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Original Research Article

Land Capability, Irrigability Classification and GIS Mapping in Asoti-4 Micro-watershed of Gadag District (Karnataka), India

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Keywords

GIS, Land capability, Land irrigability, Mapping Units, Satellite image, Soil phases, Soil series

A B S T R A C T

A study was conducted to assess land capability and irrigability classification in Asoti-4 micro-watershed of Ron *taluk*, Gadag district by using IRS P6 LISS- IV dataset, SOI-toposheet and GIS technique. Eight mapping units derived with representative seven pedons that covered different landforms were evaluated for land capability, Irrigability classification and mapped using ArcGIS software. Study revealed predominant area was moderately good land (IIItsf) with topography (t), soil physical condition (s) and fertility (f) limitation. Study also revealed that predominant area is fall under irrigable soil class (IIItws) with topography (t), wetness (w) and soil physical condition (s) limitation but, moderately suitable (S2tws) for irrigation. The eight mapping units derived from seven pedons were grouped into four soil series viz., AST-1 (P1, P2 and P6: MU1, MU6, MU7 and MU8), MNS-1 (P3 and P4: MU2 and MU5), MNS-2 (P5:MU3) and MNS-3 (P7:MU4), respectively. All the pedons were grouped under Vertisol whereas, P5 grouped under Inceptisol.

Introduction

Total geographical area of India is 328.7mha which accounts 2.4% of world and stand 7th position. Total arable land 162mha stand 2nd next to china. Total agricultural land in world is 7.5% of total geographical area. Cropping intensity of India is 140.5%. India is leading producer of pulses, tea, jute and allied fibers. India's average pulse productivity 730 kg ha^{-1} whereas, Canada's is 1900 kg ha^{-1}. India stands 2nd in rice, groundnut, sugarcane, vegetables, cattle population, buffalo population and milk production. India stands 3rd in wheat, total cereals, cotton, tobacco, mustard, rapeseed and 4th in egg production. Contribution of agriculture to GDP in 1950-51 is 54.5% and declined to 16% in 2015 so, wide scope for increase in agriculture sector. Karnataka stands 1st in sunflower, finger millet and coarse cereals production. In India 120.82 m ha (36.5% TGA) is degraded land and 105.48 m ha is under desertification (Das *et al.*, 2009). Targeted rate of agriculture in India is 4% but current agriculture development rate is 1.4%. Total irrigated area in India was 58 mha accounted 21% of world (324mha) and occupied first position. The 42% of total irrigated area located in only China and India. Area under micro-irrigation, drip irrigation, sprinkler system in the year 2014-15 is 7.73, 3.37 and 4.35mha recorded highest in Maharashtra and

Rajasthan, respectively. Total distributed area under sprinkler irrigation in world is 35mha. Irrigation through tube well and canal sources were 57 and 32%, respectively. Rice is world largest irrigated cereal occupied 29% of irrigated crop. Punjab, Haryana, UP states predominant areas under irrigation occupied 98.1, 87 and 75%, respectively. But, highest area under total irrigation is noticed in Uttar Pradesh. Overexploitation of natural resources and scarcity of inputs like chemical fertilizers denote intensive agriculture. The problems of declining soil fertility, stagnant yield level and unfettered soil erosion are associated with intensive agriculture in developed countries. Land productivity is in decline trend due to degradation and pollution aspect. To achieve sustainability, evaluation and detailed characterization of land resources giving its potential and constraints becomes pre-requisite.

At present, most systems of land evaluation are interpretative classification. A general evaluation based on limitations of land characteristics, is best illustrated in the USDA capability classification. Land capability classification is an interpretative grouping of soils mainly based on the inherent soil characteristics, external land features and climatic factors that limit the use of land for agricultural purposes. The classification points out automatically the possibilities and limitations of the climate and soil for each crop and type of agriculture. Land resource inventory is mandatory tool to decide soil health and crop productivity. Remote sensing data coupled with soil survey information (SIS) can be integrated in the Geographical Information System (GIS) to assess crop suitability for various soil and biophysical conditions. Keeping in view the above mentioned facts and figures, present investigation entitled "Land capability, Irrigability and GIS mapping in Asoti-4 micro-watershed of Gadag district (Karnataka)" was carried out.

Materials and Methods

Study area

Asoti-4 (4D7C4S2g) micro-watershed belongs to Asoti sub-watershed lies 45 km away from Gadag district, Karnataka and located in Ron *taluk*. Which covered 267.04 ha area and located between 15^0 48' 9.014" N to 15^0 49' 26.003" N latitude, 75^0 35' 23.398" E to 75^0 36' 28.813" E longitude and mean elevation ranged from 441.5 to 541.5 m above MSL. The location map was depicted in Fig 1. The watershed is flat terrain. The climate is semiarid type with mean annual temperature is 25 ºC. Average soil temperature ranged from 28 ºC to 32 ºC (> 22ºC). So, Isohyperthermic temperature regime and Ustic moisture regime was observed. The area received a mean annual rainfall of 671 mm. predominantly, basalt, schist, granite, gneiss rocks lead to development of deep black soils. The 2:1 types of clay minerals were observed in the Vertisols. The Vertisols and Inceptisols were predominant soil orders existed in micro-watershed.

Method of data collection

The False Colour Composite (FCC) of IRS P6 LISS IV satellite image (Fig 2) and SOI toposheet (Fig 3) is used to physical traverse of micro-watershed. The pedon locations were fixed based on heterogeneity (Fig 4). The seven soil profiles were studied for morphological, physical and chemical properties. The weighted mean of those results were used for land evaluation. The eight mapping units and 4 soil series were derived from seven pedons in the study area. Further, the cadastral base map was

georeferenced, vectorized and created shape files using Arc GIS 10.3 software. The land capability and Irrigability maps were prepared.

The land capability was mainly based on the inherent soil characteristics, external land features and environmental factors. The land capability classes and sub-classes were arrived as per the guidelines of Soil Survey Manual (Anon., 1971). The criteria used for land capability classification were presented in Table 1. Soil site suitability classes for irrigation are useful in grouping of soils according to their suitability for sustained use under irrigation. The classes were defined in terms of the degree of soil limitations. Soil site suitability classes for irrigation are determined as per the guide lines proposed by Sehgal (1996).

The criteria used for land Irrigability classification were presented in Table 2. The soil site characteristics used for land evaluation is given in Table 3.

Results and Discussion

The weighted mean of physico-chemical parameters of pedons (Table 4) used for taxonomic classification and land evaluation are depicted in Table 5. The soil phases and series were mapped and depicted in Fig 5 and 6.

All the mapping units were moderately good lands but limitations differed. The mapping unit, MNS2mB2Cag1- MU2 was moderately good land with only soil chemical condition as limitation (organic carbon) whereas, remaining mapping units were moderately good land with higher limitations of topographic parameter (erosion), soil physical condition (texture) and soil chemical status (organic carbon). While coding mapping units, MU1, MU2, MU3 and MU4 had higher limitations value and are likely to fall under category, IV fortunately; organic carbon content is a correctable factor by good management practices. As a result, mapping units, MU1, MU2, MU3 and MU4 were classified under land capability class-III. Nagendra and Patil (2015), Pramod and Patil (2015) and Madhan Mohan (2008) also inferred the similar observations. Predominantly, area is having topographic, soil physical condition and fertility constraints so, area fall under moderately good land- IIItsf. The pedons and mapping units evaluated for land capability classification is given in Table 6. The land capability map is shown in Fig 7.

The soils of the study area are partly under lift irrigation and partly under rainfed situation. The study area was grouped based on suitability for irrigation. The study resulted that all the mapping units were under irrigable soil class-IIItws with topography (erosion), wetness (drainage outlets) and soil physical constraints (texture).

All the mapping units are fall under irrigable soil class. The pedons and mapping units evaluated for land irrigability classification is given in Table 7. The land irrigability map is shown in Fig 8. The farmers are using traditional source of water which they call by local name *Rottibore*. The underground pipe at 20 to 30m deep conducts water by gravity from nearby natural streams to individual fields. This water is used for irrigation.

Additionally, farmers pump water from stream through electric pumps. Erratic rainfall is the main constraint in Asoti-4 micro-watershed. The micro-watershed was falls under rain shadow area. The similar observations were also made by Nagendra and Patil (2015) and Pramod and Patil (2015) through their study in the Gadag district.

Table.1 Criteria of land capability classification

Land Characteristics	Class-I	Class-II	Class-III	Class-IV	Class-V	Class-VI	Class-VII	Class-VIII
Topography(t)								
Slope (%)	0-1	1-3	3-8	8-15	Up to 3	15-35	35-50	>50
Erosion	Nil	Slight	Moderate	Severe	Nil	Nil	V. severe	
Wetness (w)								
Flooding	Nil (F0)	Nil (F0) (F0/F1)	Nil to slight (F1/F2)	Slight to mod. (F3)	Moderate to severe (F0/F3)	Nil to severe, (F0/F4)	Nil to V. severe	-
Drainage (l)	Well	Mod. well	Imperfect	Poor	V. poor	Excessive	Excessive	Excessive
Physical soil condition (s)								
Surface Texture	loam	sil &cl	sl &c	scl	s, c (m)	ls, cl	ls, s, c	ls, c, c
Soil depth (cm)	>150	150-100	100-50	50-25	-	25-10	25-10	<10
Surface stoniness (%)	<1	1-3	3-5	5-8	8-15	15-40	40-75	>75
Sub-surface Crs. Frg. (%)	<15	<15	15-35	35-50	50-75	50-75	50-75	>75
Fertility (f)								
CEC cmol (p^+) kg^{-1}	40-16	16-12	16-12	-	-	-	-	-
BS (%)	80+	80+	80-50	50-35	50-35	35-15	<15	-
OC (0-15cm) (%)	>1	0.75-1.0	0.5-0.75	<0.5	<0.5	-	-	-
Salinity EC (dS/m)	<1	2-4	2-4	4-8	8-15	15-35	35-50	>50

Table.2 Criteria of land Irrigability classification

Land irrigability classes						
Land characteristics	S1 (suitable)		S2 (moderate)	S3 (marginal)	N1 (not-suitable)	N2 (not suitable)
	Class-I	Class-II	Class-III	Class-IV	Class-V	Class-VI
Topography (t)						
Slope (%)	<1	1-3	3-5	5-10	10-15	>25
Erosion	Nil	Slight	Moderate	Severe	v. severe	Very severe
Wetness(w)						
Drainage	Well	Mod. well	Imperfect	Poor	V. poor	Excessive
Drainage outlets	Suitable outlets available			Suitable outlets not available		
Physical soil condition (s)						
Surface texture	Sandy loam to clay loam	Loamy sand, clay	Sand, clay	Sand, clay	Any texture	Any texture
Effective Soil depth (cm)	>90	45-90	22.5-45	7.5-22.5	<7.5	<7.5
Rock out crops (m) apart	40	20	15	5	<5	
Sub-surface Crs. Frg. (%)	<5	5-15	15-35	35-65	>65	>65
Chemical parameters (f)						
EC	0-4	4-8	8-16	16-30	>30	>30
ESP (%)	0-5	5-15	15-25	25-45	>45	>45
$CaCO_3$ (%)	0-5	5-15	15-30	30-50	>50	

Table.3 Soil site characteristics used for land evaluation

Site characteristics		P1	P2	P3	P4	P5	P6	P7
Climate	MARF (mm)	671mm						
	MAT (^{0}C)	25 ^{0}C						
Landform	Slope (%)	1-3	1-3	0-1	0-1	1-3	1-3	1-3
	Erosion	Moderate	Mod.	Mod.	Slight	Mod.	Mod.	Mod.
	Drainage	Moderately well drained						

Table.4 Weighted mean of soil profile parameters for land evaluation and soil classification

Pedons	Depth (cm)	Coarse fragments %	Sand %	Silt %	Clay %	pH	EC dSm^{-1}	OC gkg^{-1}	$CaCO_3$ %	CEC cmol(p+) kg^{-1}	BS%	ESP	CEC/Clay
P-1	95	0.12	14.10	20.53	65.43	8.56	0.28	4.3	7.38	60.67	93.33	4.57	0.93
P-2	55	0.17	10.00	22.40	67.65	8.68	0.56	5.8	7.50	61.00	91.15	4.54	0.90
P-3	68	0.15	10.00	22.45	67.61	8.49	0.86	7.2	9.25	60.20	95.03	4.52	0.89
P-4	100	0.14	16.65	18.57	64.77	8.80	0.46	4.0	13.09	61.03	92.90	4.10	0.94
P-5	70	0.17	18.50	14.30	67.20	8.61	0.43	3.0	4.69	58.55	93.68	4.51	0.87
P-6	65	0.17	21.30	13.15	65.55	8.59	0.29	4.9	6.25	59.10	93.15	3.98	0.91
P-7	75	0.17	35.95	15.35	48.71	8.74	0.33	3.3	4.97	51.45	88.82	3.88	1.52

Table.5 Soil taxonomical classificati and grouping of mapping units and pedons

Sl. No.	Series name	MU. No.	Mapping units/ Soil phases	Pedon No.	Taxonomic classification	Description
1	AST1-Series	MU1	MNS1mB2	P1, P 6	Very fine, smectitic, super active, isohyperthermic, Typic haplustert	Soils are deep and very fine clay textured. Within 100 cm mineral surface, presence of 25cm or more thick slickensides or wedge shaped peds. Cracks open and close periodically.
		MU6	AST2mB2	P2		
		MU7	HMN1mB2	P2		
		MU8	HMN2mB2g1	P2		
2	MNS-1series	MU2	MNS2mB2Cag1	P4	Very fine, smectitic, super active, isohyperthermic, Typic calciustert	Soils are deep and very fine clay textured. Within 100cm mineral surface, presence of 25cm or more thick slickensides or wedge shaped peds. Cracks open and close periodically. Usterts that has calcic horizon within 100cm depth.
		MU5	AST1mB2Cag1	P3		
3	MNS-2 series	MU3	MNS3mB2	P5	Very fine, smectitic, super active, isohyperthermic, Typic haplustept	Soils are deep and very fine clay textured, presence of cambic horizon within 100cm of mineral surface
4	MNS-3 series	MU4	MNS4mB2	P7	Fine, smectitic, super active, isohyperthermic, Typic haplustert	Soils are deep and fine clay textured. Within 100cm mineral surface, presence of 25cm or more thick slickensides or wedge shaped peds. Cracks open and close periodically.

Table.6 Land capability classification of pedons in Asoti-4 micro-watershed

Pedons	Landform/ topography (t)		Wetness (w)		Physical properties (s)				Chemical properties and fertility status (f)				LCC
	Slope	Erosion	Drainage	Flood	Depth	Surface stoniness	Texture	Coarse Fragments	EC	OC	CEC	BS	
Pedon-1 (MU 1)	II	III	II	I	I	I	III	I	I	IV	I	I	III* (t, s, f)
Pedon-2 (MU 6, 7, 8)	II	III	II	I	I	I	III	I	I	III	I	I	III (t, s, f)
Pedon-3 (MU 5)	I	III	II	I	I	I	III	I	I	III	I	I	III (f, t, s)
Pedon-4 (MU2)	I	II	II	I	I	I	III	I	I	IV	I	I	III* (s, f)
Pedon-5 (MU 3)	II	III	II	I	I	I	III	I	I	IV	I	I	III* (t, s, f)
Pedon-6 (MU 1)	II	III	II	I	I	I	III	I	I	IV	I	I	III* (t, s, f)
Pedon-7 (MU 4)	II	III	II	I	I	I	III	I	I	IV	I	I	III* (t, s, f)

Note: *: It indicated correctable organic carbon limitation

Table.7 Land irrigability classification of pedons in Asoti-4 micro-watershed

Pedons	Landform/ topography (t)		Wetness (w)		Physical properties (s)				Chemical properties and fertility status (f)			Land Irrigability classification	Suitability for irrigation
	Slope	Erosion	Drainage	Drainage outlets	Depth	Rock outcrops	Texture	Coarse Fragments	EC	ESP	$CaCO_3$		
Pedon-1 (MU 1)	II	III	II	III	I	I	III	I	I	I	II	III (t, w, s)	S2 (t, w, s)
Pedon-2 (MU 6, 7, 8)	II	III	II	III	I	I	III	I	I	I	II	III (t, w, s)	S2 (t, w, s)
Pedon-3 (MU 5)	I	III	II	III	I	I	III	I	I	I	II	III (t, w, s)	S2 (t, w, s)
Pedon-4 (MU2)	I	III	II	III	I	I	III	I	I	I	II	III (t, w, s)	S2 (t, w, s)
Pedon-5 (MU 3)	II	III	II	III	I	I	III	I	I	I	I	III (t, w, s)	S2 (t, w, s)
Pedon-6 (MU 1)	II	III	II	III	I	I	III	I	I	I	II	III (t, w, s)	S2 (t, w, s)
Pedon-7 (MU 4)	II	III	II	III	I	I	III	I	I	I	I	III (t, w, s)	S2 (t, w, s)

Table.8 Overall land capability and irrigability classification

Land capability classification			
Sl. No	Land capability sub-class	Interpretations	Mapping Units
1	III fts	Moderately good land (Drainage, fertility, pH and soil physical condition as limitations)-good for cultivation	HMN1mB2, HMN2mB2g1, AST1mB2Cag1, MNS1mB2, MNS3mB2, MNS4mB2 and AST2mB2
2	IIIsf	Moderately good land (Limitation of fertility, pH and soil physical condition).	MNS2mB2Cag1,
Land irrigability classification			
Sl. No	Land irrigability sub-class	Interpretations	Mapping Units
1	III tws	Suitable for irrigation using stream water	HMN1mB2, HMN2mB2g1, AST1mB2Cag1, AST2mB2, MNS1mB2, MNS2mB2Cag1, MNS3mB2 and MNS4mB2

Fig.1 Location of Asoti-4 micro-watershed in Ron *taluk* of Gadag district

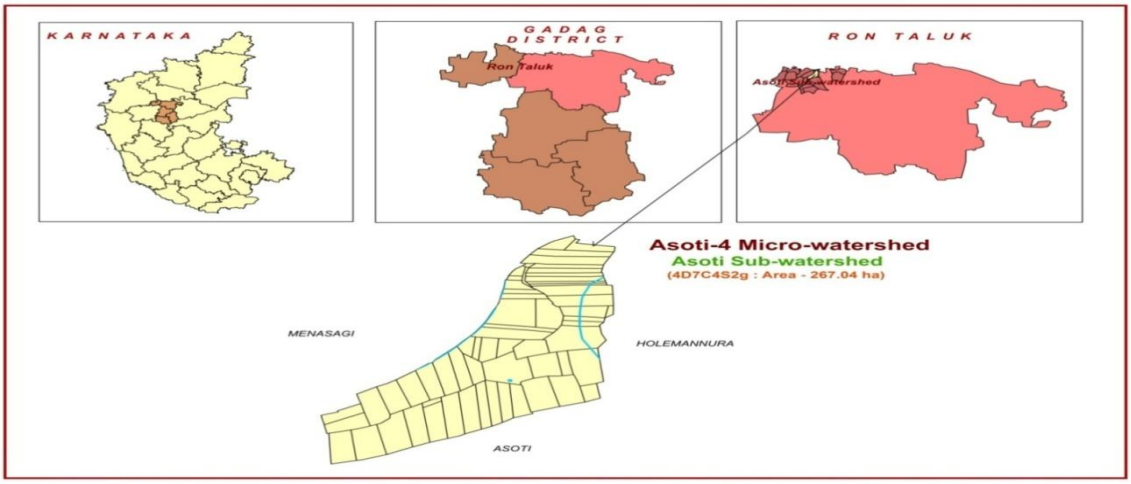


Fig.2 The IRS-P6-LISS IV satellite image of Asoti-4 micro-watershed

Fig.3 The cadastral base map

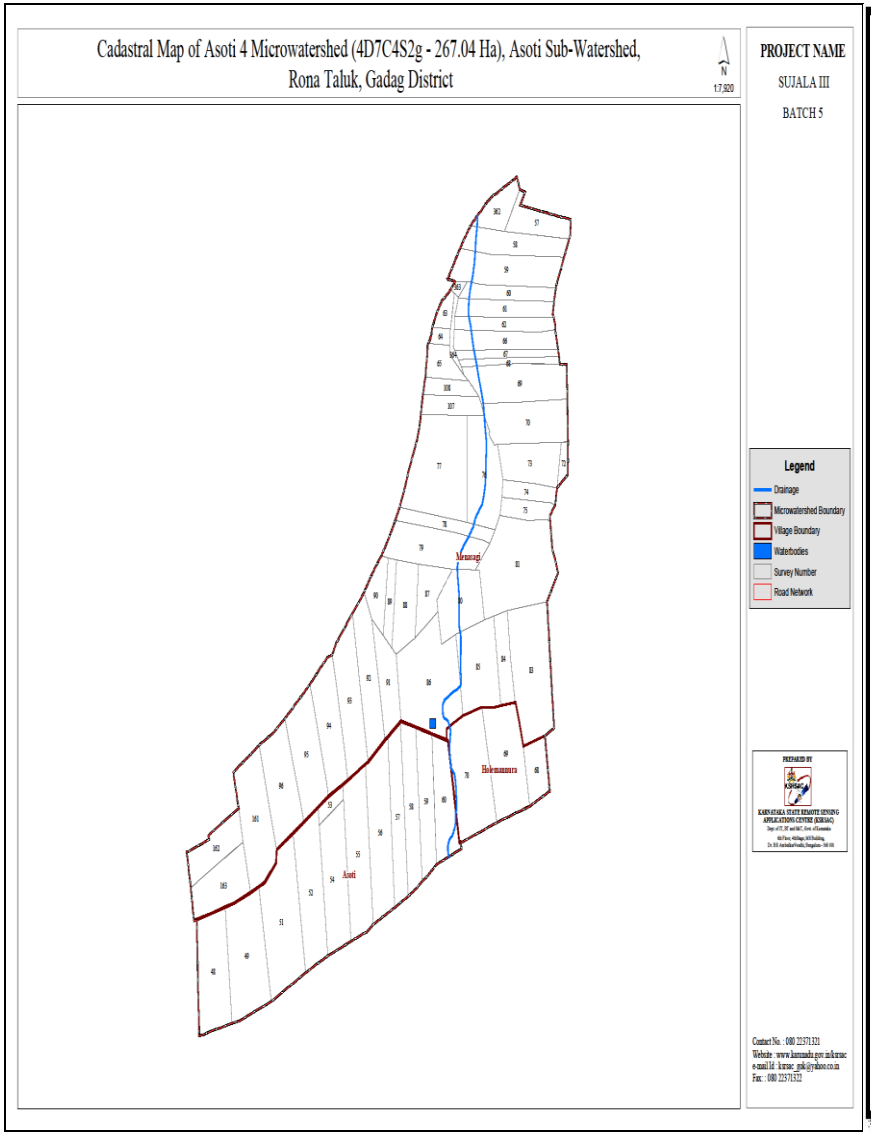


Fig.4 Pedon locations

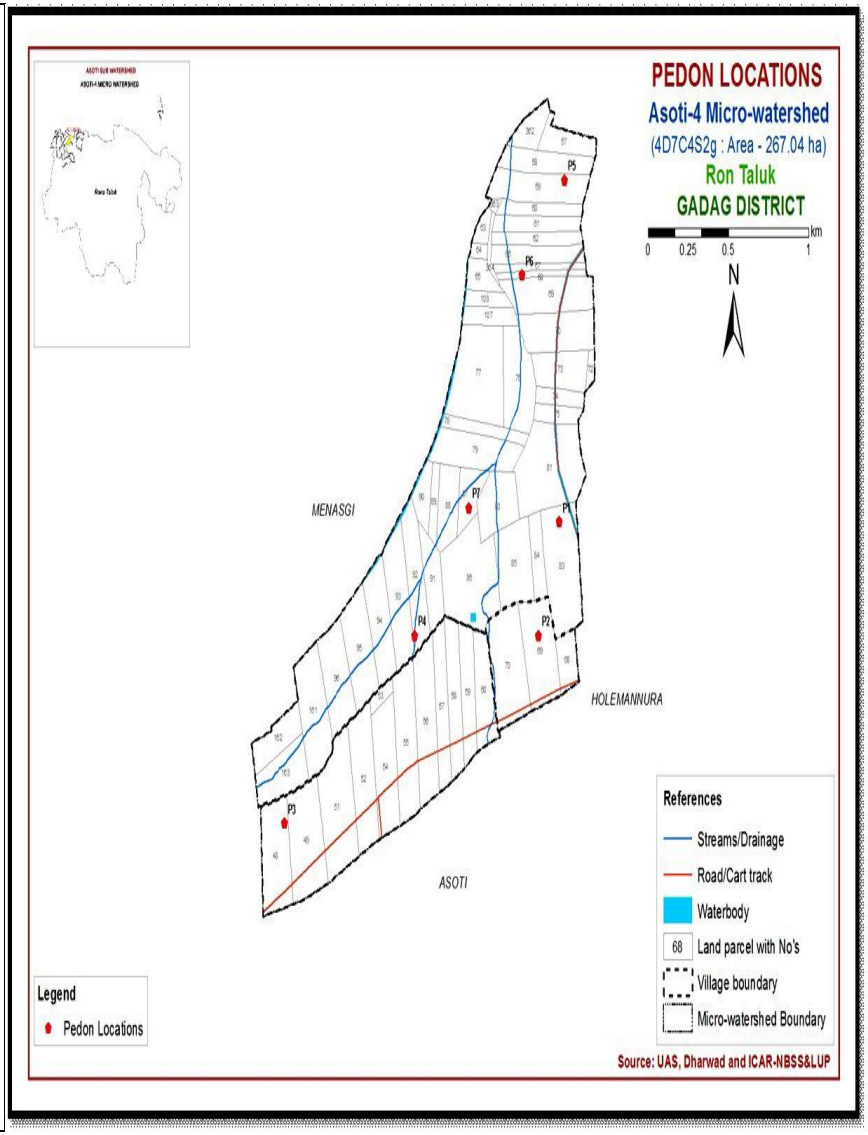


Fig.5 Soil phases map

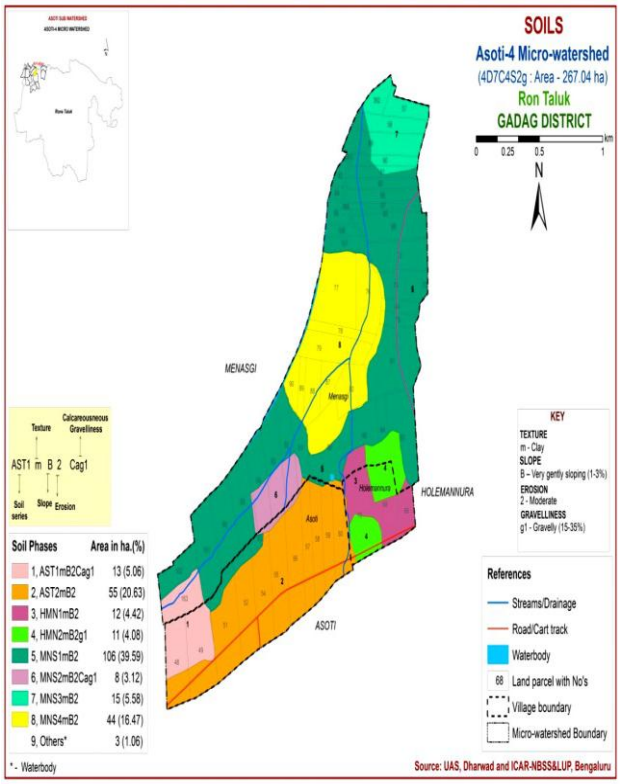


Fig.6 Soil series map

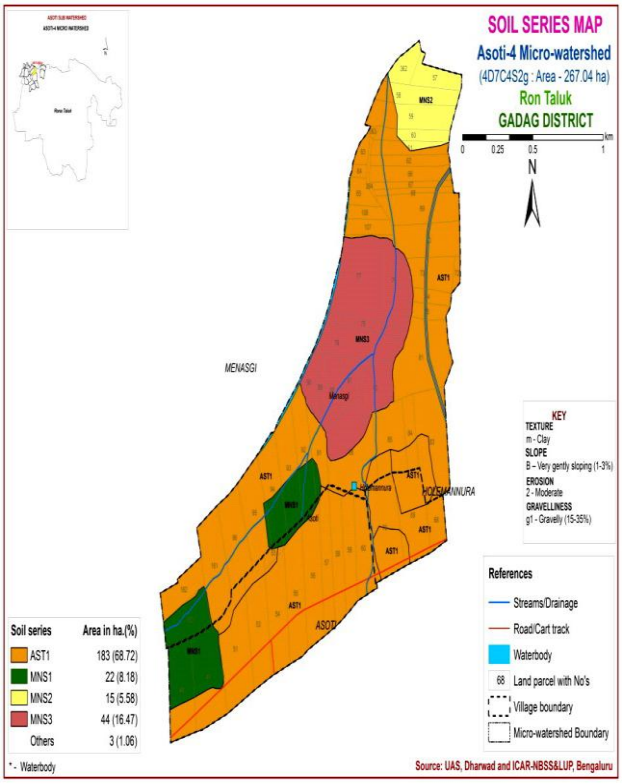


Fig.7 Land Capability Map

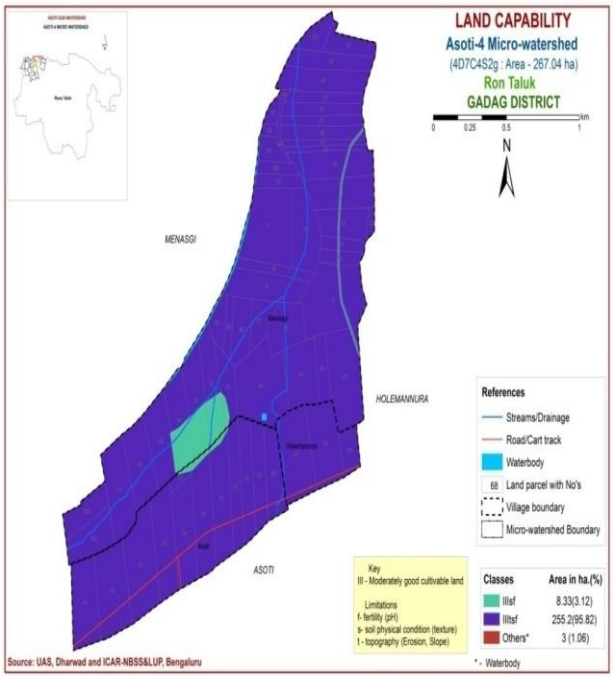
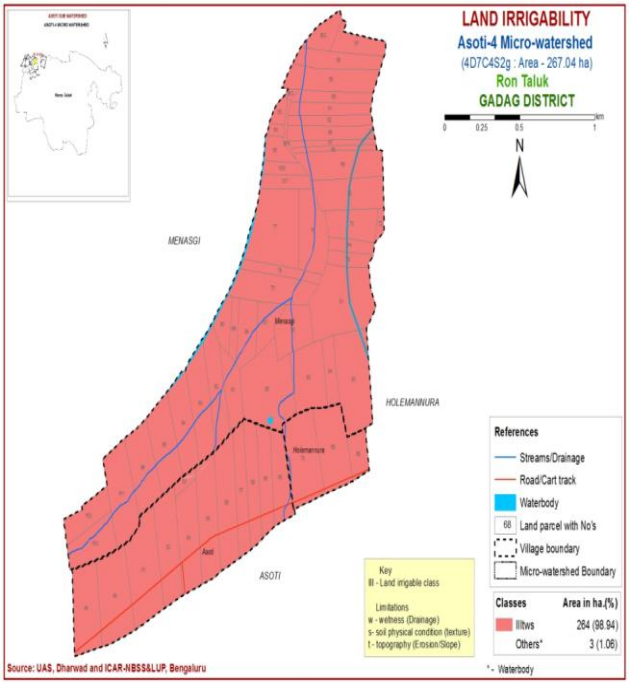


Fig.8 Land Irrigability map



The overall land capability and irrigability classification for mapping units is given in Table 8. The remote sensing and GIS technology is the best technology used for land capability and land irrigability classification at cadastral level. The IRS P6 LISS-IV satellite image is best sensor used in land capability and irrigability mapping. The seven pedons grouped into eight mapping units and four soil series. Predominantly, Asoti-4 micro-watershed fall under moderately good land (III) and irrigable soil class (III) and moderately suitable for irrigation (S2).

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