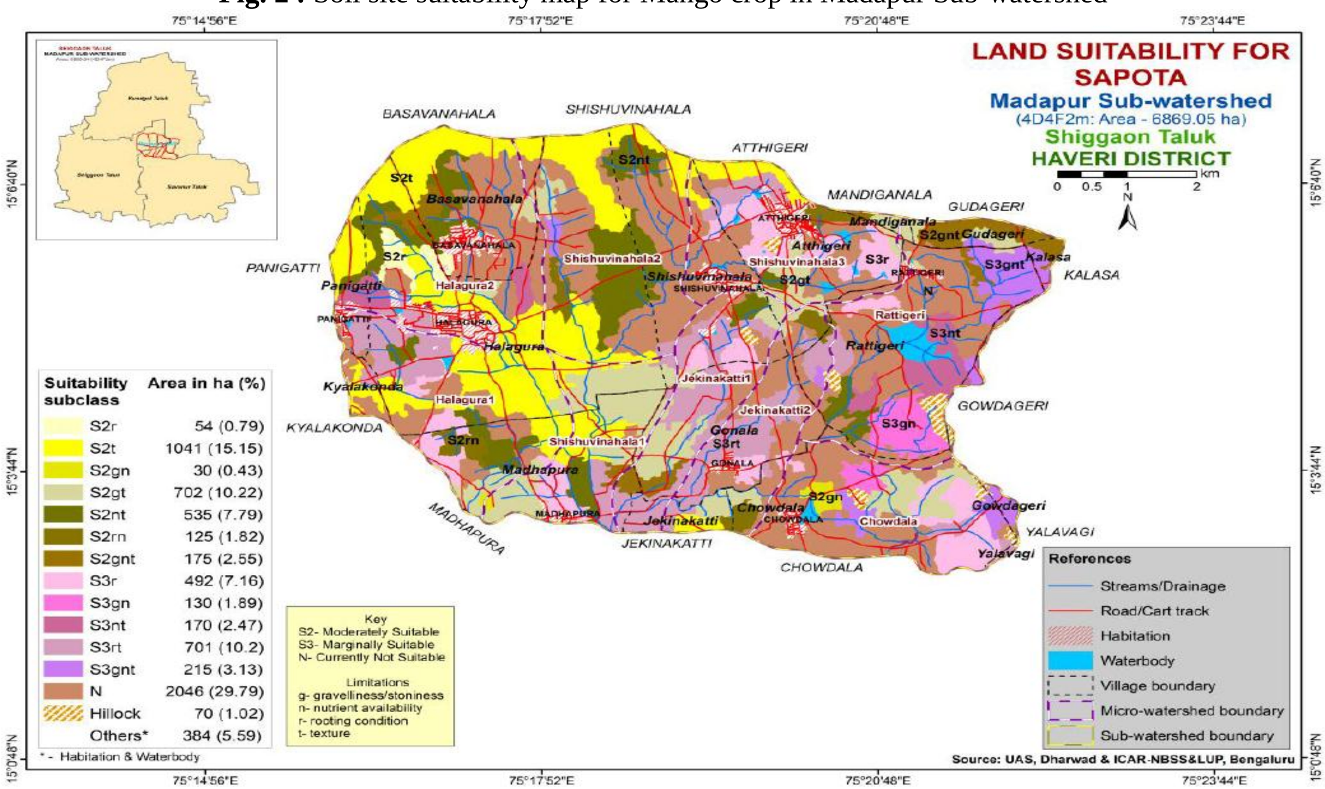

Fig. 3: Soil site suitability map for Mango crop in Madapur Sub-watershed

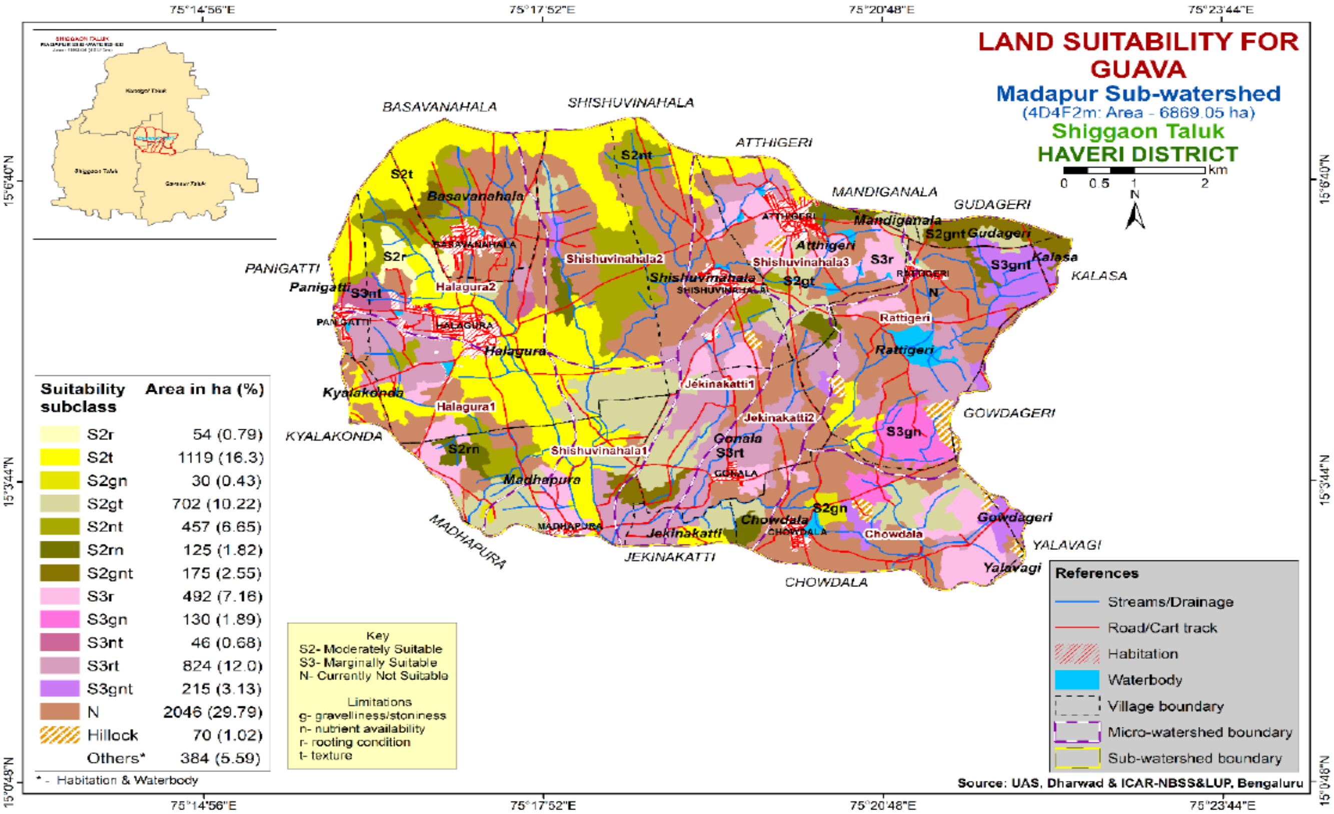

Fig. 4: Soil site suitability map for Guava crop in Madapur Sub-watershed

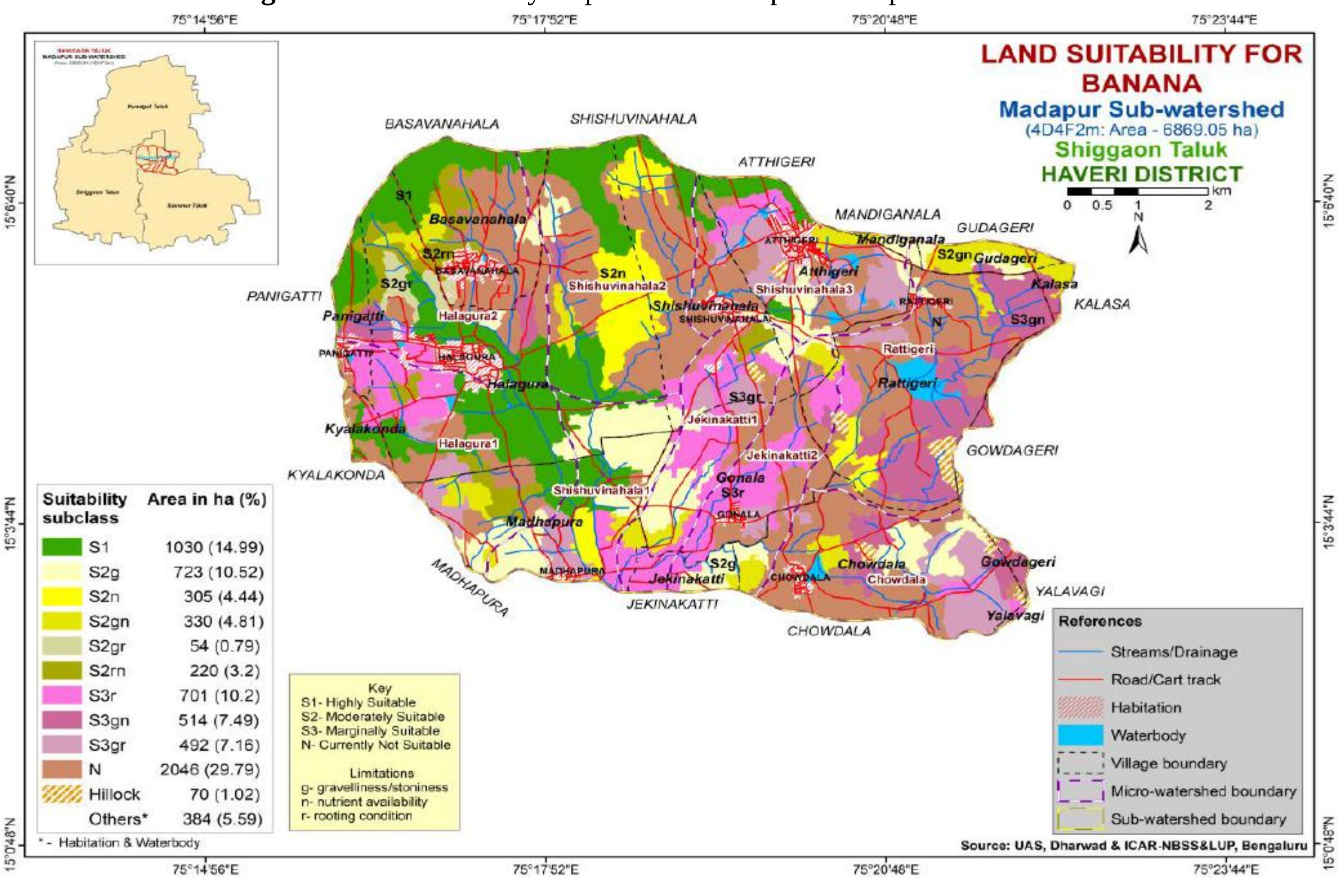

Fig. 5 : Soil site suitability map for Banana crop in Madapur Sub-watershed

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