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ICAR-NBSS&LUP Sujala SWS-LRI Atlas No. 81

Land Resource and Hydrological Inventory of Tyagatur Sub-watershed for Watershed Planning and Development Gubbi Taluk, Tumkur District, Karnataka (AESR 8.2)

Sujala – III
Karnataka Watershed Development Project- II
Funded by World Bank



ICAR - NBSS & LUP



ICAR - National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore
Watershed Development Department, Govt. of Karnataka, Bangalore

About ICAR - NBSS&LUP

The National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS&LUP), Nagpur, a premier Institute of the Indian Council of Agricultural Research (ICAR), was set up during 1976 with the objective to prepare soil resource maps at national, state and district levels and to provide research inputs in soil resource mapping and its applications, land evaluation, land use planning, land resource management, and database management using GIS for optimising land use on different kinds of soils in the country.

The Bureau has been engaged in carrying out soil resource survey, agro-ecological and soil degradation mapping at the country, state and district levels for qualitative assessment and monitoring the soil health towards viable land use planning. The research activities have resulted in identifying the soil potentials and problems, and the various applications of the soil surveys with the ultimate objective of sustainable agricultural development. The Bureau has the mandate to correlate and classify soils of the country and maintain a National Register of all the established soil series. The Institute is also imparting in-service training to staff of the soil survey agencies in the area of soil survey, land evaluation and soil survey interpretations for land use planning. The Bureau in collaboration with Panjabrao Krishi Vidyapeeth, Akola is running post-graduate teaching and research programme in land resource management, leading to M.Sc. and Ph.D. degrees.

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PART - A

Land Resource Inventory of Tyagatur Sub-watershed for Watershed Planning and Development Gubbi Taluk, Tumkur District, Karnataka (AESR 8.2)

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How to read and use the Atlas

The Land Resource Inventory of Tyagatur Sub-watershed (Gubbi Taluk, Tumkur District) for Watershed Planning (AESR 8.2) was undertaken to provide comprehensive site-specific cadastral level information useful for farm level planning and integrated development of the area under Sujala – III, Karnataka Watershed Development Project- II.

This atlas contains the basic information on kinds of soils, their geographic distribution, characteristics and classification. The soil map and soil based thematic maps derived from soils data on soil depth, soil gravelliness, slope, land suitability for various crops and land use management maps are presented on 1:12,500 scale. The maps of fertility status (soil reaction, organic carbon, available phosphorus, available potassium, available sulphur, available calcium, available copper, available manganese, available zinc, available iron, available boron and salinity (EC) on 1:12,500 scale were derived from grid point sampling of the surface soils from the watersheds.

The atlas illustrates maps and tables that depict the soil resources of the watershed and the need for their sustainable management.

The user, depending on his/her requirement, can refer this atlas first by identifying his/her field and survey number on the village soil map and by referring the soil legend which is provided in tabular form after the soil map for details pertaining to his/her area of interest.

The atlas explains in simple terms the different kinds of soils present in the watershed, their potentials and problems through a series of thematic maps that help to develop site-specific plans as well as the need to conserve and manage this increasingly threatened natural resource through sustainable land use management. The Land Resource Atlas contains database collected at land parcel/ survey number level on soils, climate, water, vegetation, crops and cropping patterns, socio-economic conditions, marketing facilities *etc.* helps in identifying soil and water conservation measures required, suitability for crops and other uses and finally for preparing a viable and sustainable land use options for each and every land parcel.

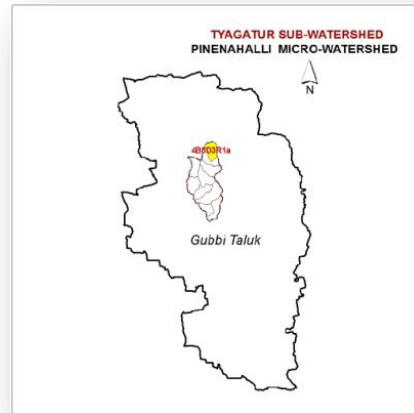
For easy map reading and understanding the information contain in different maps, the physical, cultural and scientific symbols used in the maps are illustrated in the form of colors, graphics and tables.

Physical, Cultural and Scientific symbols used in the Atlas

Each map in the atlas sheet is complemented with the physical, cultural and scientific symbols to facilitate easy map reading.

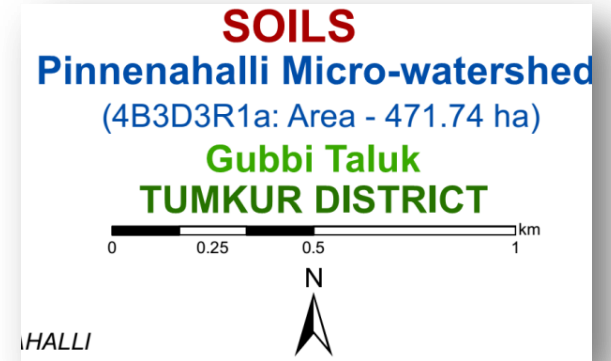
Inset map

Inset provided in each map conveys its strategic location i.e. Taluk, Sub-watershed and Micro-watershed.



Map title

Map title conveys the relevance of thematic information presented along with a graphical scale, geographical location and watershed details in text form.



Legends and symbols

Two legends accompany each map, a map reference, which depicts geographic features and a thematic legend which portrays spatial information. Picking up the symbol and colour of a particular enables one to go to the legends to obtain the required information.

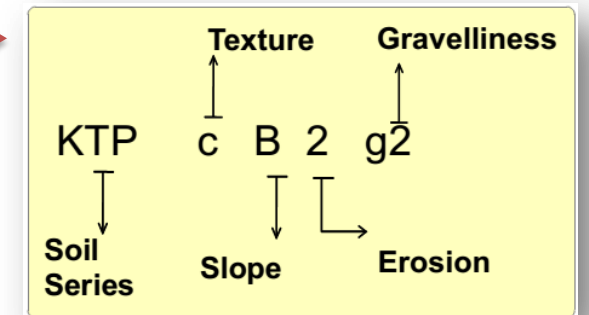
References	
	Stream/Drainage
	Road/Cart track
	Habitation
	Waterbody
	Land parcel with No's
	Village boundary
	Micro-watershed boundary

Soil Phase	Area in ha (%)
1, KTPcB2g2	24 (4.99)
2, BDGcB1g2	19 (3.99)
3, BDGcB2g2	26 (5.52)
4, BDGhB1g1	31 (6.6)
5, SNHIB1	9 (1.97)
6, BPRcB1	78 (16.59)
7, BPRcB1g1	42 (8.81)
8, BPRcB2	8 (1.7)
9, BPRcB2g1	34 (7.2)
10, BPRhB1	12 (2.55)
11, BPRhB2g1	28 (5.92)
12, BPRIB1	15 (3.08)
13, NDLCc2g2	31 (6.66)
14, KDTThB1	60 (12.62)
15, KDTIB1	40 (8.53)
16, KDTIB1g1	9 (2.0)
17, Rock outcrops	1 (0.27)
18, Others*	5 (0.99)

* - Habitation & Waterbody

Soil Units

The soil map may be read at different levels. The most detailed level is that of the soil phase. Soil phases are distinguished within soil series mainly based on differences in surface of soil texture, slope, gravelliness, erosion, etc.



Map colours

Different shades of colours are used as an aid to distinguish the different classes of soils, crop suitability and other maps.

Land Management Units (LMU)

Grouping of similar soil areas based on their soil-site characteristics into management units that respond similarly for a given level of management are designated as land management units

LMU	Area in ha (%)
LMU-1	119 (25.13)
LMU-2	248 (52.51)
LMU-3	76 (16.11)
LMU-4	24 (4.99)
Rock outcrops	1 (0.27)
Others*	5 (0.99)

Map key

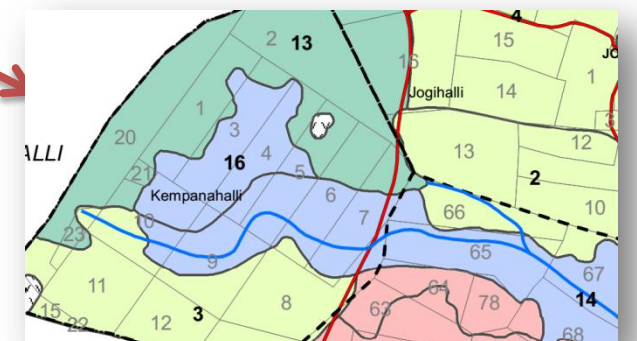
There are many thematic types to be differentiated on the map solely based on colour. Therefore soils and suitability types and their limitations are distinguished by colours with a combination of alpha-numeric characters.

KEY	
TEXTURE	
c	- Sandy loam
h	- Sandy clay loam
i	- Sandy clay
SLOPE	
B	- Very gently sloping (1-3%)
C	- Gently sloping (3-5%)
EROSION	
1	- Slight
2	- Moderate
3	- Severe
GRAVELLINESS	
g1	- Gravelly (15-35%)
g2	- Very gravelly (35-60%)
DEPTH	
KTP-	Moderately shallow(50-75 cm)
BDG-	Moderately deep(75-100 cm)
BPR,SNH-	Deep(100-150 cm)
NDL, KDT	-Very deep(>150 cm)

Key	
S1	-Highly Suitable
S2	-Moderately Suitable
S3	-Marginally Suitable
N-	Not Suitable
Limitations	
g-	gravelliness
r-	rooting condition
e-	erosion
l-	topography

Soil and plot boundaries

Soil units shown on the map are represented by both the color and a numeral. The soil boundaries are superimposed on land parcel with revenue survey number boundaries to visualize its spatial extent.



LAND RESOURCE INVENTORY OF TYAGATUR SUB-WATERSHED FOR PLANNING

GUBBI TALUK, TUMKUR DISTRICT

A pilot study by ICAR-NBSS&LUP, Bangalore

INTRODUCTION

Land is a scarce resource and basic unit for any material production. It can support the needs of the growing population, provided they use land in a rational and judicious manner. But what is happening in many areas of the state is a cause for concern to anyone involved in the management of land resources at the grassroots level. In India the area available for agriculture is about 51 per cent of the total area and more than 60 per cent of the people are still relying on agriculture for their livelihood. The limited land area is under severe stress and strain due to increasing population pressure and competing demands of various land uses. Due to this, every year there is a significant diversion of farm lands and water resources for non-agricultural purposes. Apart from this, due to lack of interest for farming among the farmers in many areas, large tracts of cultivable lands are turning into fallows and this trend is continuing at an alarming rate.

The watershed management programs are aimed at designing suitable soil and water conservation measures, productivity enhancement of existing crops, crop diversification with horticultural species, greening the wastelands with forestry species of multiple uses and improving the livelihood opportunities for landless people.

The objectives can be met to a great extent when an appropriate Natural Resources Management (NRM) plan is prepared and implemented. It is essential to have site specific Land Resources Inventory (LRI) indicating the potentials and constraints for developing such a site specific plan. LRI can be obtained by carrying out detailed characterization and mapping of all the existing land resources like soils, climate, water, minerals and rocks, vegetation, crops, land use pattern, socio-economic conditions, infrastructure, marketing facilities and various schemes and developmental works of the government. From the data collected at farm level, the specific problems and potentials of the area can be identified and highlighted, conservation measures required for the area can be planned on a scientific footing,

suitability of the area for various uses can be worked out and finally viable and sustainable land use options suitable for each and every land holding can be prescribed to the farmer and other land users of the area.

Tumakuru District popularly known as Kalpataru Nadu (For production of Coconuts) is located 71 kms away from the capital city of Karnataka state. The district is located in the Southern part of the state and lies between 12° 45' and 14° 22' North latitude and between 76° 24' and 77° 30' east longitude. The district has total geographical area of 10598 sq. kms. Majority of the population is dependent on agriculture in the district. The geology of the district consists of Granite gneiss and Schist. The average rainfall in the district is 688 mm. The major crops grown are ragi, groundnut, maize, sorghum, sugarcane, coconut, arecanut, mango, banana, mulberry, horsegram, greengram, field bean, pigeon pea and cow pea etc.

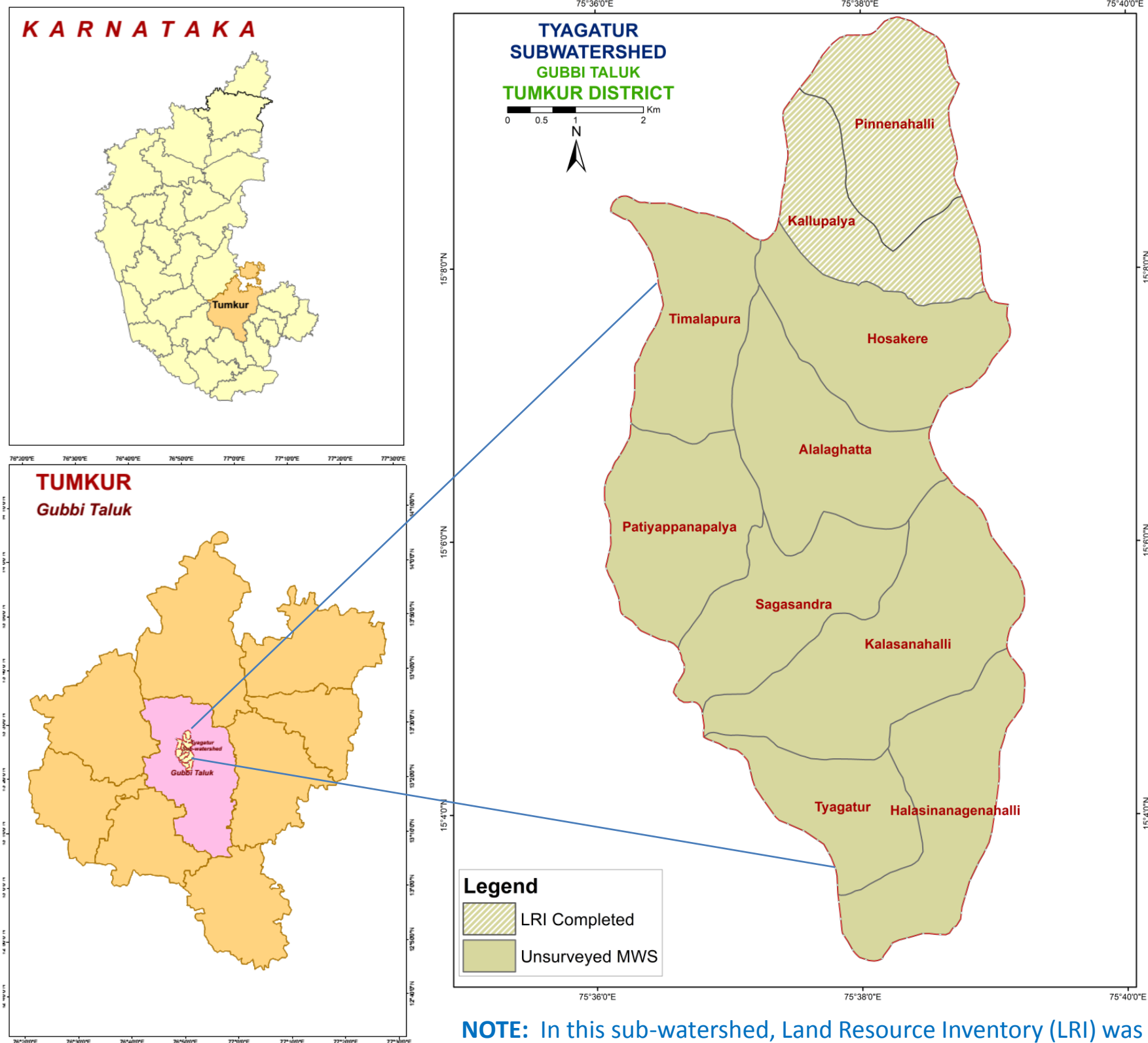
As a pilot study, **ICAR-NBSS&LUP, Bangalore** carried out the generation of LRI for the Tygatur sub-watershed in Gubbi taluk, Tumkur district. It was selected for data base generation under batch VI of Sujala III project. This sub-watershed encompasses of 10 MWs namely Alalaghatta (4B3D3R1d), Halasinanagenahalli (4B3D3R2f), Hosakere (4B3D3R1c), Kalasanahalli (4B3D3R2d), Kallupalya (4B3D3R1b), Patiyappanapalya (4B3D3R2b), Pinnenahalli (4B3D3R1a), Sagasandra (4B3D3R2c), Timalapura (4B3D3R2a) and Tyagatur (4B3D3R2e). Land Resource Inventory (LRI) was generated for two (Pinnenahalli-4B3D3R1a and Kallupalya-4B3D3R1b), among the ten micro-watersheds.

The major landforms identified in the micro-watersheds (Pinnenahalli-4B3D3R1a and Kallupalya-4B3D3R1b) of Tyagatur sub-watershed are uplands and low lands. The database was generated by using cadastral map of the village as a base along with high resolution satellite imagery (IRS LISS IV and Cartosat-1). The objectives of the land resource survey, carried out in the Tyagatur Sub-watershed are indicated below.

- Detailed characterization of all the land resources like soil, water, land use, cropping pattern and other resources available at parcel level in the village.
- Delineation of homogenous areas based on soil-site characteristics into management units.
- Collection and interpretation of climatic and agronomical data for crop planning.
- Identification of problems and potentials of the area and strategies for their management.
- Assessment of the suitability of land resources for various crops and other uses.
- Establishment of village level digital land resources database in a GIS framework.
- Enable the watershed and other line departments to prepare an action plan for the integrated development of the watershed.

LOCATION AND EXTENT

LOCATION MAP OF TYAGATUR SUB-WATERSHED



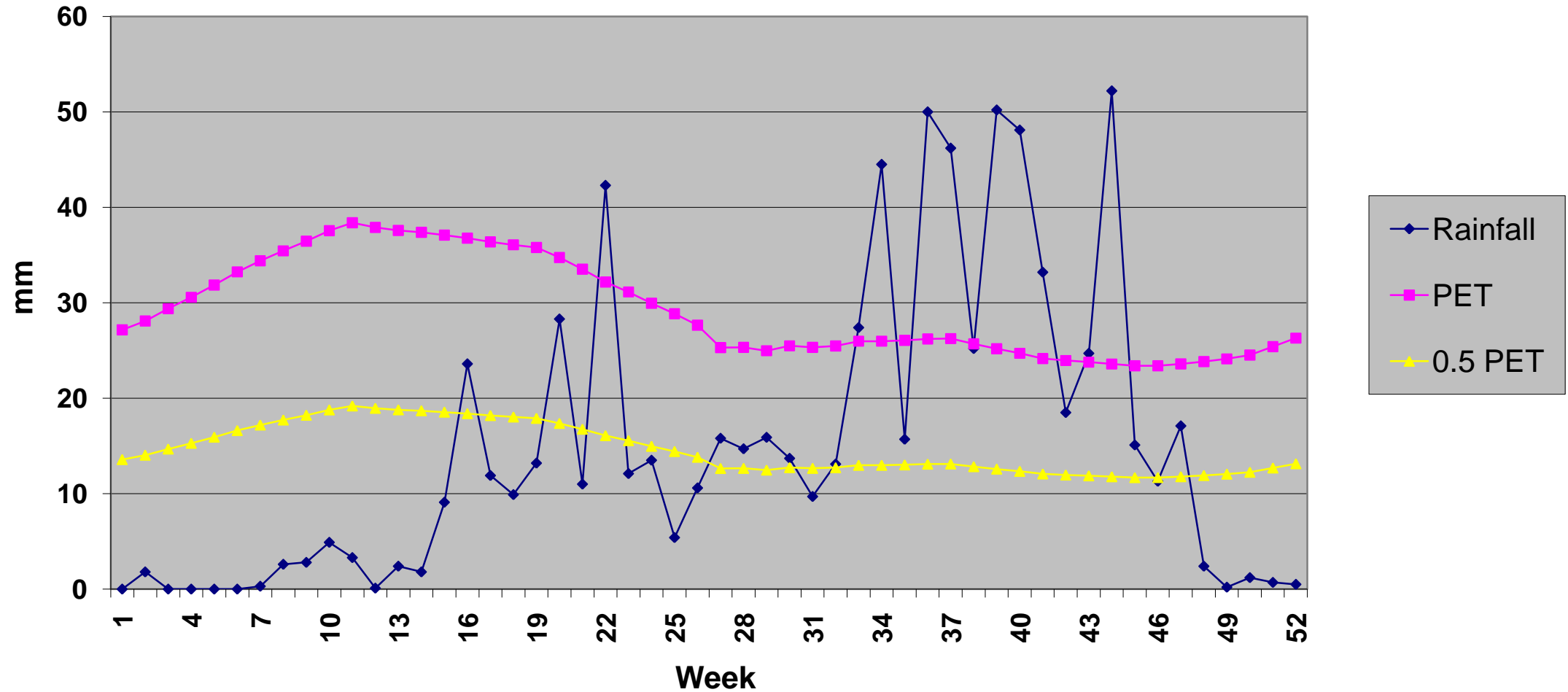
Tyagatur sub-watershed (Gubbi Taluk, Tumkur District) is located between 13^o21' 15"-13^o28' 47" North latitudes and 76^o 47'17"- 76^o 53'42" East longitudes, covering an area of about 5380 ha.

Agro Ecological Sub Region (AESR) 8.2: Central Karnataka Plateau, hot moist semi-arid ESR with medium to deep Red loamy soils, low AWC and LGP 120-150 days

Agro-climatic Zone 5: Eastern Dry Zone: The zone covers entire Bangalore and Kolar districts and 2 taluks of Tumkur. It has an area of 1.80 M ha with 0.85 M ha under cultivation. About 0.23 M ha are irrigated mainly from tanks and wells. Elevation ranges from 800 to 1500m MSL with major area falling between 800 and 900m. The major soil type is non-gravelly red loam with a narrow belt of lateritic soil. Average annual rainfall ranges between 680 and 890mm. The principal crops of the zone are ragi, rice, pulses, maize, oil seeds and mulberry. A sizeable area is also under vegetables and flowering plants

NOTE: In this sub-watershed, Land Resource Inventory (LRI) was generated for two micro-watersheds (Pinnenahalli-4B3D3R1a and Kallupalya-4B3D3R1b) among the ten micro-watersheds.

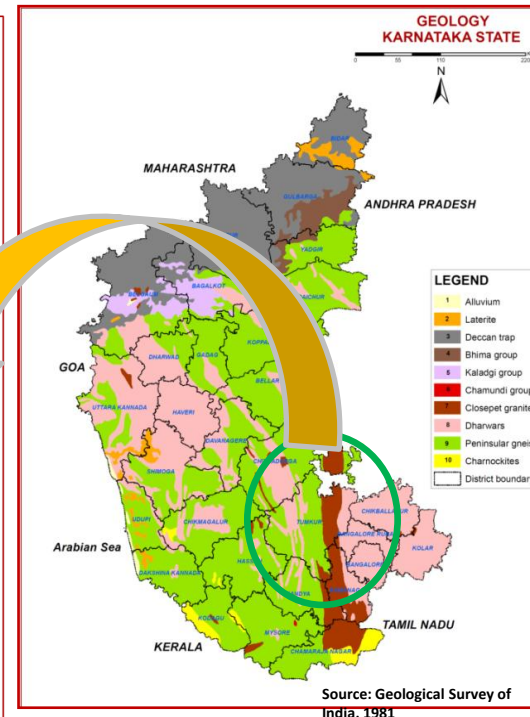
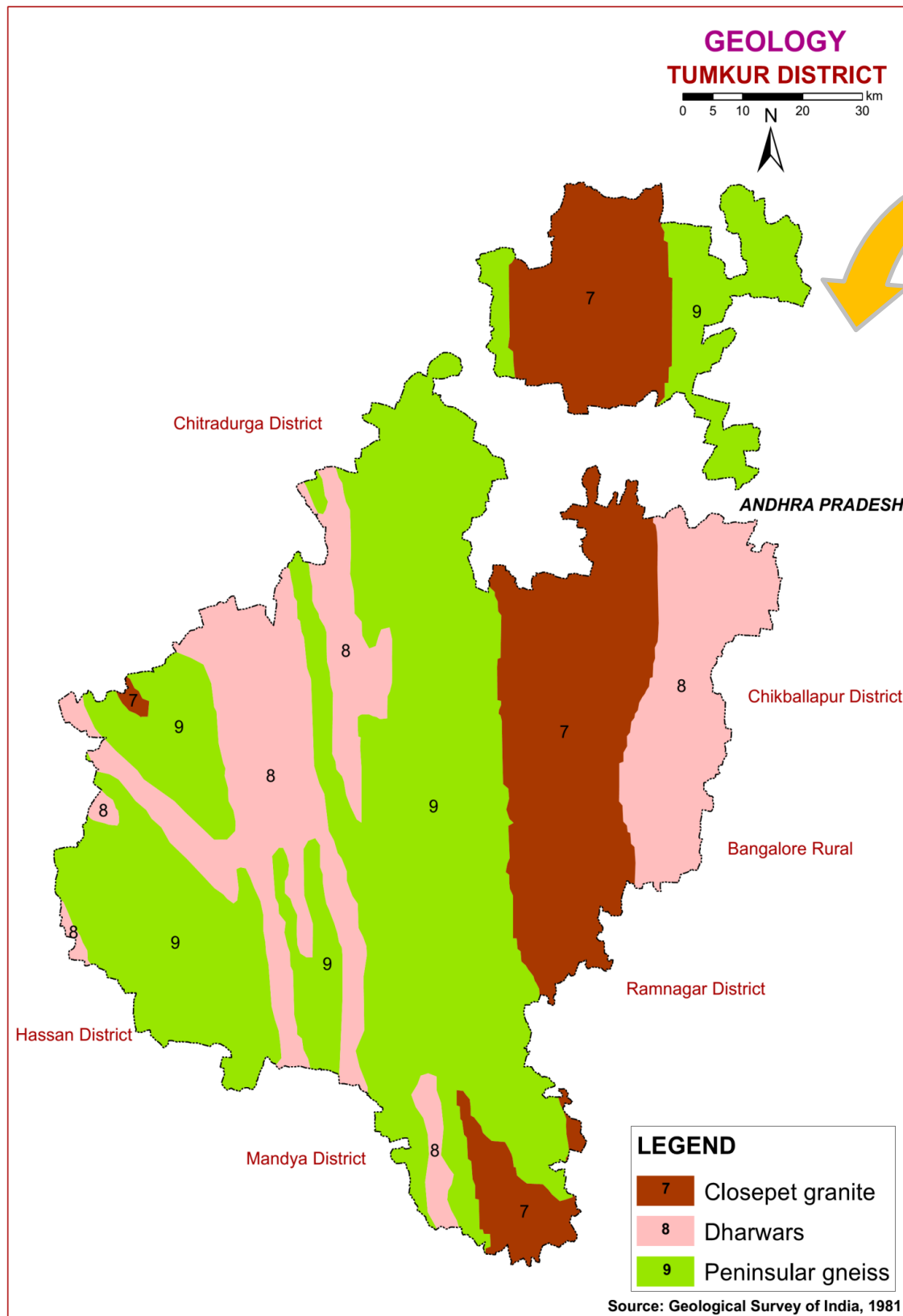
Cheluru Hobli, Gubbi Taluk and Tumkur District



Length of Growing Period (LGP) is varying from July 1st week to 4th week of November about 120-150 days.

Annual Rainfall : 778mm. in the Cheluru Hobli, Gubbi taluk.

Geology



GEOLOGY - KARNATAKA STATE

Karnataka forms part of the Peninsular Shield, which is an ancient stable block of the earth's crust. The shield is composed of geologically ancient rocks of diverse origin. These rocks have undergone various degrees of metamorphism and crushing. Overlying these ancient rocks are Proterozoic, late Cretaceous to Palaeocene, Palaeocene to Recent, and Recent sediments.

In the stratigraphic succession of rocks in Karnataka the Archaean group is the oldest, followed by Proterozoic, Mesozoic and Cainozoic formations.

GEOLOGY - TUMKUR DISTRICT

Upper Proterozoic Group

Formations of the Upper Proterozoic in Karnataka are Closepet granites, Chamundi granites, Kaladgi series and Bhima series. Out of these Chamarajanagara district consists of Closepet granites.

Closepet granites

Closepet granites are also known as Ramanagaram granites, constitute a well-defined range of hills and composed of various types of granite, granodiorite and granite porphyry

Archaean group: The Archaean group of rocks of Karnataka are the oldest formations (> 3000 million years) of the earth's crust. They are unfossiliferous, thoroughly crystalline, extremely contorted and faulted rocks, with well-defined foliated structure. They are intruded by plutonic rocks. The Archeans are also known as the Basement Complex or the Gneissic Complex. The important formations of this group are Peninsular Gneiss, Dharwar schists, and Charnockites.

Peninsular Gneiss

Exposed over a large area of Karnataka in all the districts except Bidar is the Peninsular Gneiss which is a heterogeneous mixture of several types of granitic rocks such as banded gneisses, granitic gneisses, granites and gneissic granites, granodiorites and diorites. The banded gneisses consist of white bands of quartz-feldspar alternating with dark bands of biotite, hornblende, and minor accessories. The granite group includes granites of all shades with varying composition. Peninsular gneiss seems to have formed by the granitization of the older rocks.

Dharwar schists

The Dharwar schists consist of a complex series of crystalline schists associated with ultrabasic rocks such as amphibolite, peridotites and dunites. These schists are found in long, narrow bands of various dimensions running NW-SE through the Peninsular Gneiss. The Dharwars are divided into Upper and Lower.

Upper Dharwars are equivalent to the Archaean to Lower Proterozoic, and are divided into Bababudan (comprises banded ferruginous quartzites, pyroxenite, gabbro, serpentinite, acid volcanic, phyllites, metabasalt, and quartz-chlorite schist) and Chitradurga groups (includes quartzite, limestone, dolomite, chlorite-schist, and manganese and iron ores with phyllite, metabasalt and conglomerates).

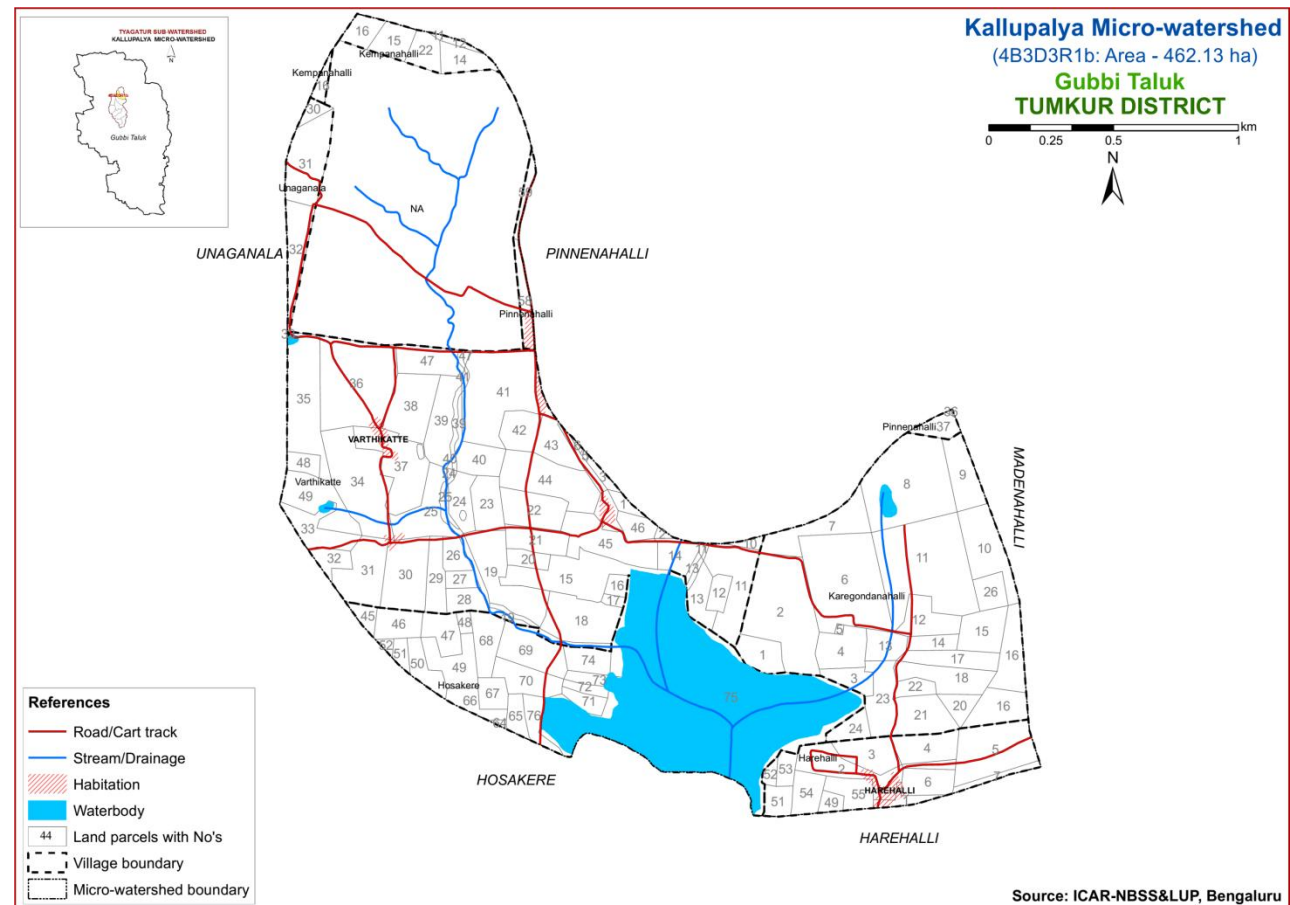
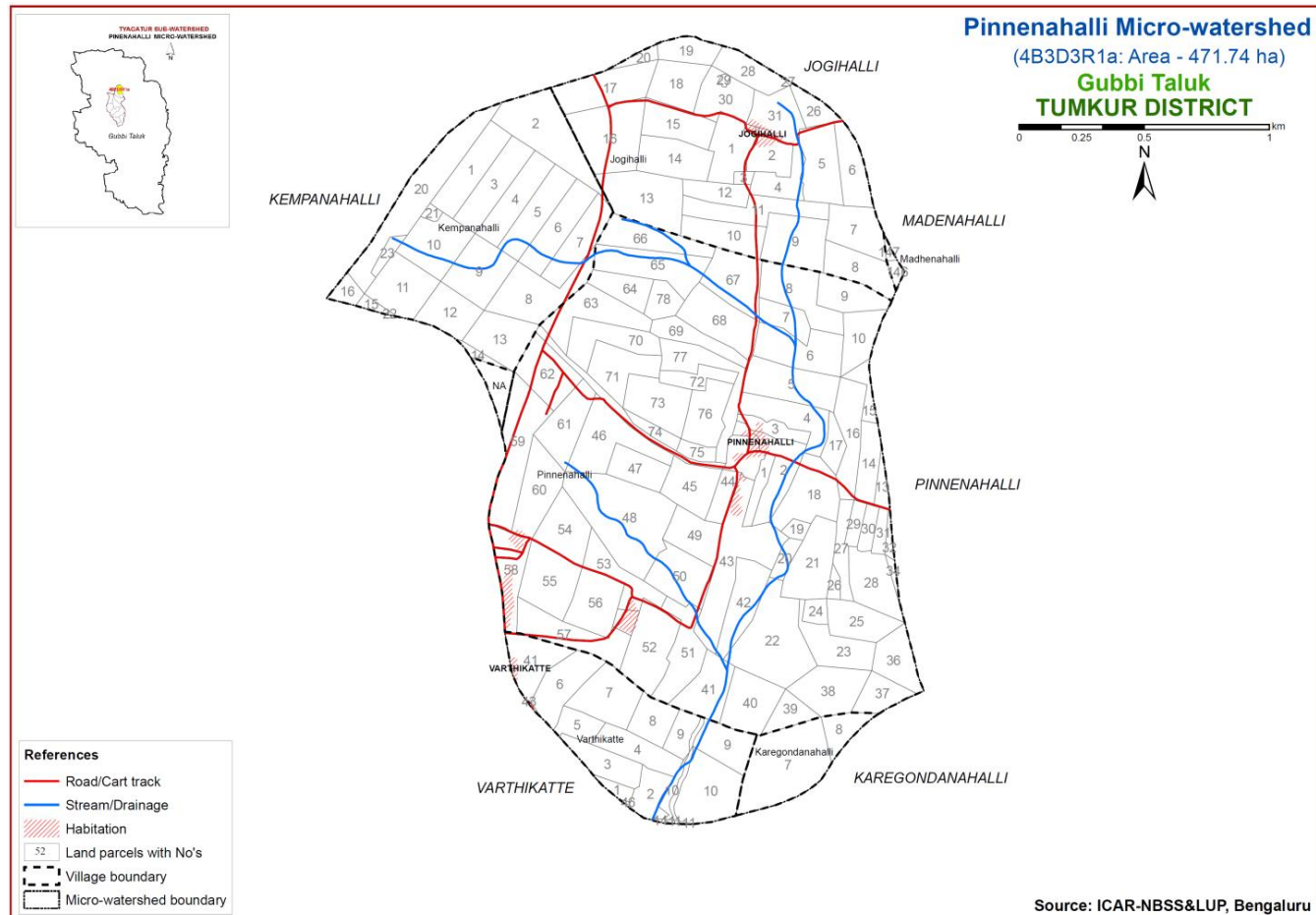
Lower Dharwars occur in Mysore district and include amphibolite schist, quartzite, ironstone and marble.

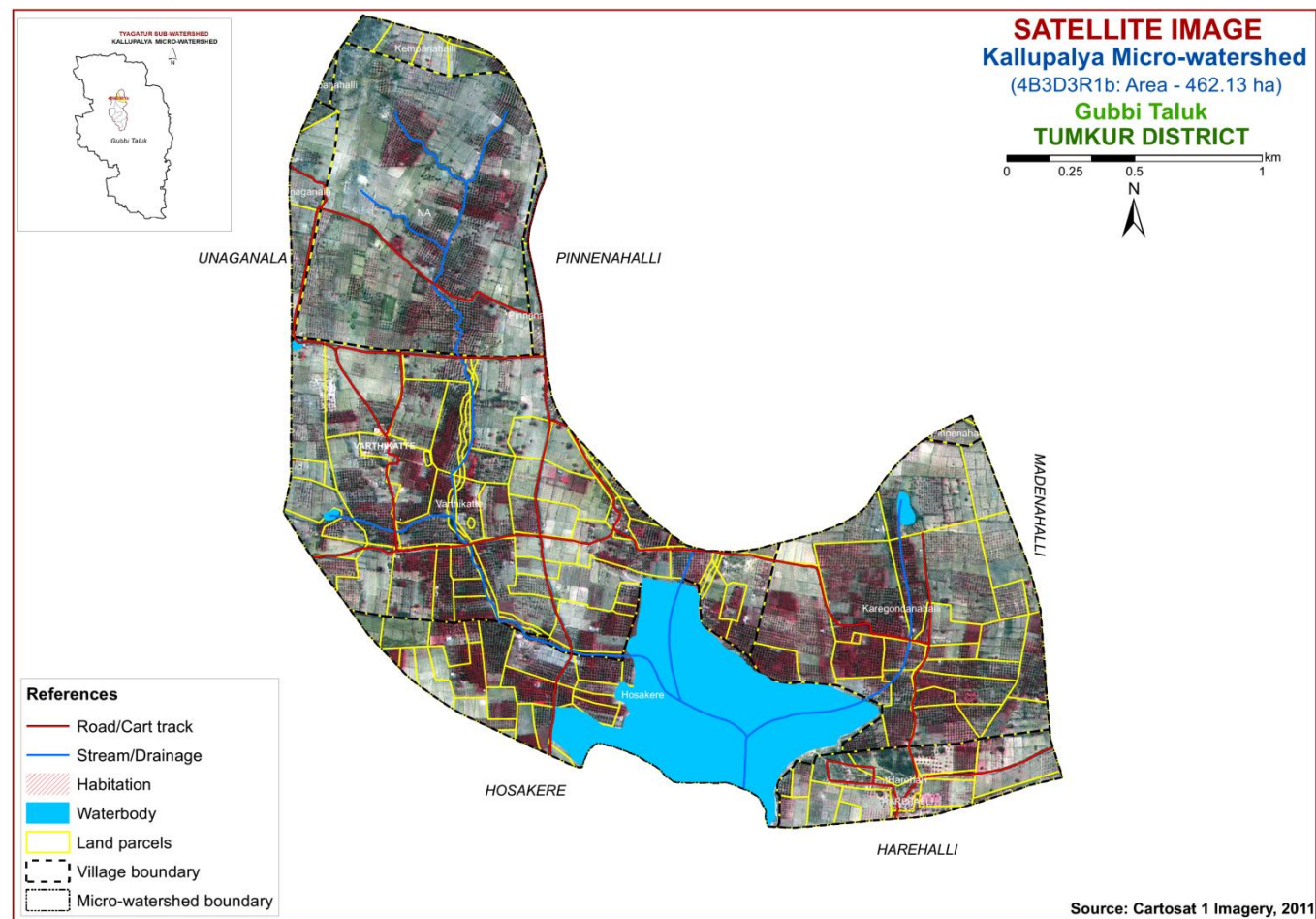
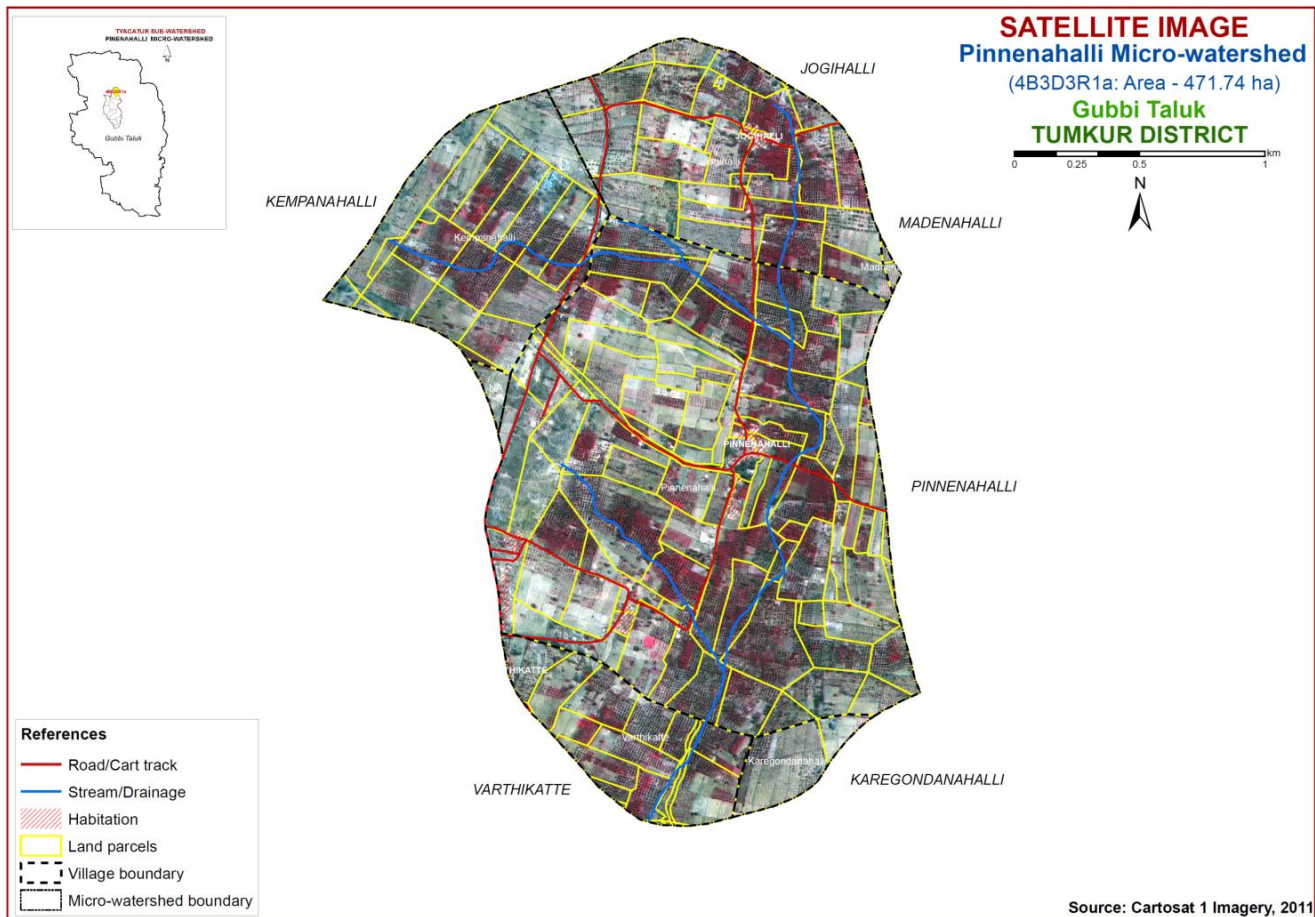
SURVEY METHODOLOGY

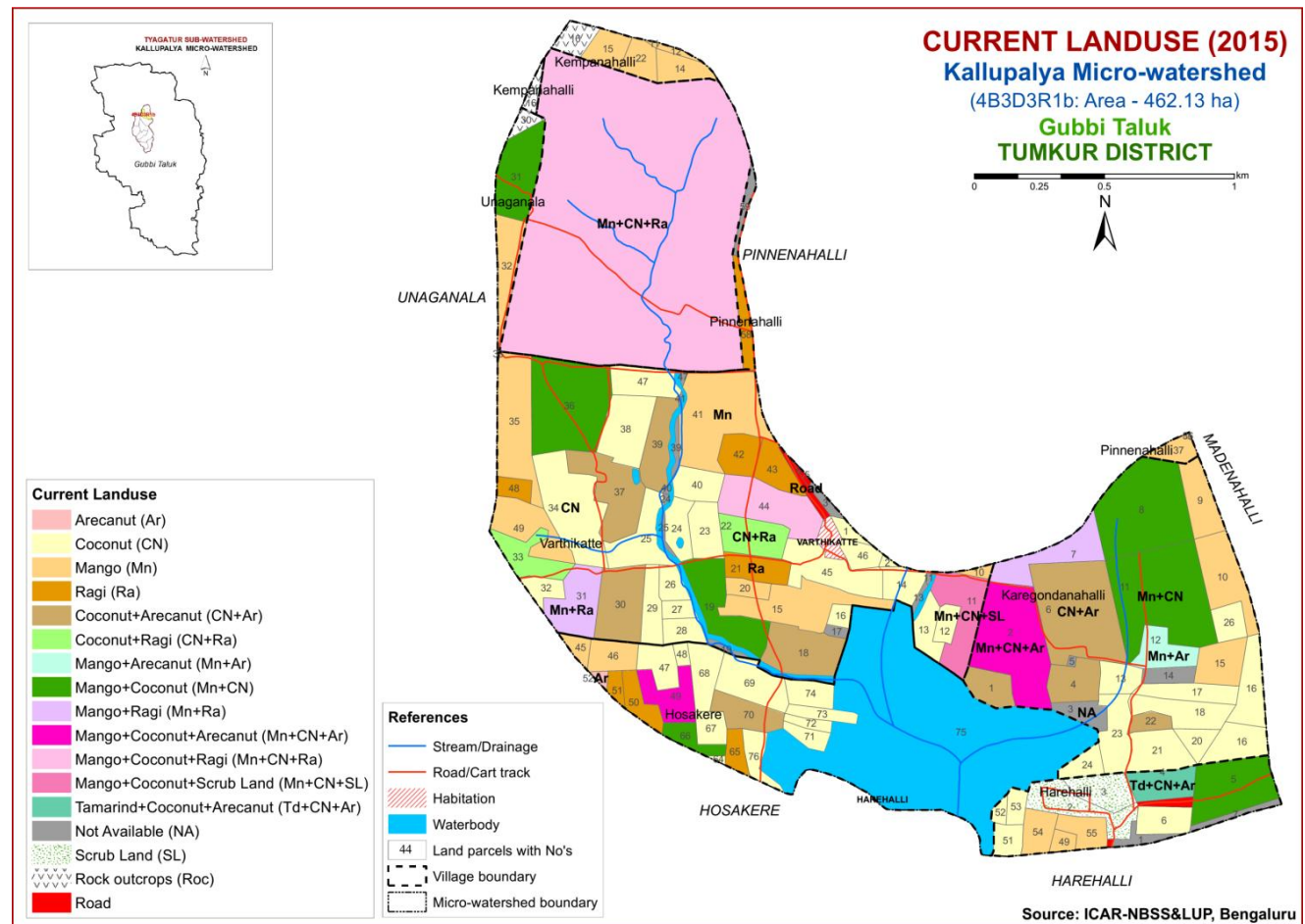
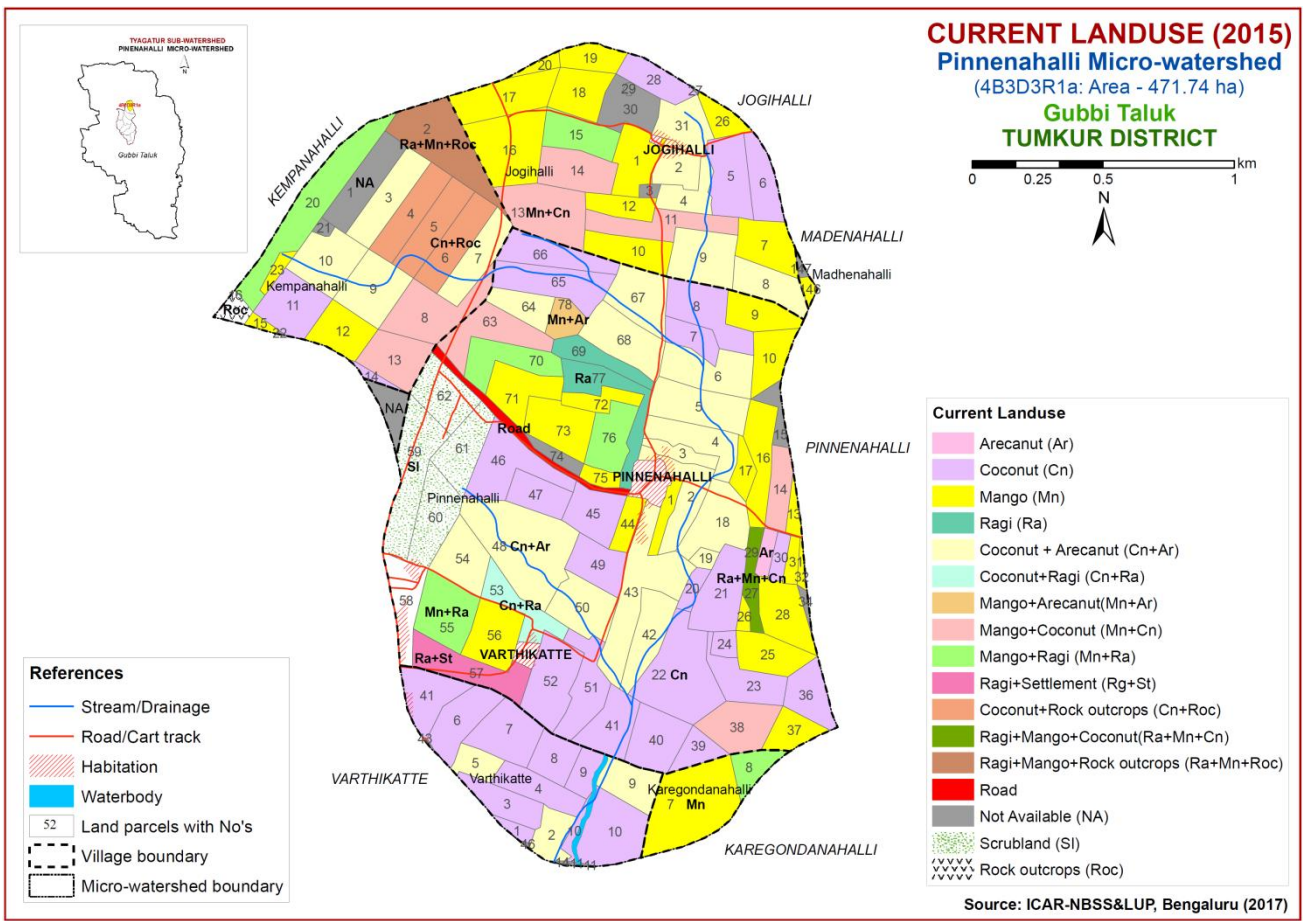
Sequence of activities in generation of LRI

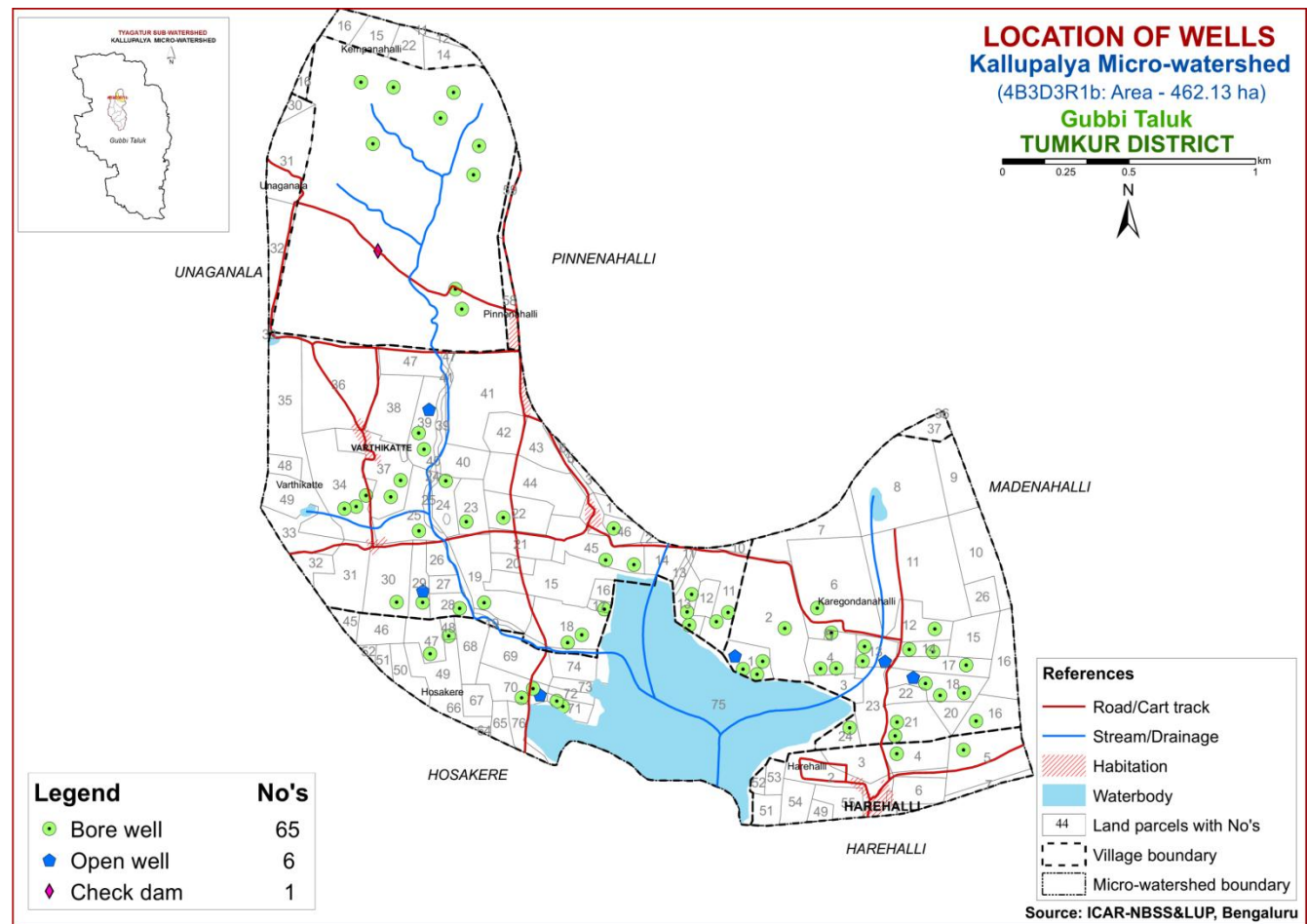
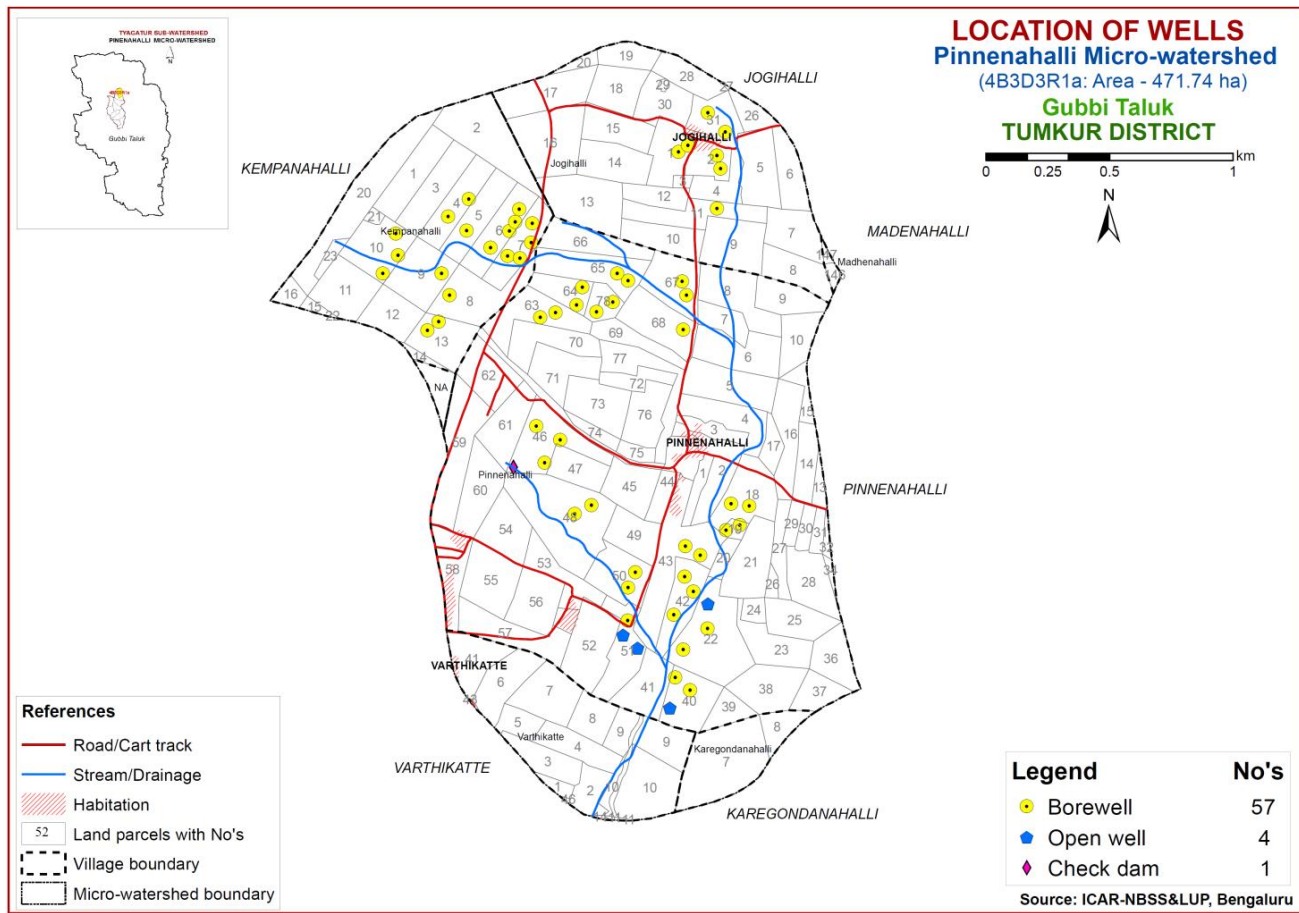
- Traversing the watershed using cadastral maps and imagery as base
- Identifying landforms, geology, land use and other features
- Selecting fields representing land units
- Opening profiles to 2 m depth
- Studying soil and site characteristics
- Grouping similar areas based on their soil-site characteristics into land management units
- Preparation of crop, soil and water conservation plan
- Socio-economic evaluation

The required site and soil characteristics are described and recorded on a standard proforma by following the protocols and guidelines given in the soil survey manual and field guide. Collection of soil samples from representative pedons for laboratory characterization and collection of surface soil samples from selected fields covering most of the management units for macro and micro-nutrient analysis is being carried out (250m grid intervals). Further processing of data at chemical lab and GIS lab are carried out to generate various thematic maps for each of the study area.







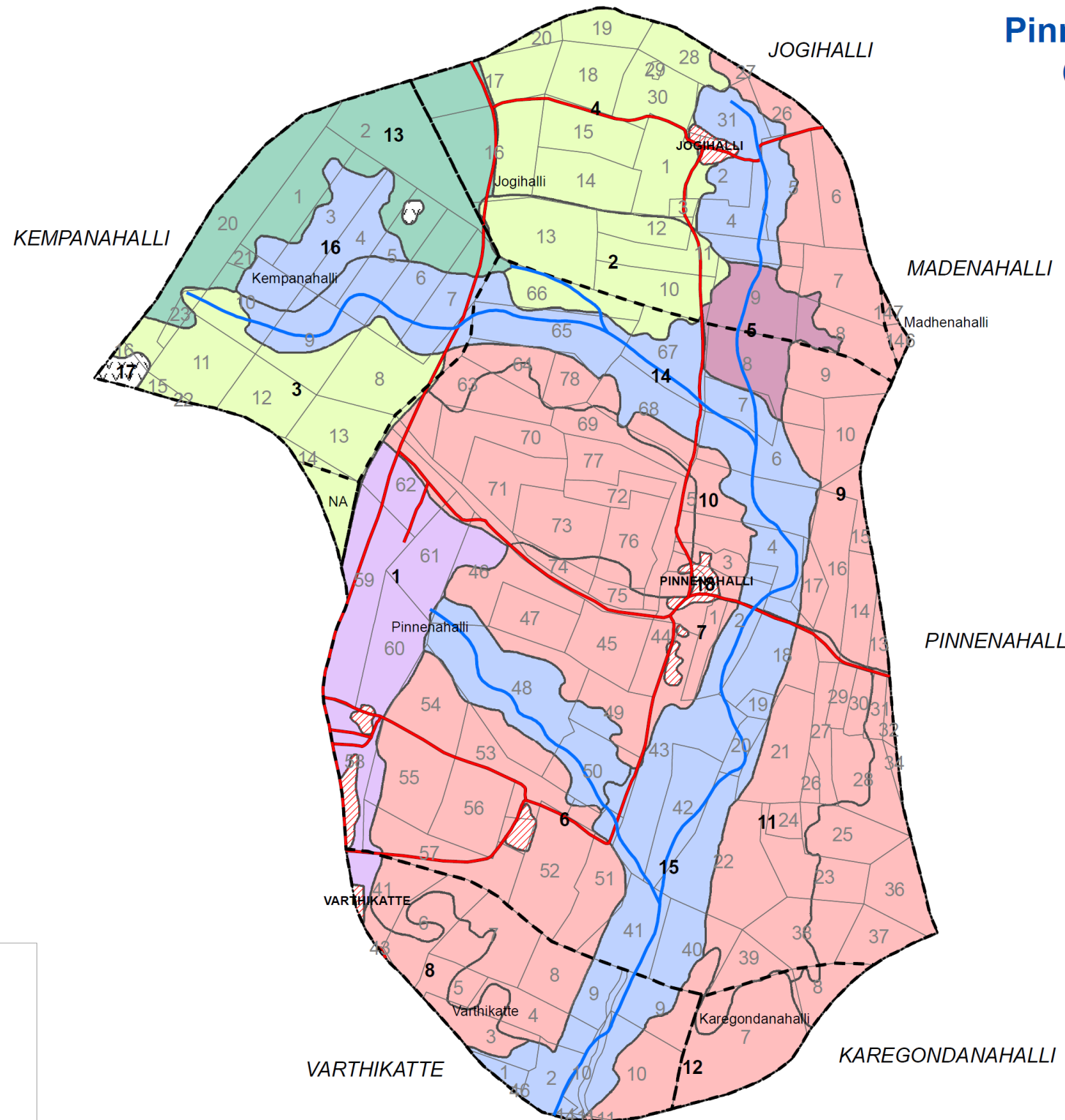
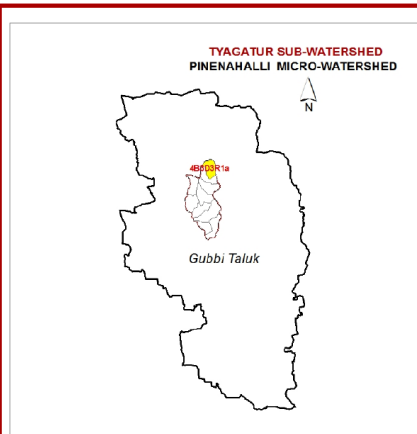
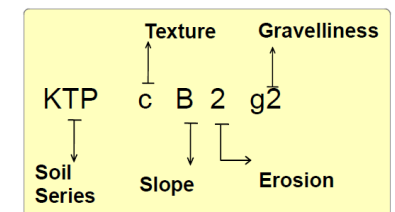
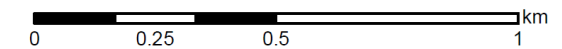


SOILS

Pinnenahalli Micro-watershed

(4B3D3R1a: Area - 471.74 ha)

Gubbi Taluk
TUMKUR DISTRICT



KEY

TEXTURE
c - Sandy loam
h - Sandy clay loam
i - Sandy clay

SLOPE
B - Very gently sloping (1-3%)
C - Gently sloping (3-5%)

EROSION
1 - Slight
2 - Moderate
3 - Severe

GRAVELLINESS
g1 - Gravelly (15-35 %)
g2 - Very gravelly (35-60 %)

DEPTH
KTP- Moderately shallow(50-75 cm)
BDG-Moderately deep(75-100 cm)
BPR,SNH-Deep(100-150 cm)
NDL, KDT -Very deep(>150 cm)

Soil Phase	Area in ha (%)
1, KTPcB2g2	24 (4.99)
2, BDGcB1g2	19 (3.99)
3, BDGcB2g2	26 (5.52)
4, BDGhB1g1	31 (6.6)
5, SNHiB1	9 (1.97)
6, BPRcB1	78 (16.59)
7, BPRcB1g1	42 (8.81)
8, BPRcB2	8 (1.7)
9, BPRcB2g1	34 (7.2)
10, BPRhB1	12 (2.55)
11, BPRhB2g1	28 (5.92)
12, BPRiB1	15 (3.08)
13, NDLcC2g2	31 (6.66)
14, KDTiB1	60 (12.62)
15, KDTiB1	40 (8.53)
16, KDTiB1g1	9 (2.0)
17, Rock outcrops	1 (0.27)
18, Others*	5 (0.99)

References

- Road/Cart track
- Stream/Drainage
- ▨ Habitation
- 52 Land parcels with No's
- - - Village boundary
- ▭ Micro-watershed boundary

* - Habitation & Waterbody
Source: ICAR-NBSS&LUP, Bengaluru

Mapping unit description of Pinnenahalli Micro-watershed in Gubbi taluk, Tumkur district

Soil No*	Soil Series	Soil Phase	Mapping Unit Description	Area in ha (%)
SOILS OF GRANITE GNEISS LANDSCAPE				
	KTP	Kethanapura soils are moderately shallow (50-75 cm), well drained, have dark reddish brown gravelly sandy clay loam soils occurring on very gently sloping uplands under cultivation		24 (4.99)
1		KTPcB2g2	Sandy loam surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	24 (4.99)
	BDG	Bidanagere soils are moderately deep (75-100 cm), well drained, have dark reddish brown gravelly sandy clay loam to sandy clay soils occurring on very gently sloping uplands under cultivation		76 (16.11)
2		BDGcB1g2	Sandy loam surface, slope 1-3%, slight erosion, very gravelly (35-60%)	19 (3.99)
3		BDGcB2g2	Sandy loam surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	26 (5.52)
4		BDGhB1g1	Sandy clay loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	31 (6.60)
	SNH	Shyanadrahalli soils are deep (100-150 cm), moderately well drained, have dark brown to very dark grayish brown cracking clay soils occurring very gently sloping uplands under cultivation		9.30 (1.97)
5		SNHiB1	Sandy clay surface, slope 1-3%, slight erosion	9.30 (1.97)
	BPR	Balapur soils are deep (100-150 cm), well drained, have dark reddish brown to dark red gravelly sandy clay to clay soils occurring on very gently sloping uplands under cultivation		217 (45.85)
6		BPRcB1	Sandy loam surface, slope 1-3%, slight erosion	78 (16.59)
7		BPRcB1g1	Sandy loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	42 (8.81)
8		BPRcB2	Sandy loam surface, slope 1-3%, moderate erosion	8 (1.70)
9		BPRcB2g1	Sandy loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	34 (7.20)
10		BPRhB1	Sandy clay loam surface, slope 1-3%, slight erosion	12 (2.55)
11		BPRhB2g1	Sandy clay loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	28 (5.92)
12		BPRiB1	Sandy clay surface, slope 1-3%, slight erosion	15 (3.08)

To be continued..

Soil No*	Soil Series	Soil Phase	Mapping Unit Description	Area in ha (%)
	NDL		Niduvalalu soils are very deep (>150 cm), well drained, have red to dark reddish brown gravelly sandy clay soils occurring on very gently sloping uplands under cultivation	31 (6.66)
13		NDLcC2g2	Sandy loam surface, slope 3-5%, moderate erosion, very gravelly (35-60%)	31 (6.66)
	KDT		Kadagathur soils are very deep (>150 cm), moderately well drained, have dark brown to very dark grayish brown sandy clay to clay soils occurring on very gently sloping uplands under cultivation	109 (23.15)
14		KDThB1	Sandy clay loam surface, slope 1-3%, slight erosion	60 (12.62)
15		KDTiB1	Sandy clay surface, slope 1-3%, slight erosion	40 (8.53)
16		KDTiB1g1	Sandy clay surface, slope 1-3%, slight erosion, gravelly (15-35%)	9 (2.00)
17		Rock outcrops		1 (0.27)
18		Others		5 (0.99)

*Soil map unit numbers are continuous for the taluk, not the micro-watershed

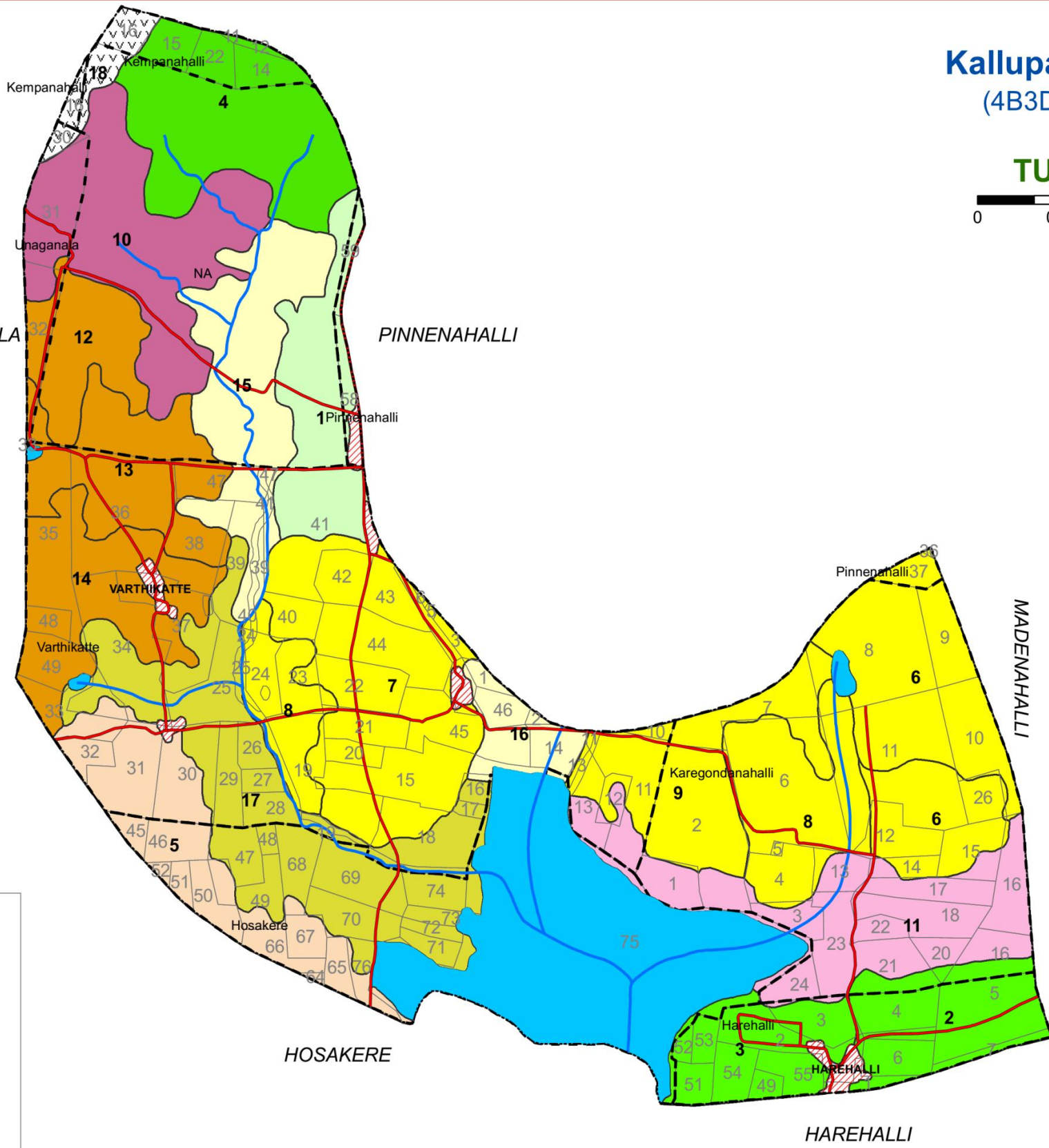
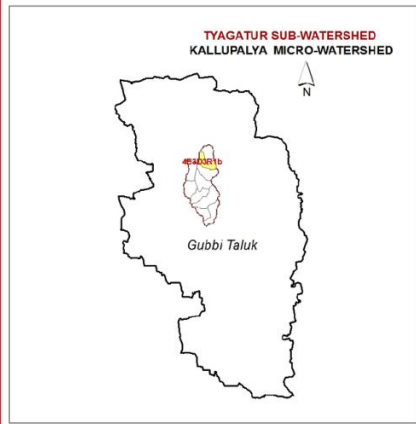
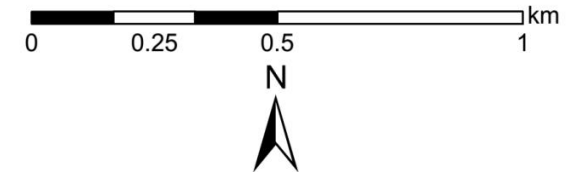
SOILS

Kallupalya Micro-watershed

(4B3D3R1b: Area - 462.13 ha)

Gubbi Taluk

TUMKUR DISTRICT



KEY

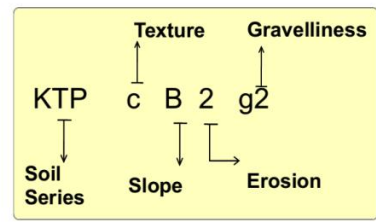
TEXTURE
 c - Sandy loam
 h - Sandy clay loam
 i - Sandy clay

SLOPE
 A - Nearly level (0-1%)
 B - Very gently sloping (1-3%)
 C - Gently sloping (3-5%)

EROSION
 1 - Slight
 2 - Moderate
 3 - Severe

GRAVELLINESS
 g1 - Gravelly (15-35%)
 g2 - Very gravelly (35-60%)
 g3 - Extremely gravelly (60-80%)

DEPTH
 KTP - Moderately shallow(50-75 cm)
 BDG - Moderately deep(75-100 cm)
 MNL, BPR, NGP - Deep(100-150 cm)
 HLK, MRD, KDT, TSD - Very deep(>150 cm)



References

- Road/Cart track
- Stream/Drainage
- Habitation
- Waterbody
- Land parcels with No's
- Village boundary
- Micro-watershed boundary

Soil Phase	Area in ha (%)
1, KTPcB2g2	17 (3.6)
2, BDGcB1	16 (3.44)
3, BDGcB1g1	14 (2.98)
4, BDGcB2g2	28 (5.99)
5, MNLhB2g3	23 (5.0)
6, BPRcB1g1	34 (7.45)
7, BPRcB2	37 (8.05)
8, BPRhB1g1	26 (5.7)
9, BPRiB1	21 (4.45)
10, NGPcC3g3	30 (6.53)
11, HLKhB1	31 (6.79)
12, MRDcB2g1	12 (2.6)
13, MRDcB2g3	19 (4.13)
14, MRDhB1g2	21 (4.47)
15, KDTThB1	24 (5.19)
16, KDTiB1	7 (1.43)
17, TSDhA1	45 (9.68)
18, Rock outcrops	4 (0.93)
19, Others*	53 (11.57)

* - Habitation & Waterbody

Source: ICAR-NBSS&LUP, Bengaluru

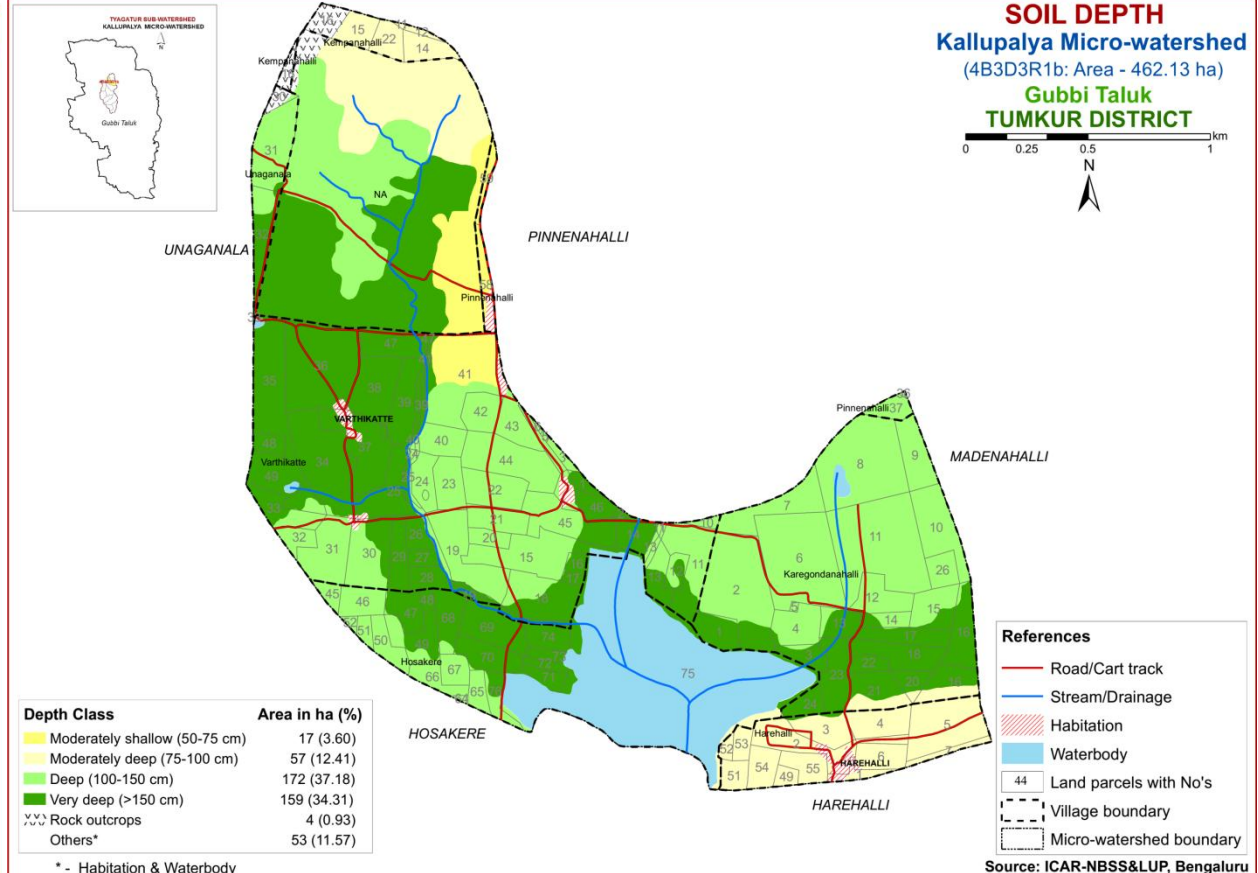
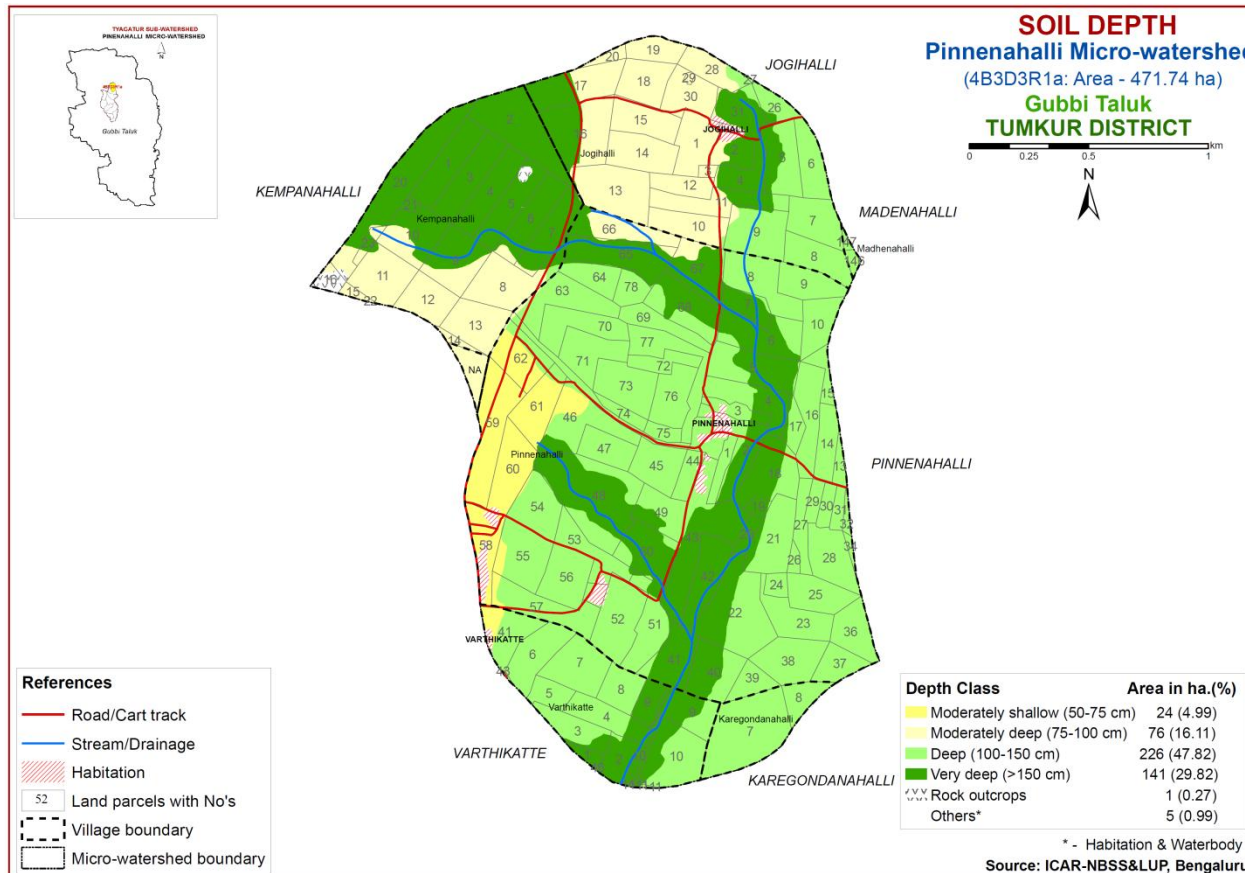
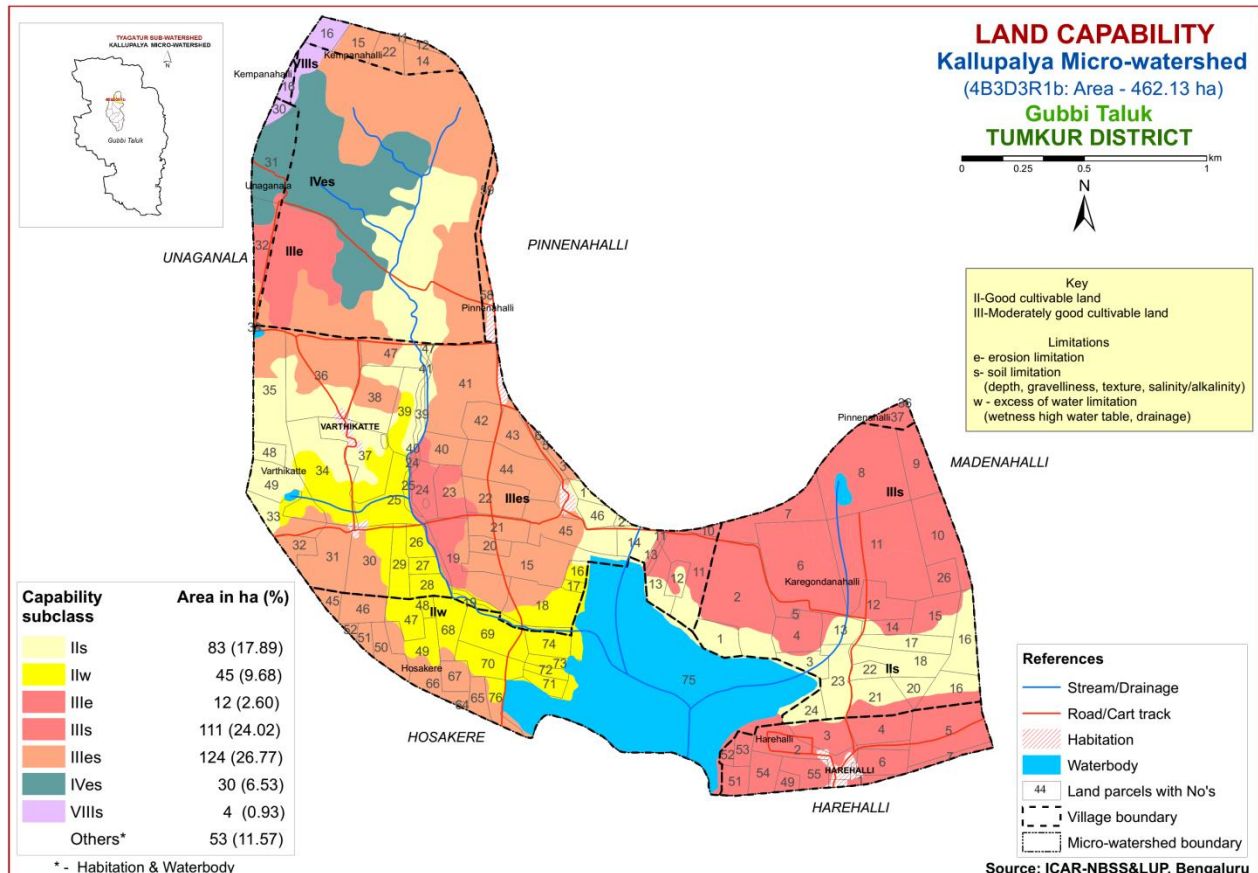
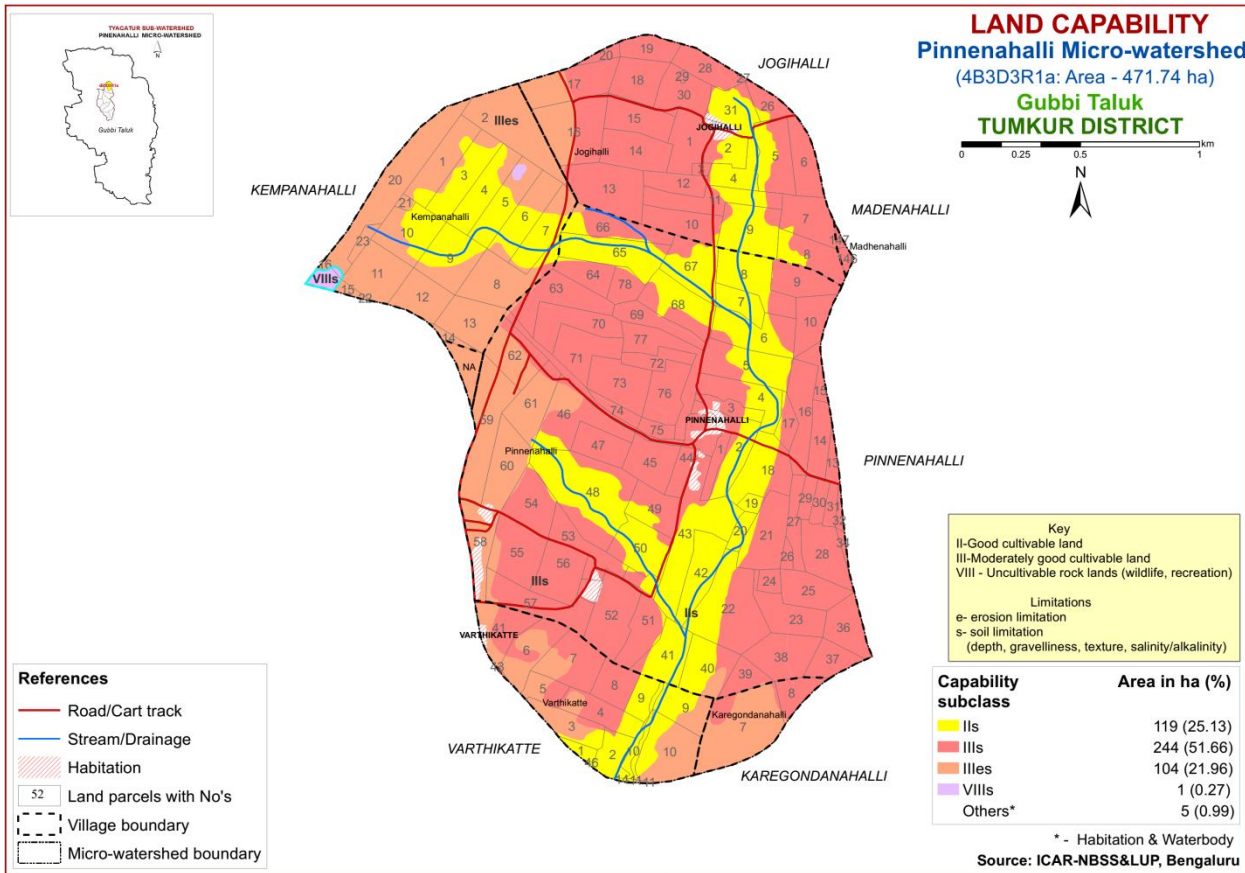
Mapping unit description of Kallupalya Micro-watershed in Gubbi taluk, Tumkur district

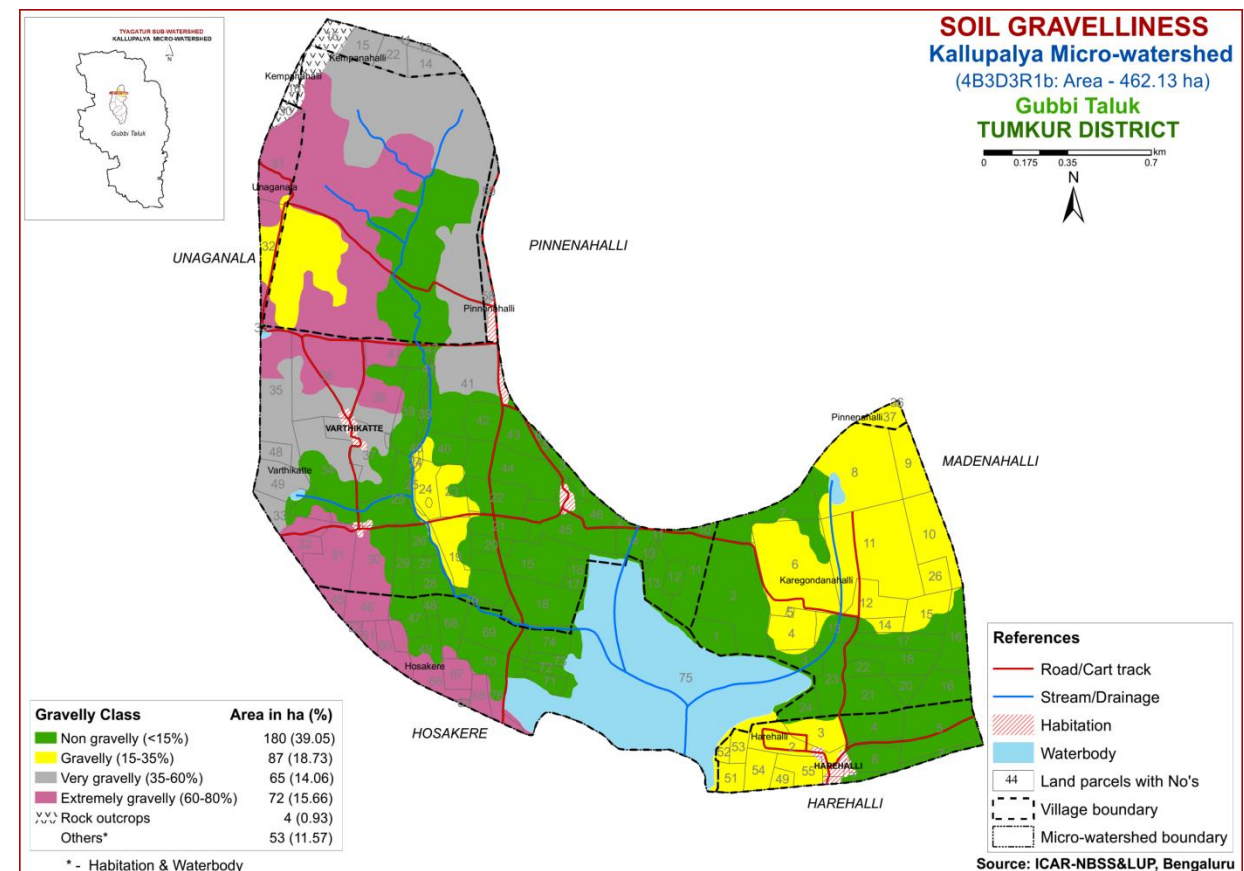
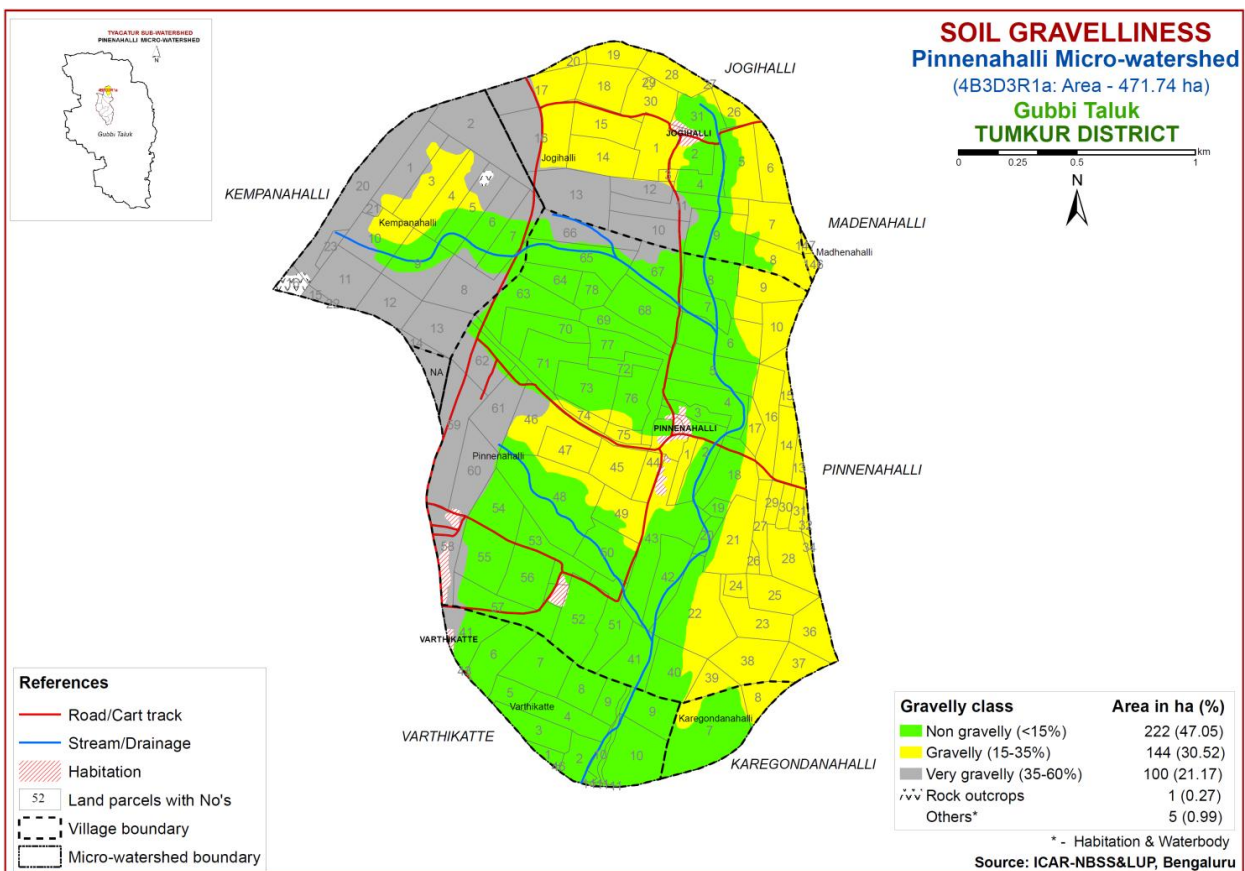
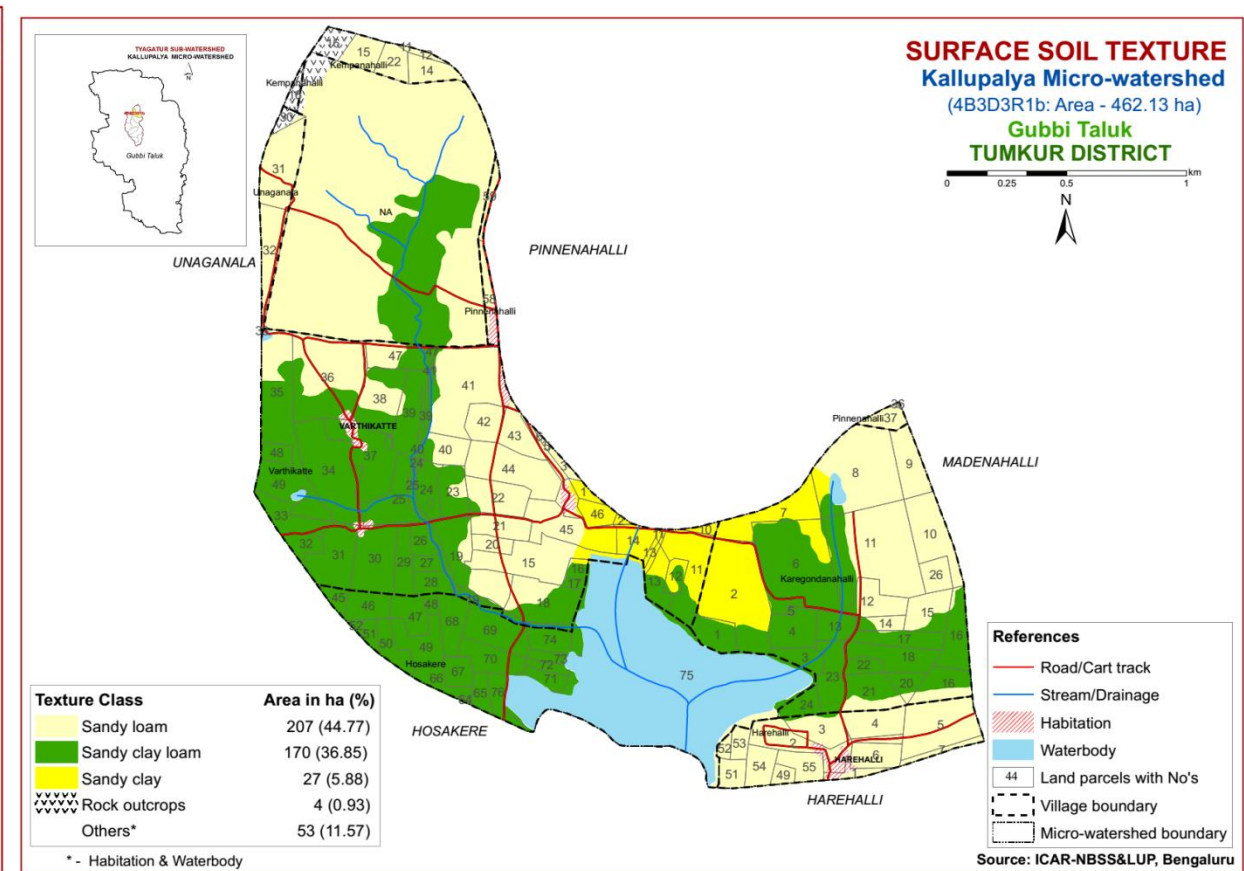
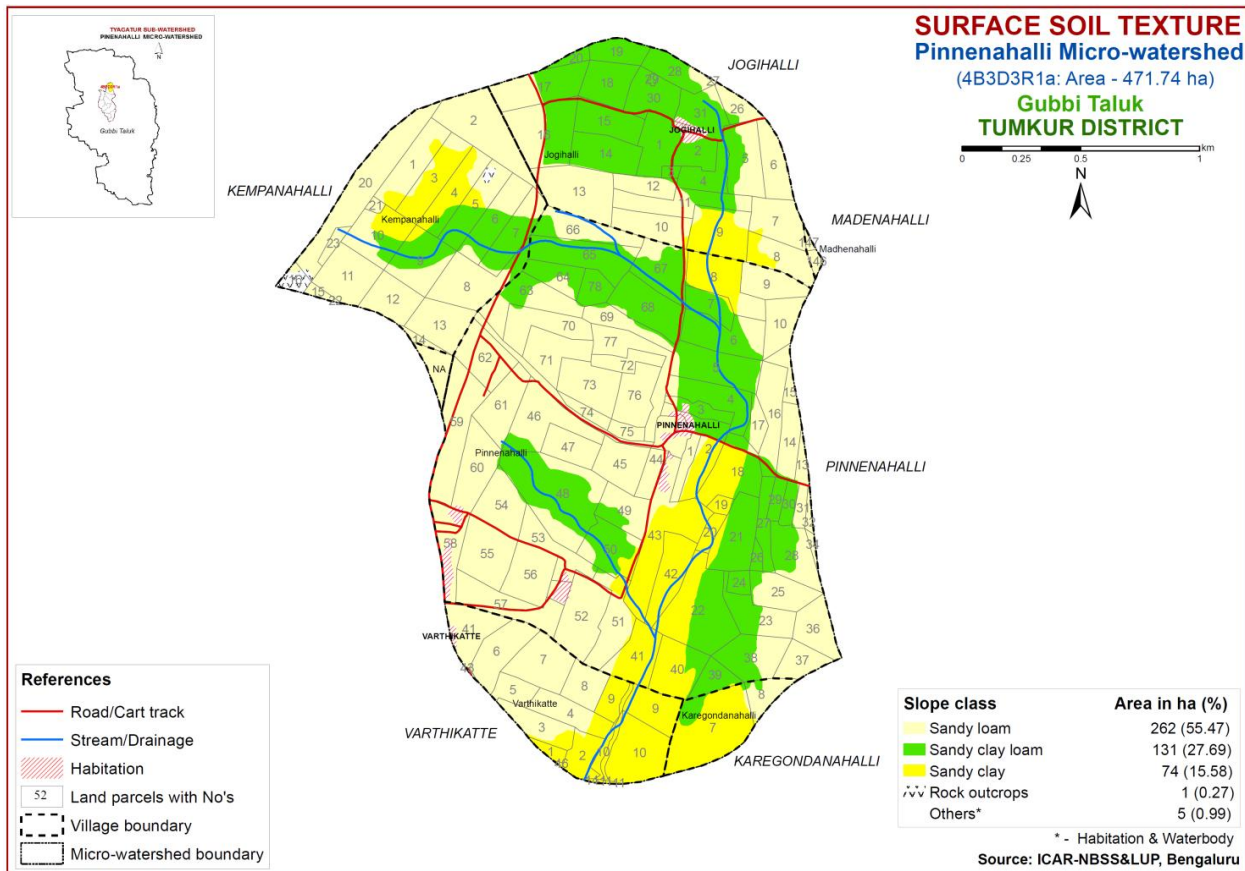
Soil No	Soil Series	Soil Phase	Mapping Unit Description	Area in ha (%)
SOILS OF GRANITE GNEISS LANDSCAPE				
	KTP	Kethanapura soils are moderately shallow (50-75 cm), well drained, have dark reddish brown gravelly sandy clay loam soils occurring on very gently sloping uplands under cultivation		17 (3.60)
1		KTPcB2g2	Sandy loam surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	17 (3.60)
	BDG	Bidanagere soils are moderately deep (75-100 cm), well drained, have dark reddish brown gravelly sandy clay loam to sandy clay soils occurring on very gently sloping uplands under cultivation		58 (12.41)
2		BDGcB1	Sandy loam surface, slope 1-3%, slight erosion	16 (3.44)
3		BDGcB1g1	Sandy loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	14 (2.98)
4		BDGcB2g2	Sandy loam surface, slope 1-3%, moderate erosion, very gravelly (35-60%)	28 (5.99)
	MNL	Mornal soils are deep (100-150 cm), well drained, have dark reddish brown to red gravelly sandy clay loam to sandy clay soils occurring on very gently sloping uplands under cultivation		23 (5.00)
5		MNLhB2g3	Sandy clay loam surface, slope 1-3%, moderate erosion, extremely gravelly (60-80%)	23 (5.00)
	BPR	Balapur soils are deep (100-150 cm), well drained, have dark reddish brown to dark red gravelly sandy clay to clay soils occurring on very gently sloping uplands under cultivation		118 (25.65)
6		BPRcB1g1	Sandy loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	34 (7.45)
7		BPRcB2	Sandy loam surface, slope 1-3%, moderate erosion	37 (8.05)
8		BPRhB1g1	Sandy clay loam surface, slope 1-3%, slight erosion, gravelly (15-35%)	26 (5.70)
9		BPRiB1	Sandy clay surface, slope 1-3%, slight erosion	21 (4.45)
	NGP	Nagalapur soils are deep (100-150 cm), well drained, have dark reddish brown to dark red gravelly sandy clay to clay soils occurring on gently sloping uplands under cultivation		30 (6.53)
10		NGPcC3g3	Sandy loam surface, slope 3-5%, severe erosion, extremely gravelly (60-80%)	30 (6.53)

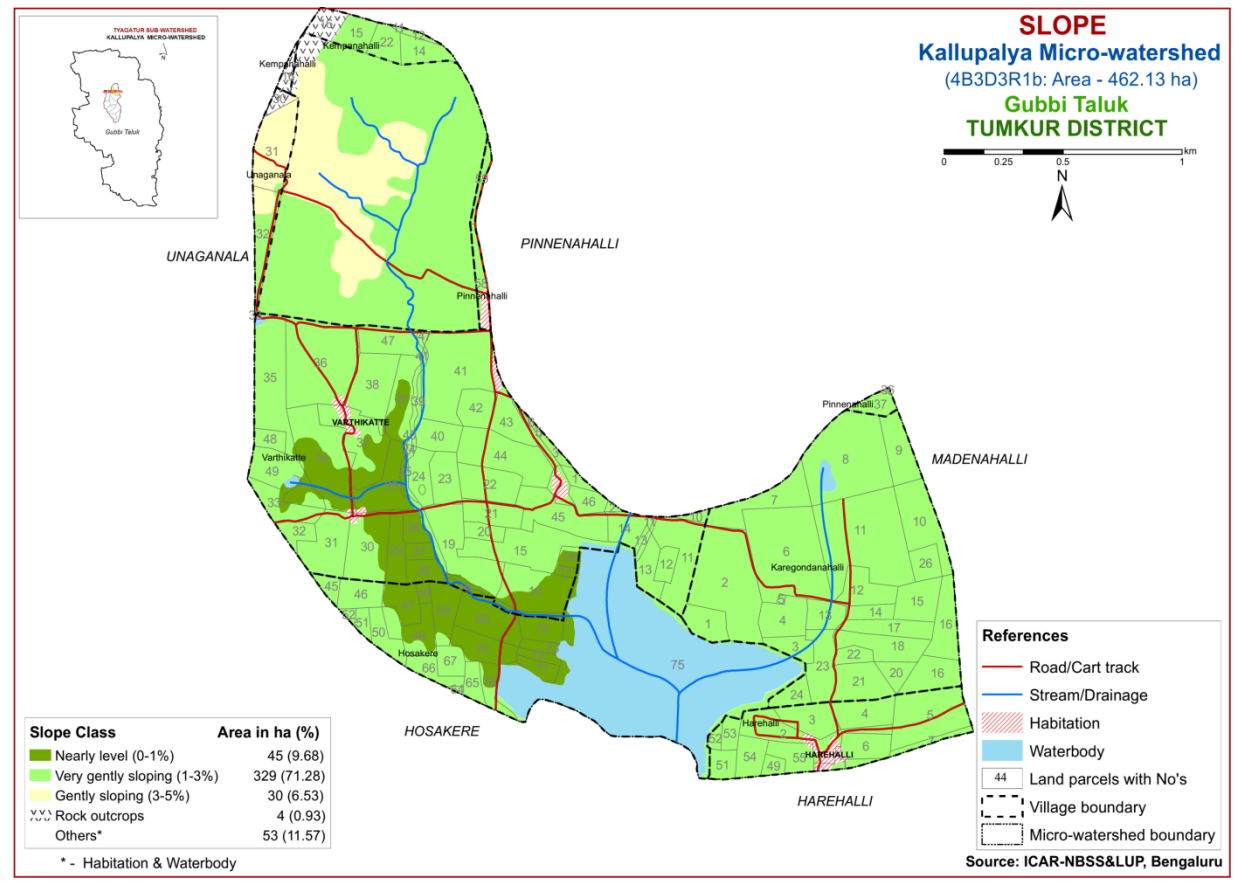
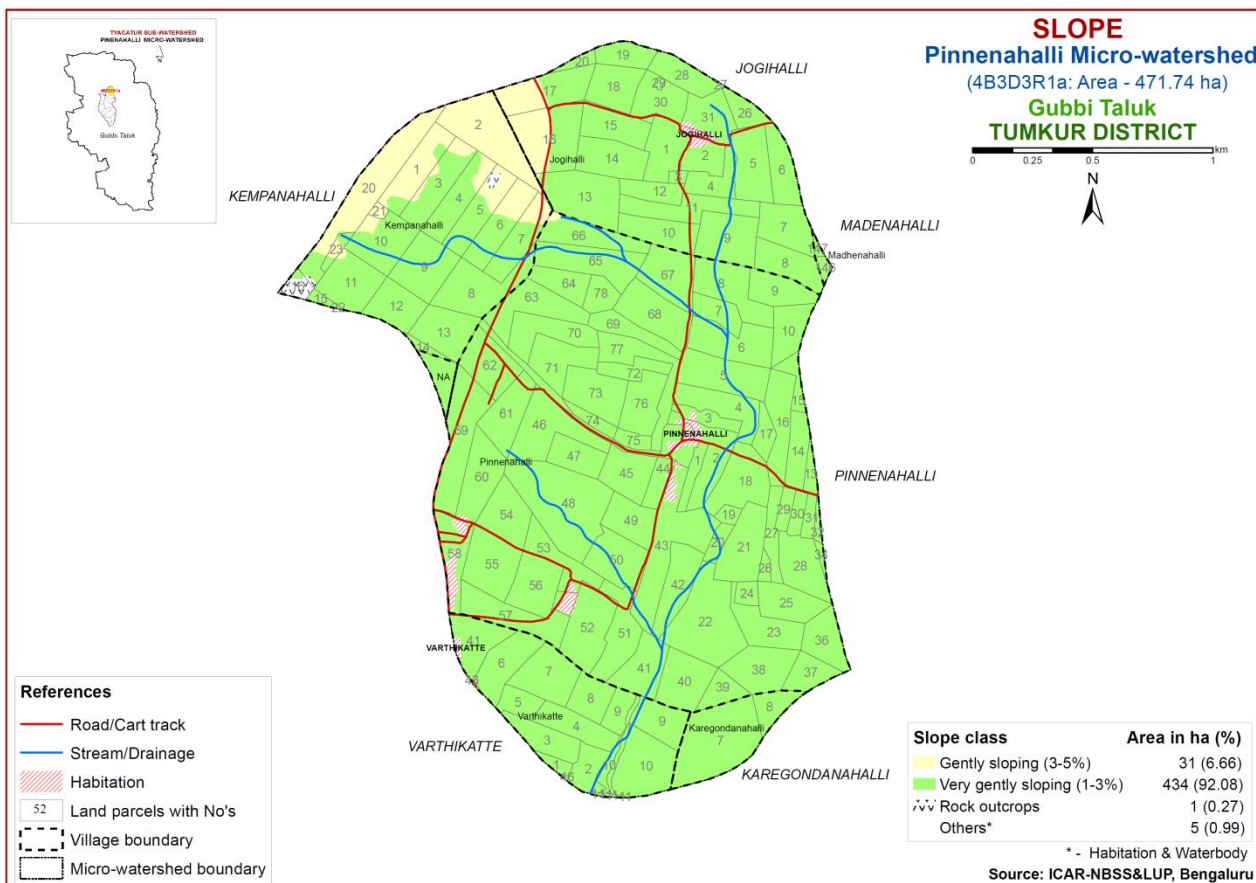
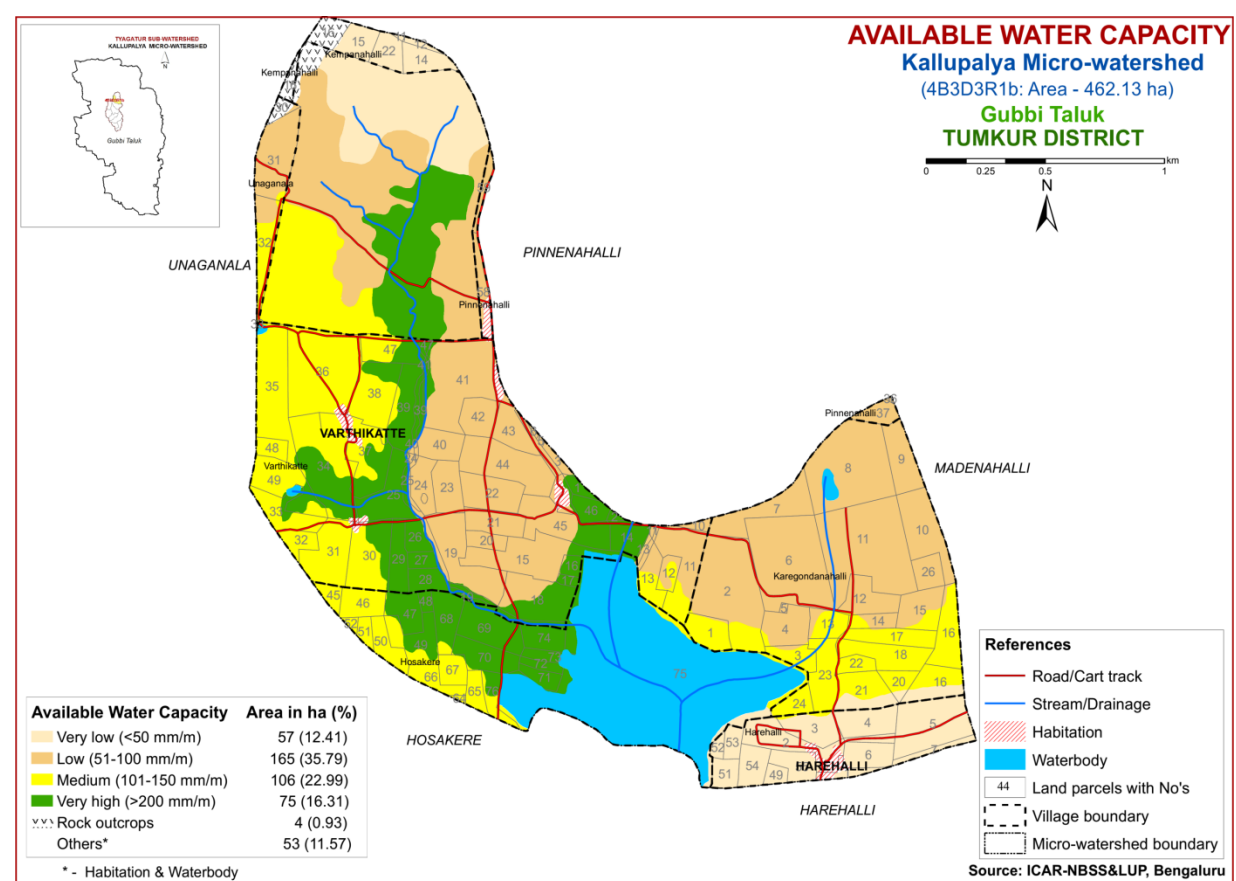
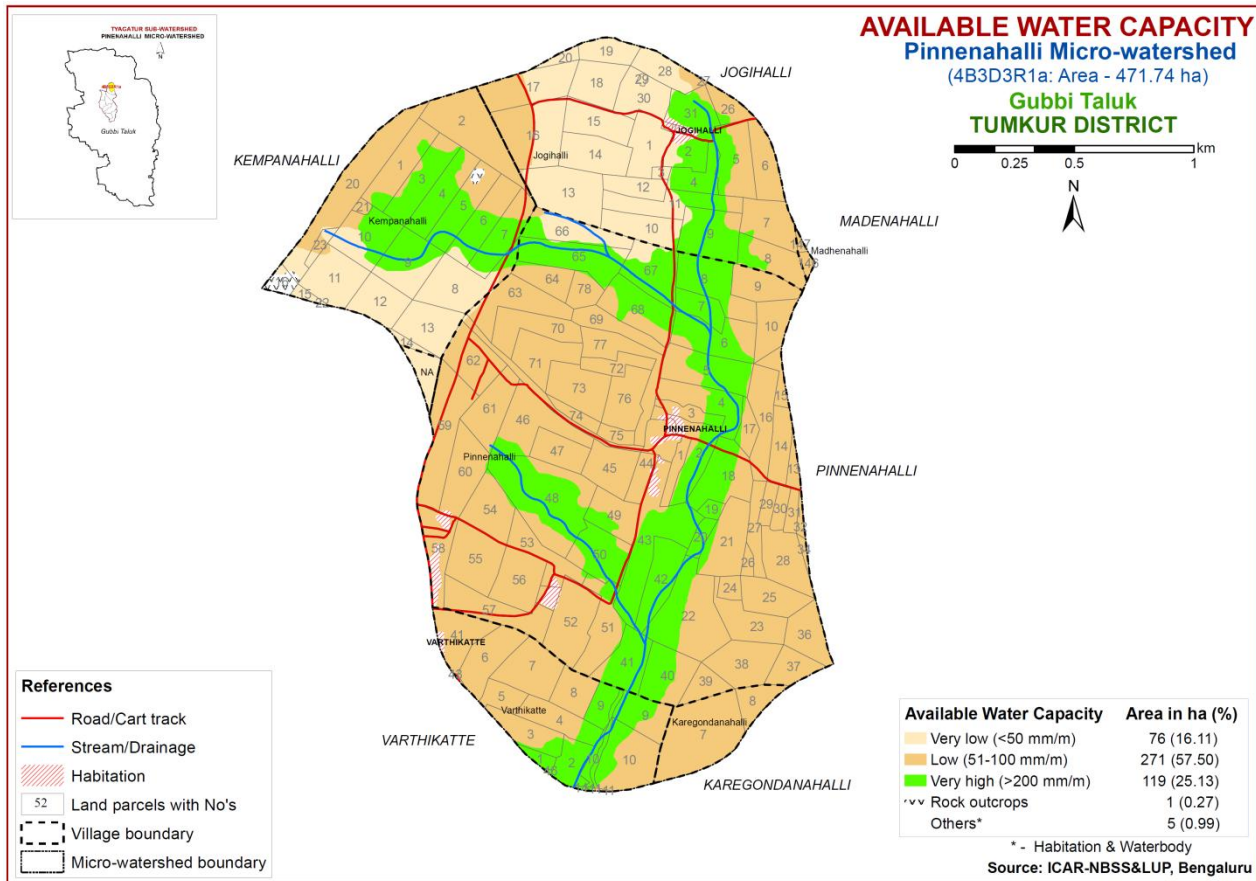
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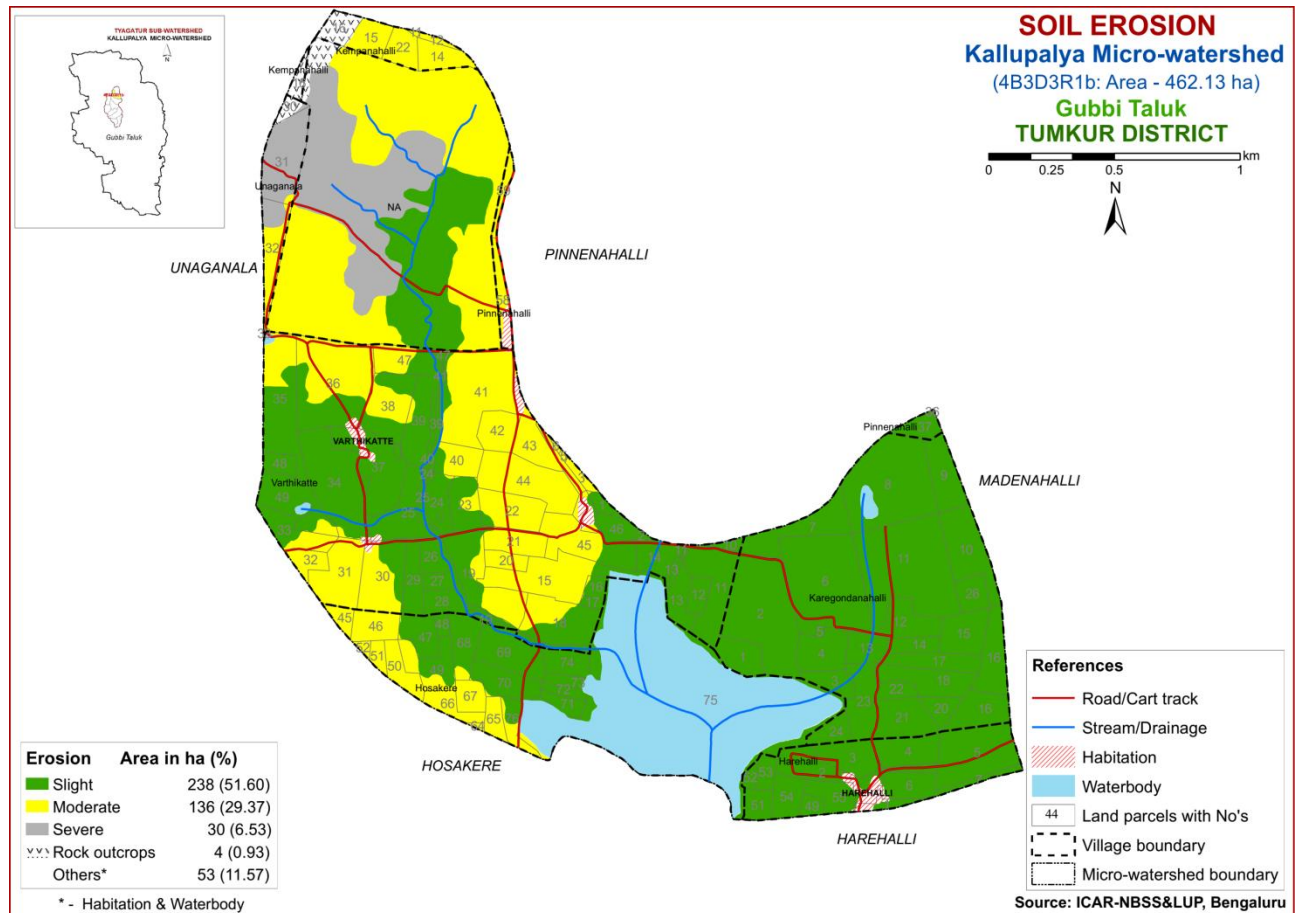
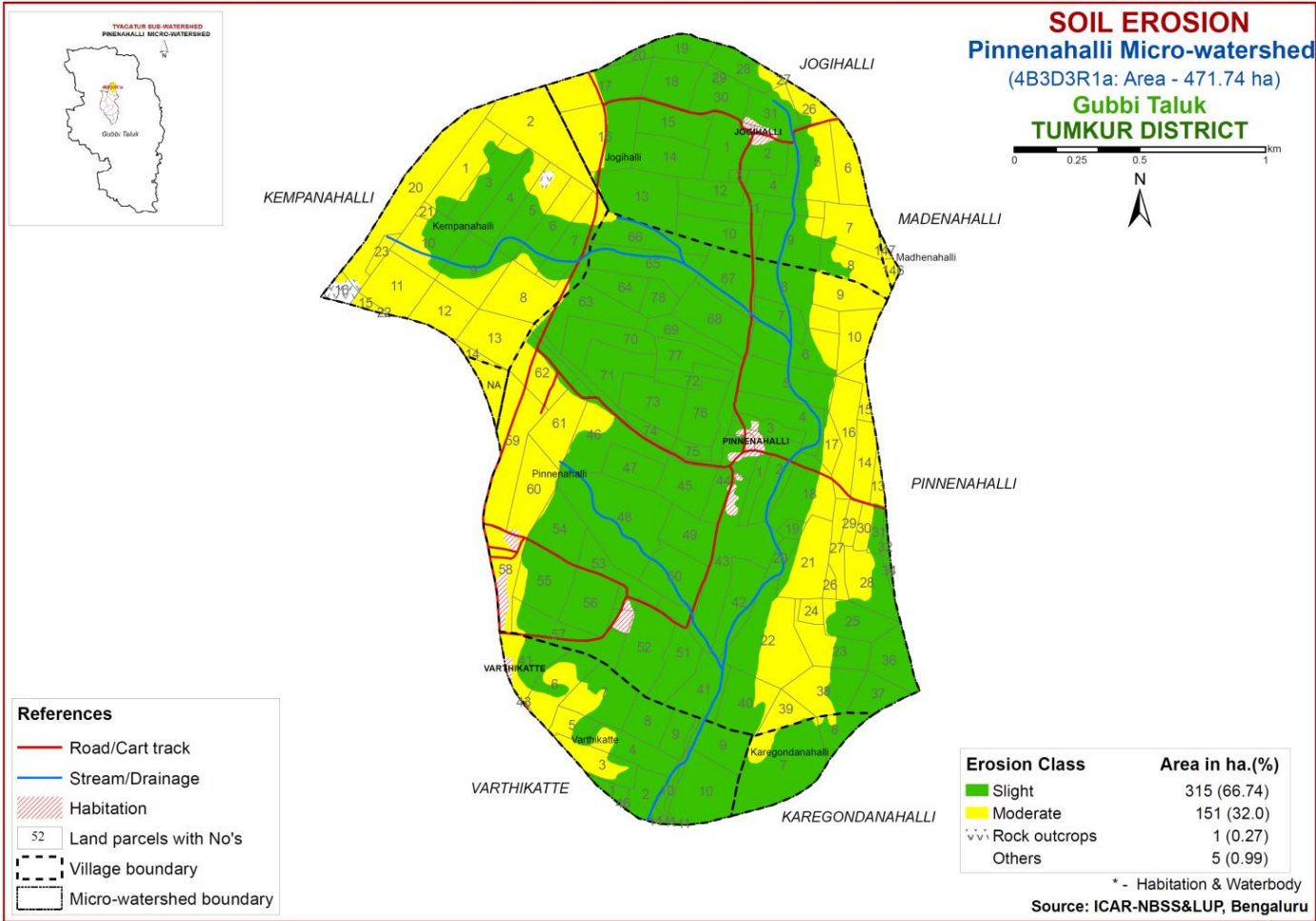
Soil No	Soil Series	Soil Phase	Mapping Unit Description	Area in ha (%)
	HLK	Hallikere soils are very deep (>150 cm), well drained, have dark brown to dark reddish brown clayey soils occurring on very gently sloping uplands under cultivation		31 (6.79)
11		HLKhB1	Sandy clay loam surface, slope 1-3%, slight erosion	31 (6.79)
	MRD	Muradi soils are very deep (>150 cm), well drained, have red to dark red sandy clay loam to sandy clay soils occurring on very gently sloping uplands under cultivation		52 (11.2)
12		MRDcB2g1	Sandy loam surface, slope 1-3%, moderate erosion, gravelly (15-35%)	12 (2.60)
13		MRDcB2g3	Sandy loam surface, slope 1-3%, moderate erosion, extremely gravelly (60-80%)	19 (4.13)
14		MRDhB1g2	Sandy clay loam surface, slope 1-3%, slight erosion, very gravelly (35-60%)	21 (4.47)
	KDT	Kadagathur soils are very deep (>150 cm), moderately well drained, have dark brown to very dark grayish brown sandy clay to clay soils occurring on very gently sloping uplands under cultivation		31 (6.62)
15		KDThB1	Sandy clay loam surface, slope 1-3%, slight erosion	24 (5.19)
16		KDTiB1	Sandy clay surface, slope 1-3%, slight erosion	7 (1.43)
	TSD	Thimmasandra soils are very deep (>150 cm), moderately well drained, have very dark brown to very dark grayish brown sandy clay to clay soils occurring on nearly level to very gently sloping lowlands under cultivation		45 (9.68)
17		TSDhA1	Sandy clay loam surface, slope 0-1%, slight erosion	45 (9.68)
18		Rock outcrops		4 (0.93)
19		Others		53 (11.57)

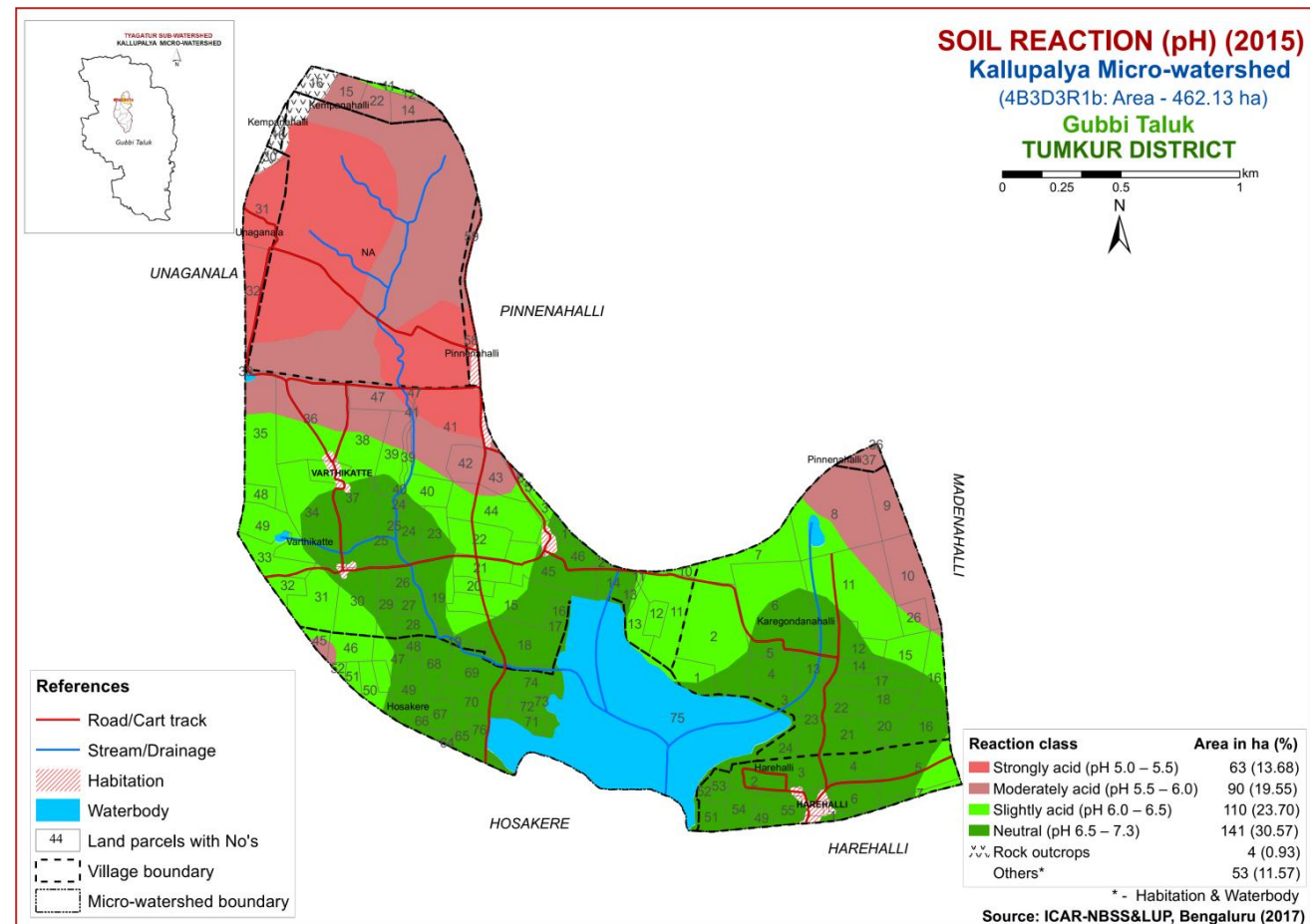
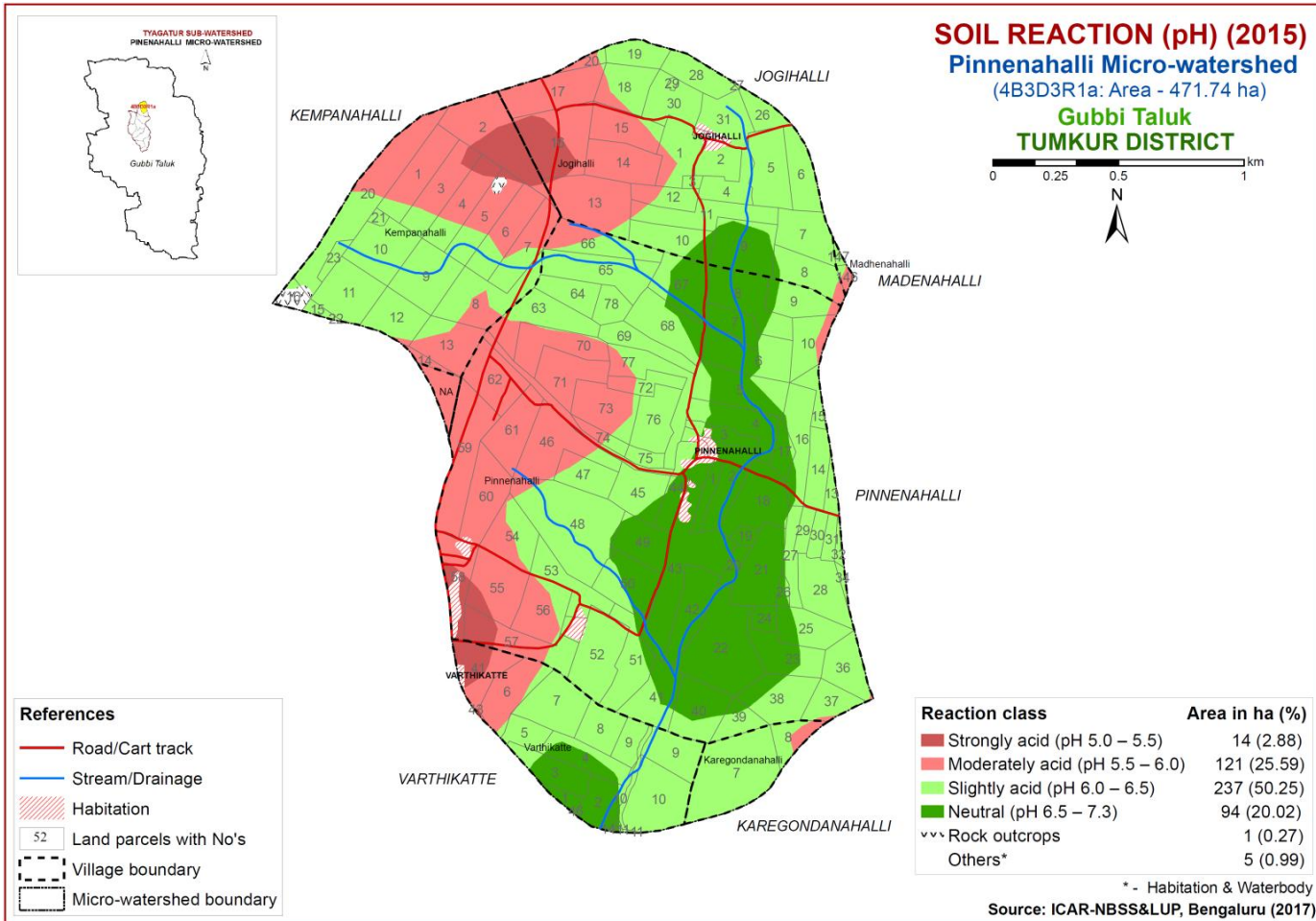
*Soil map unit numbers are continuous for the taluk, not the micro-watershed

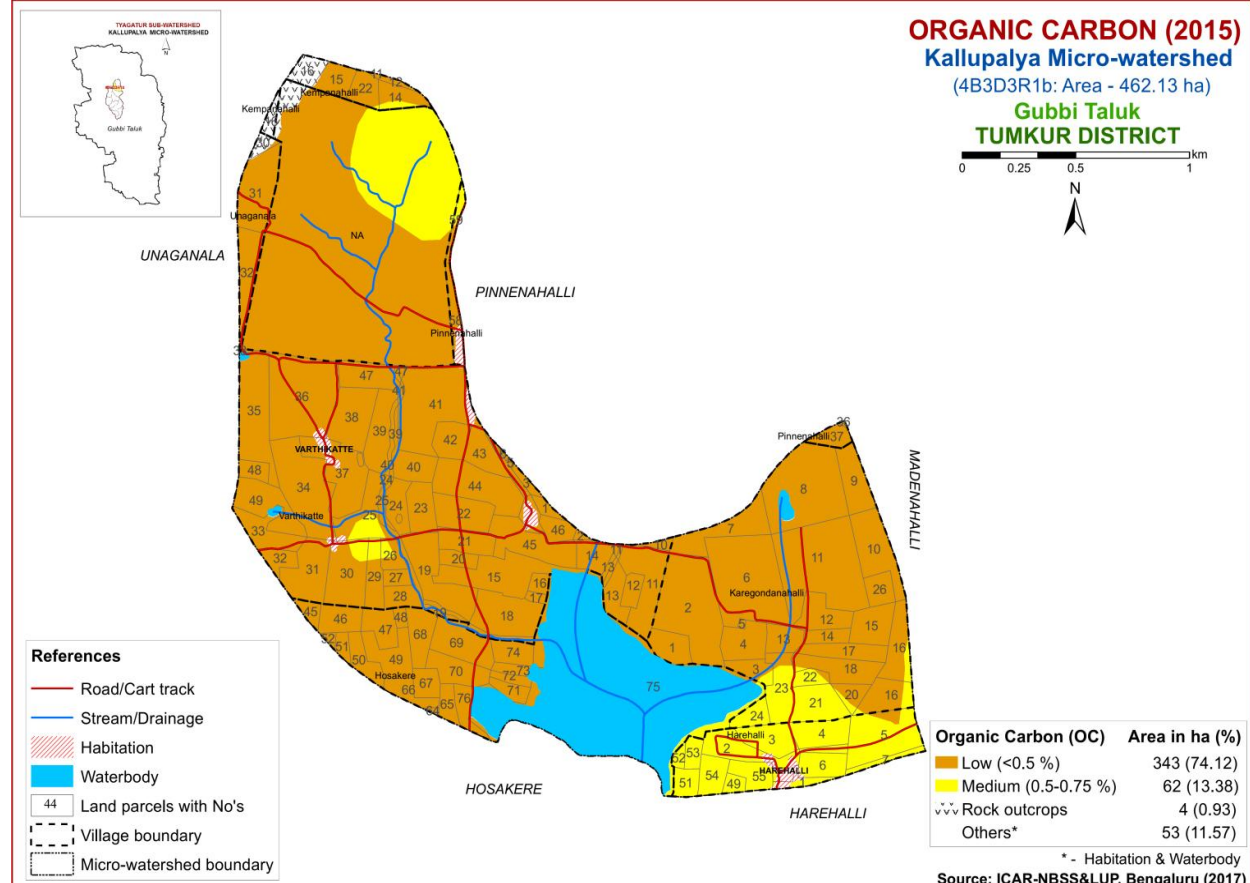
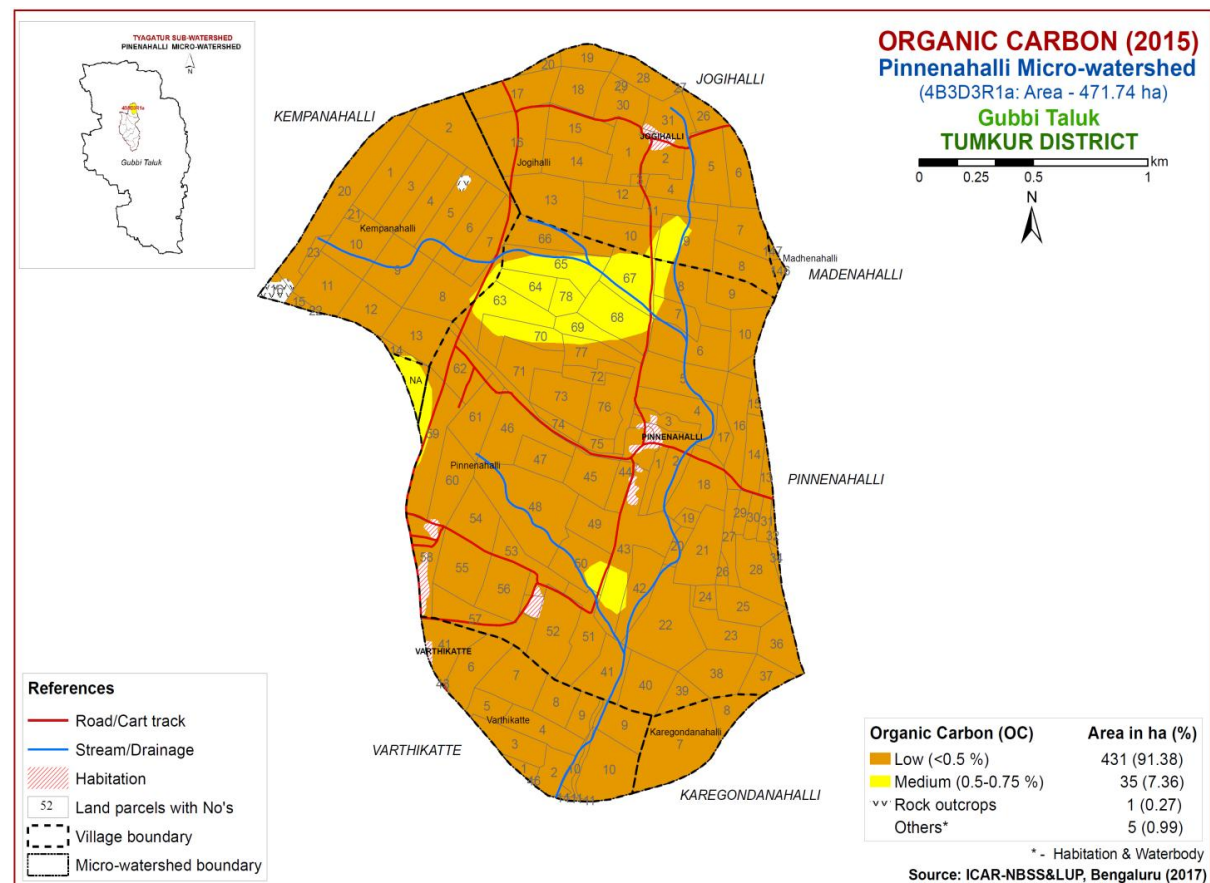
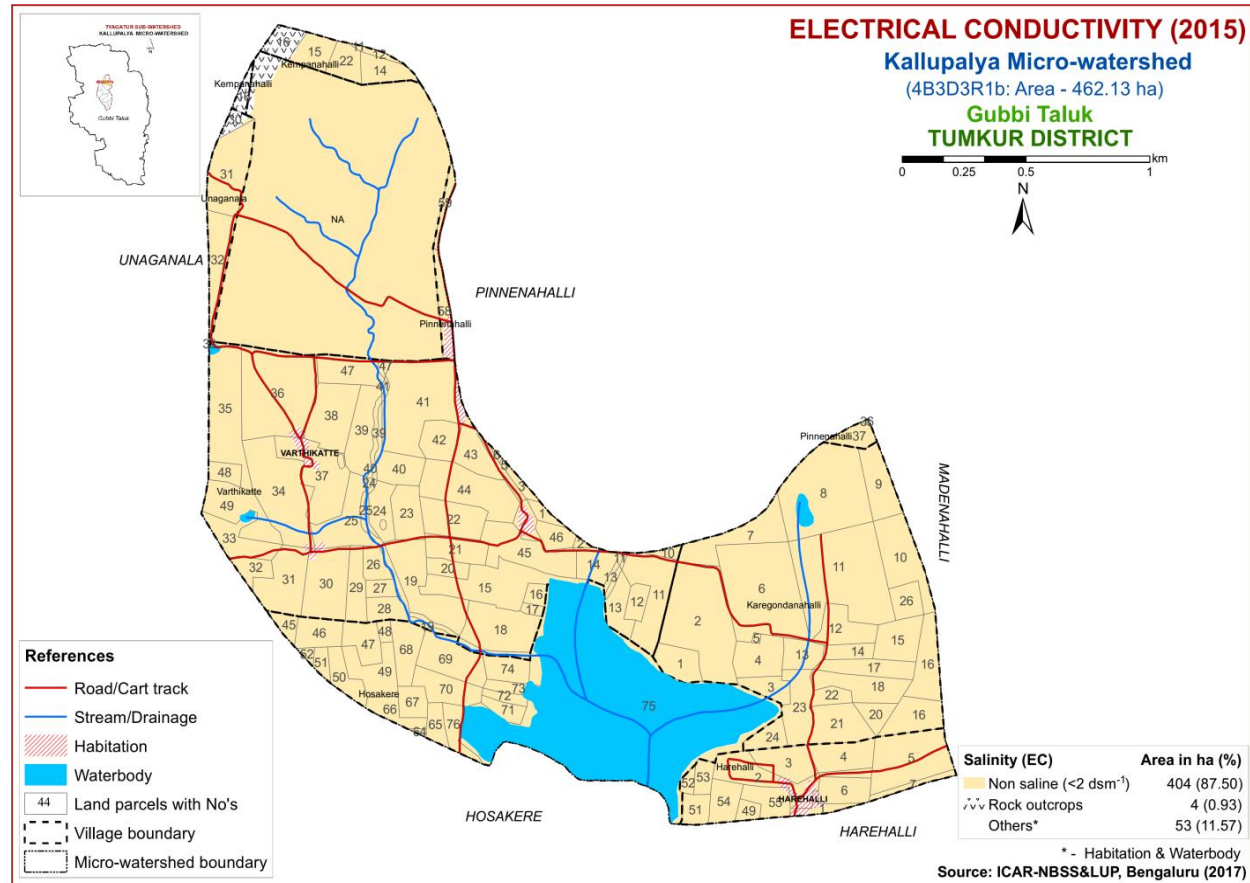
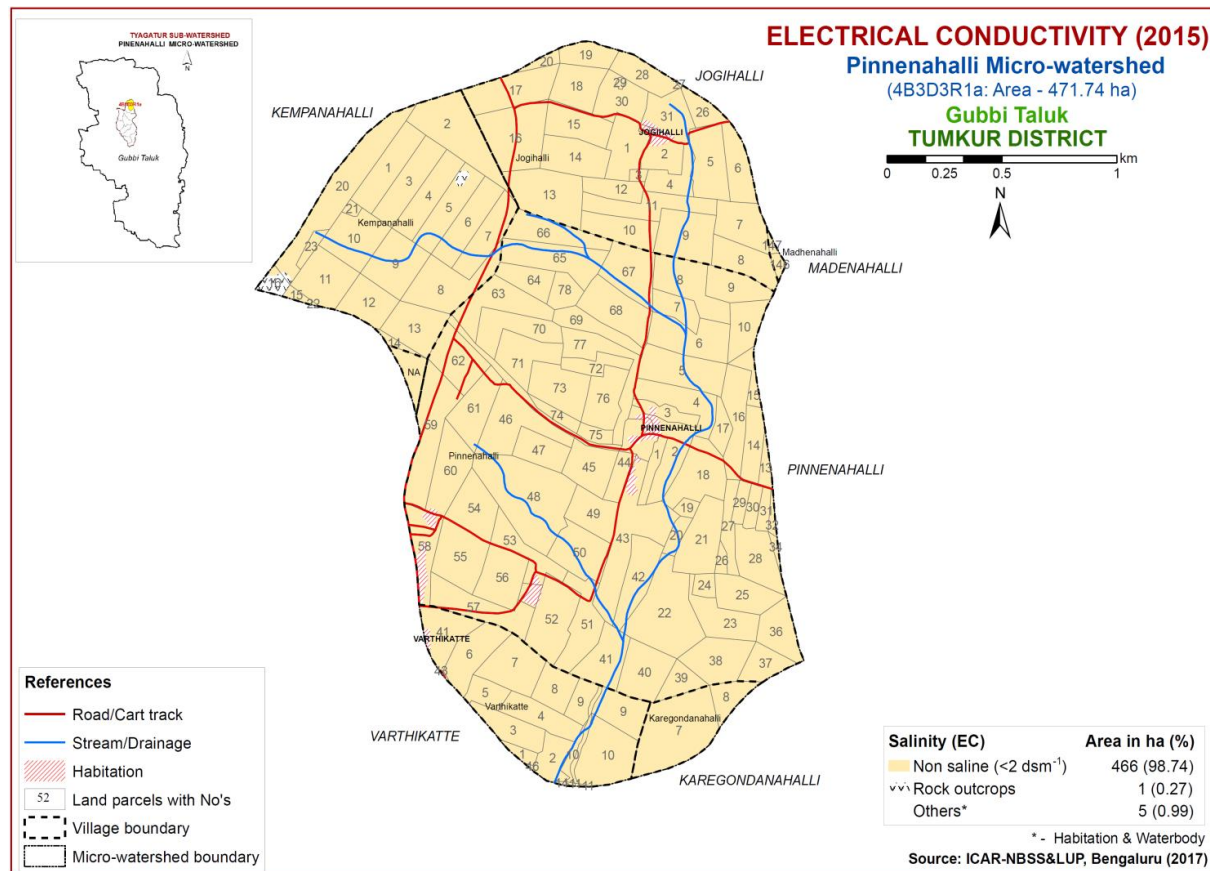


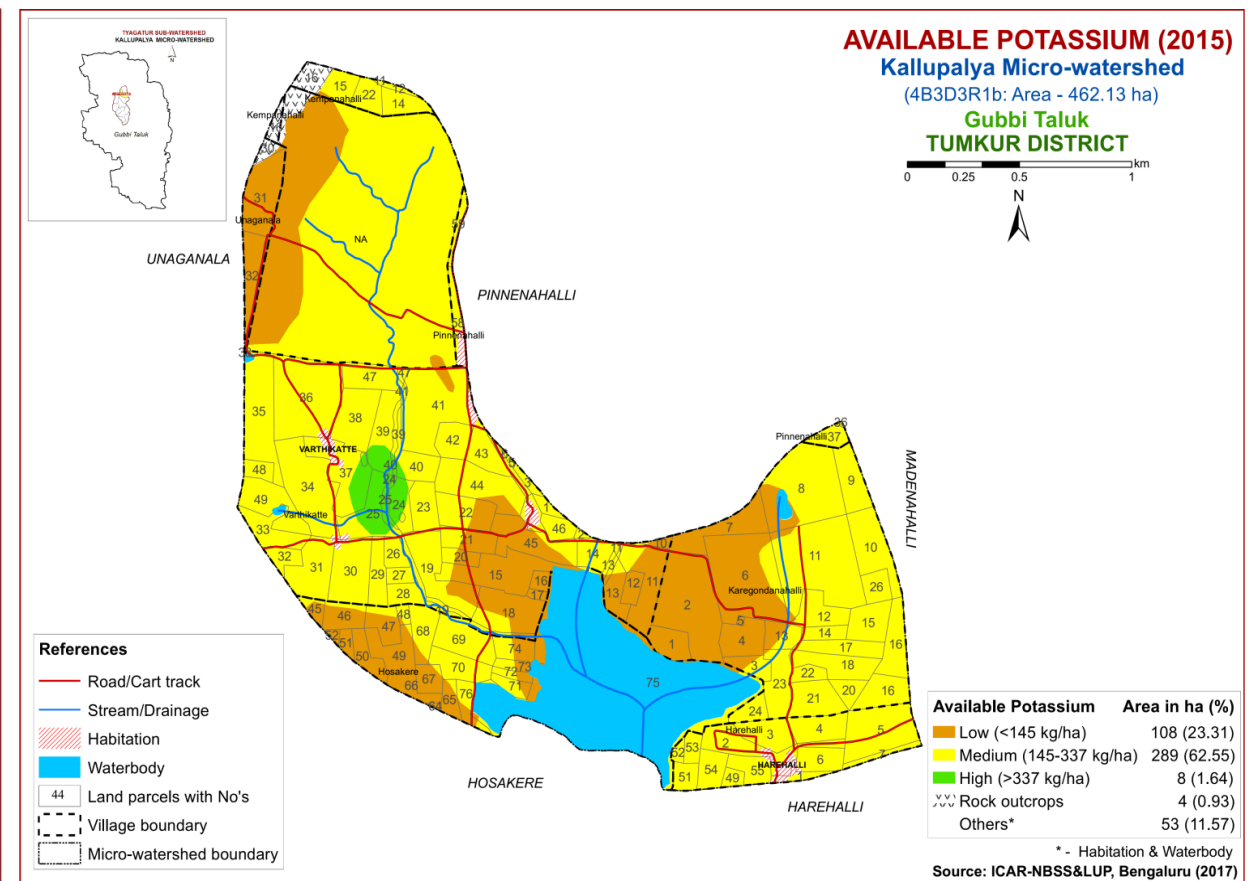
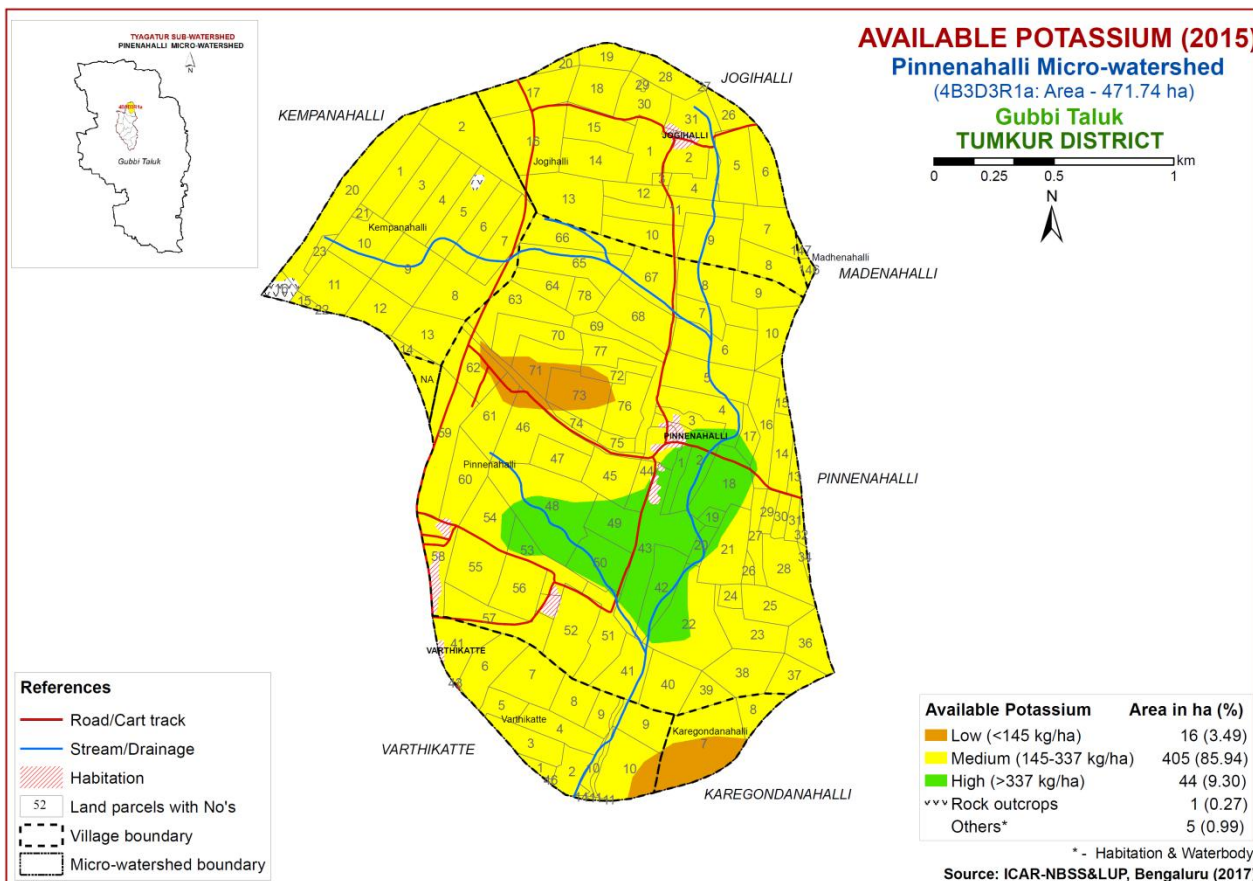
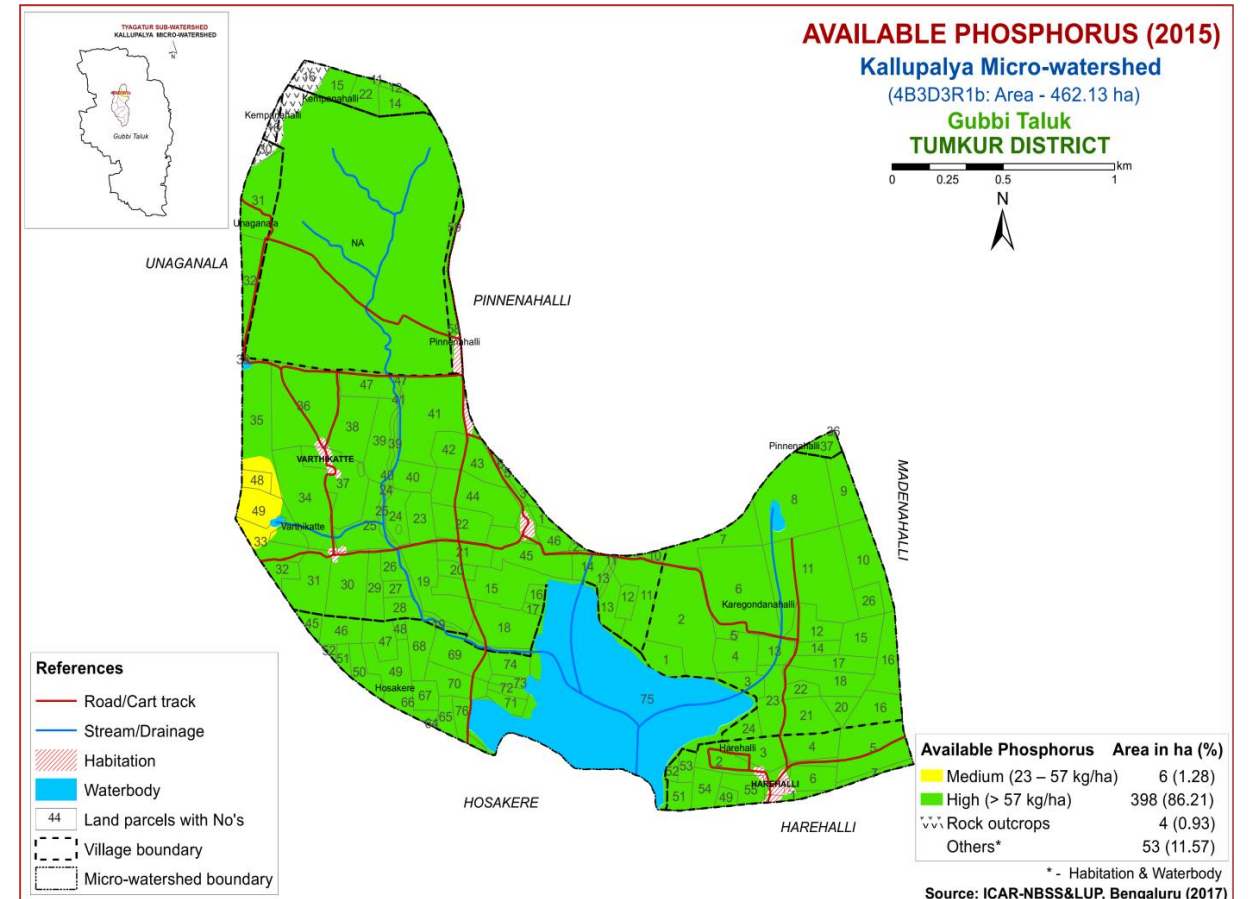
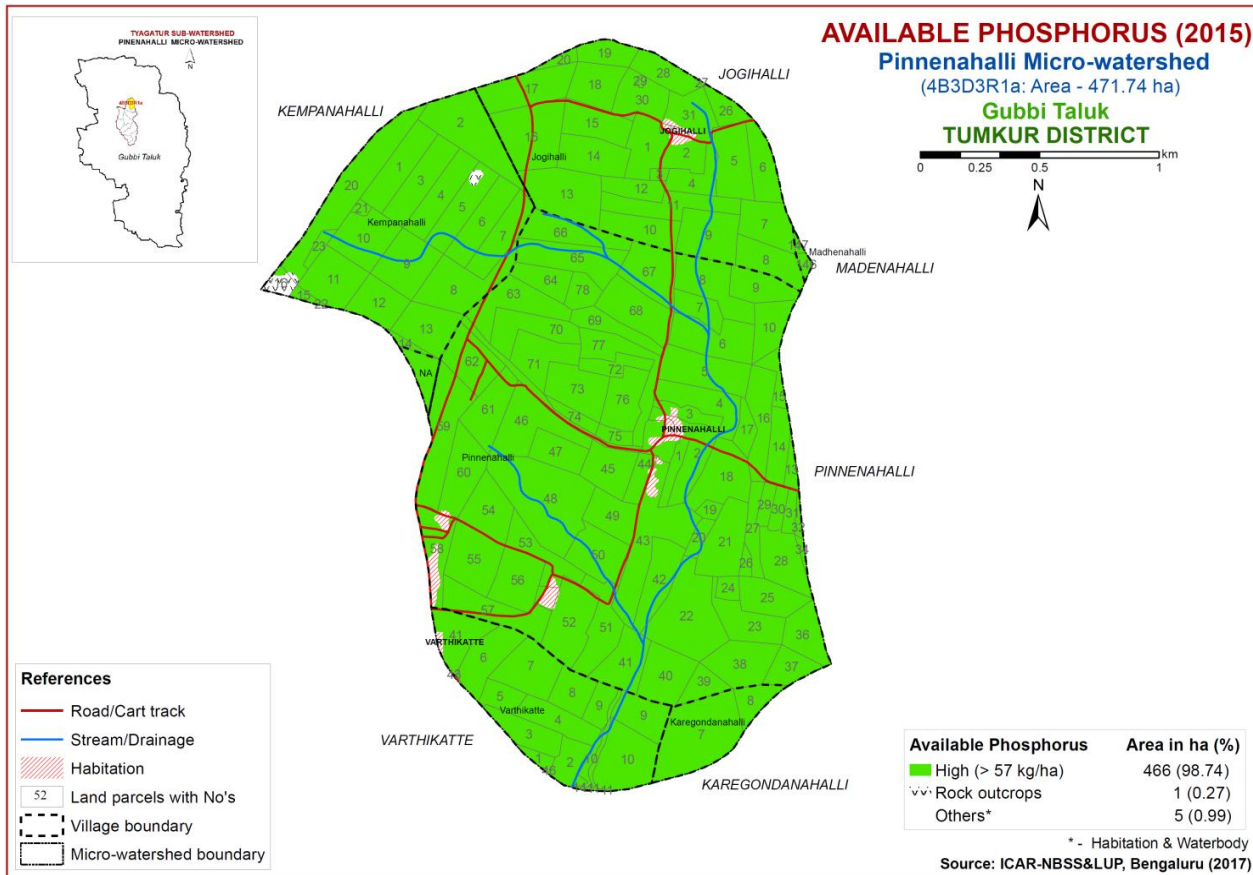


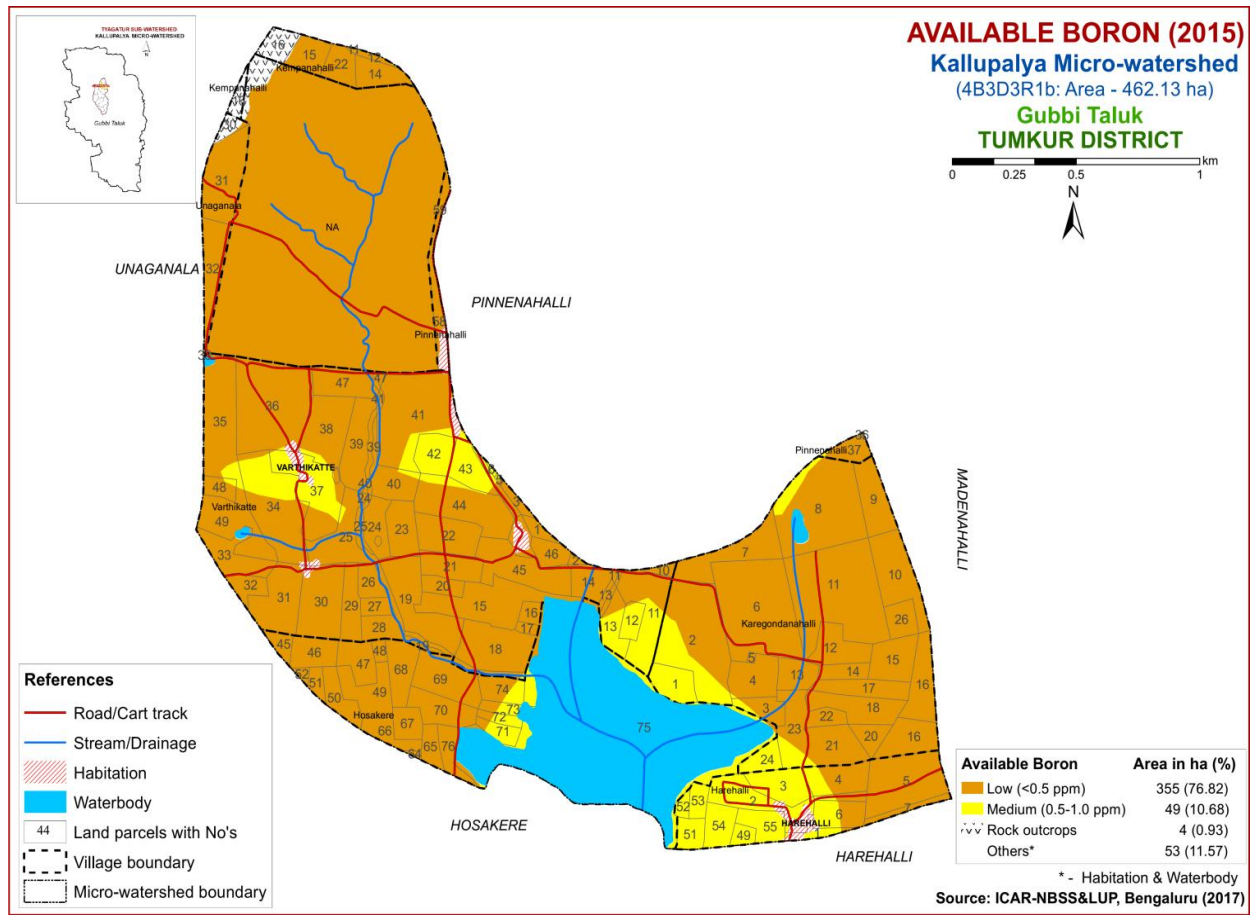
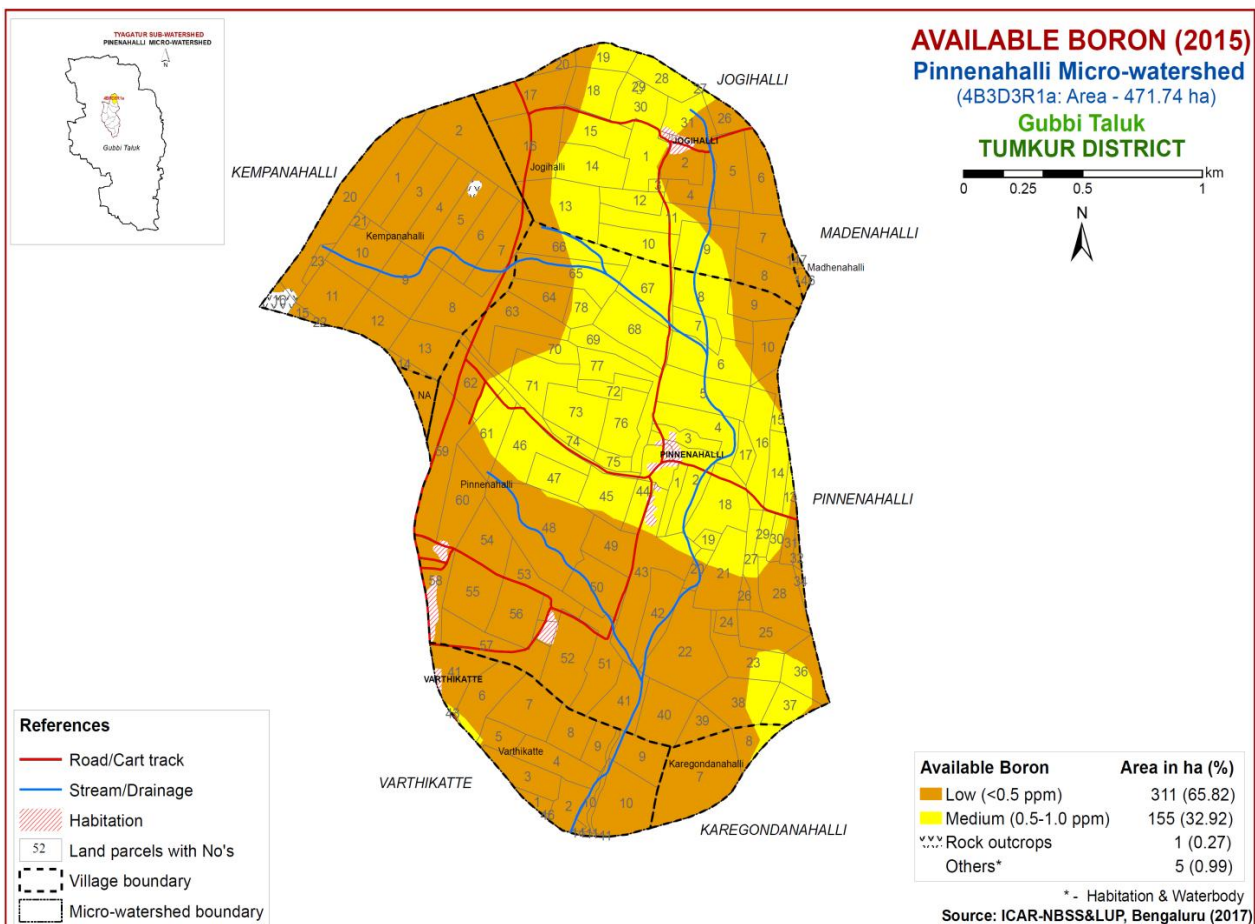
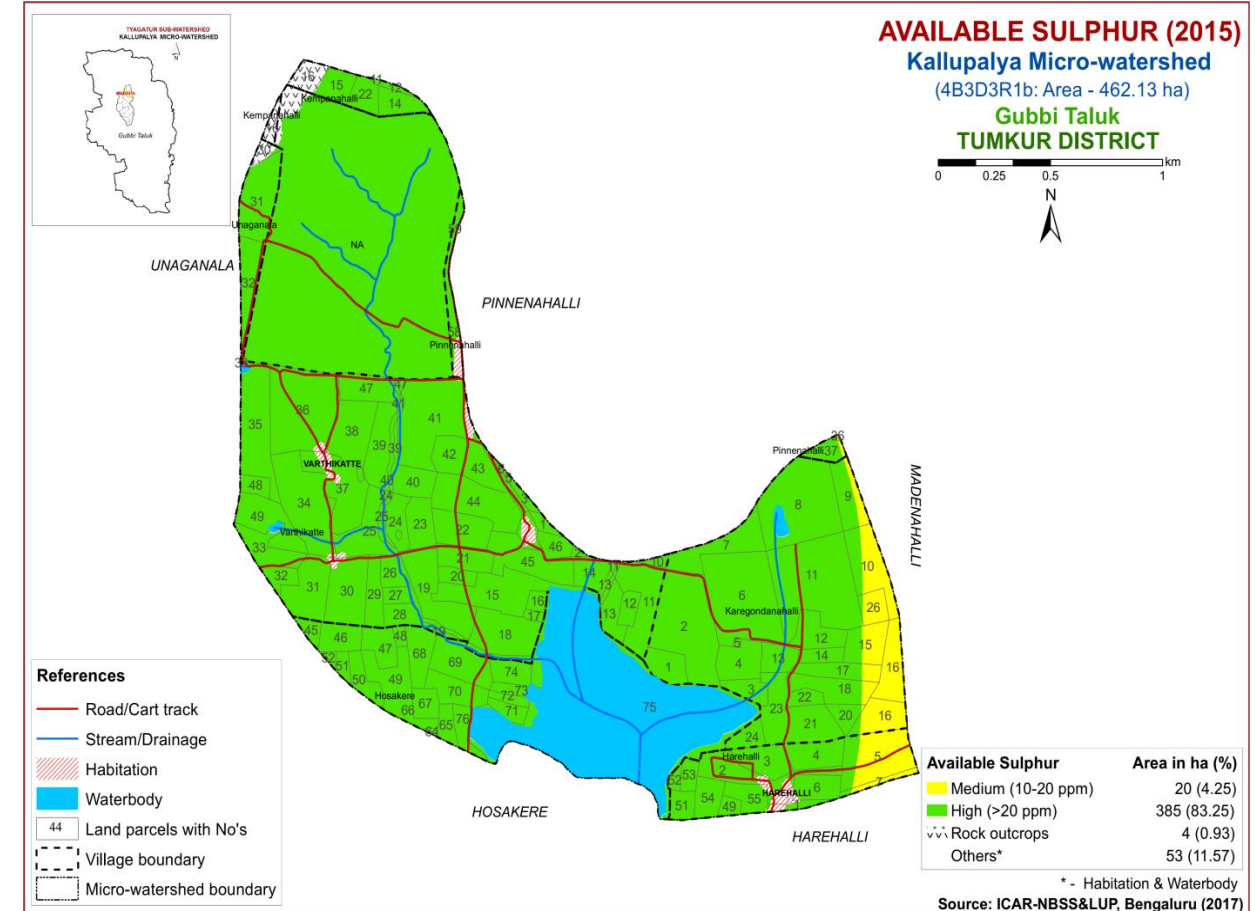
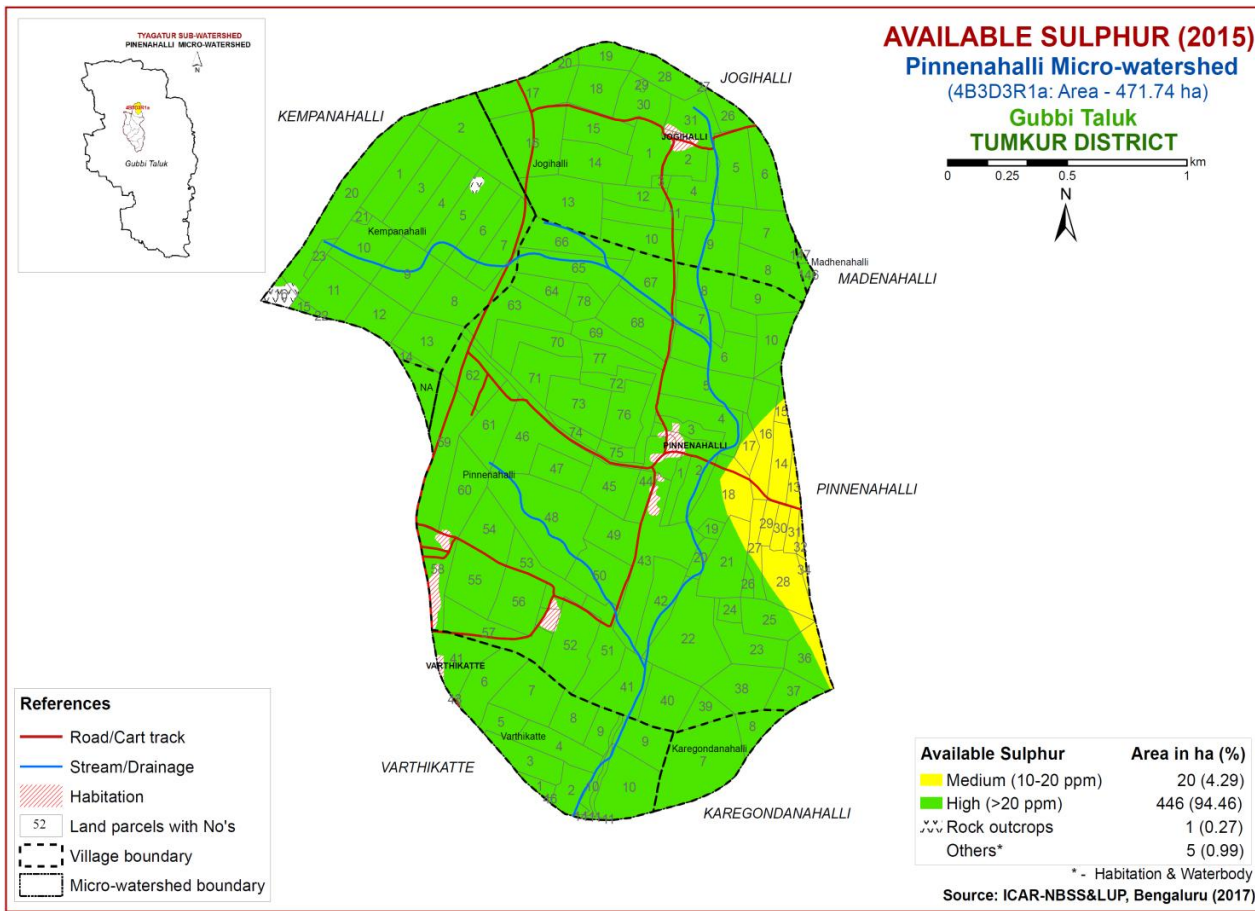


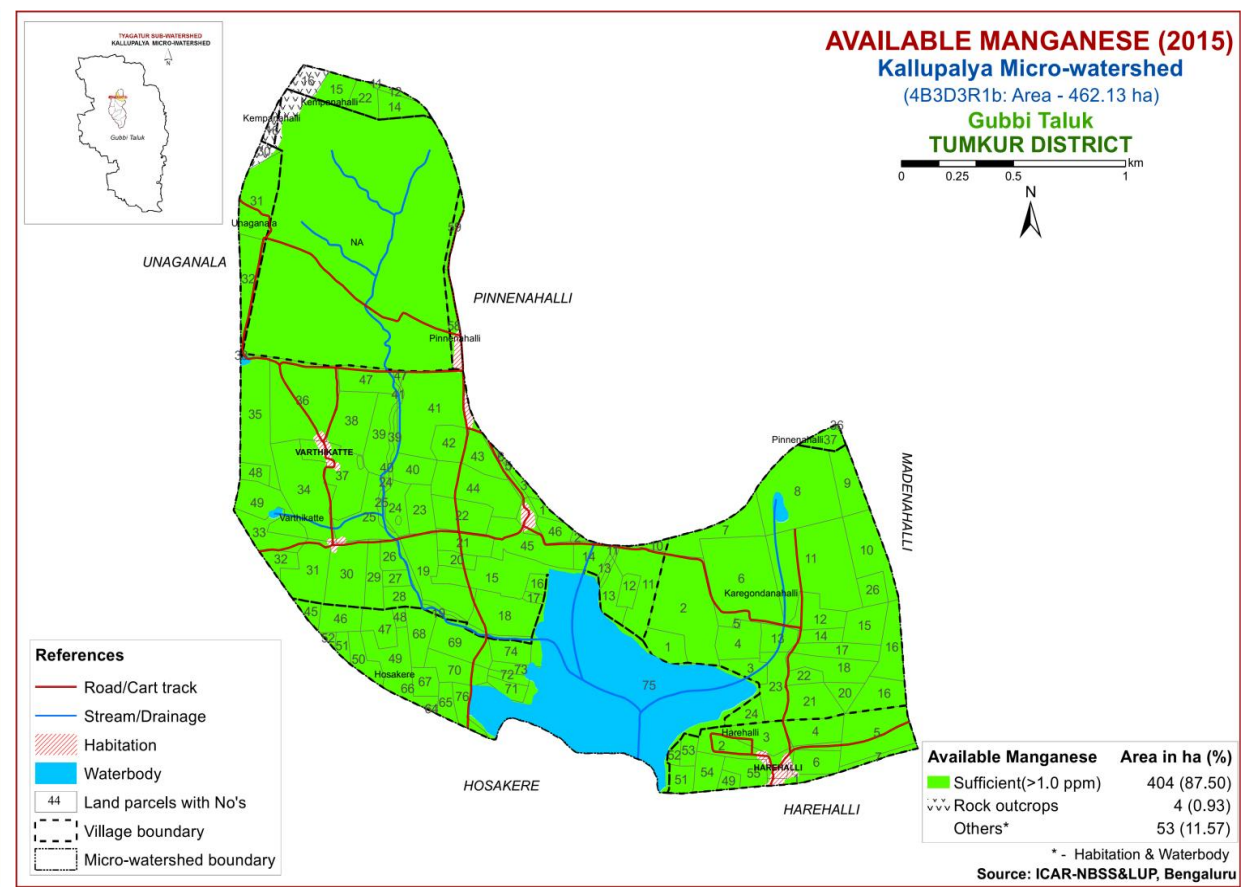
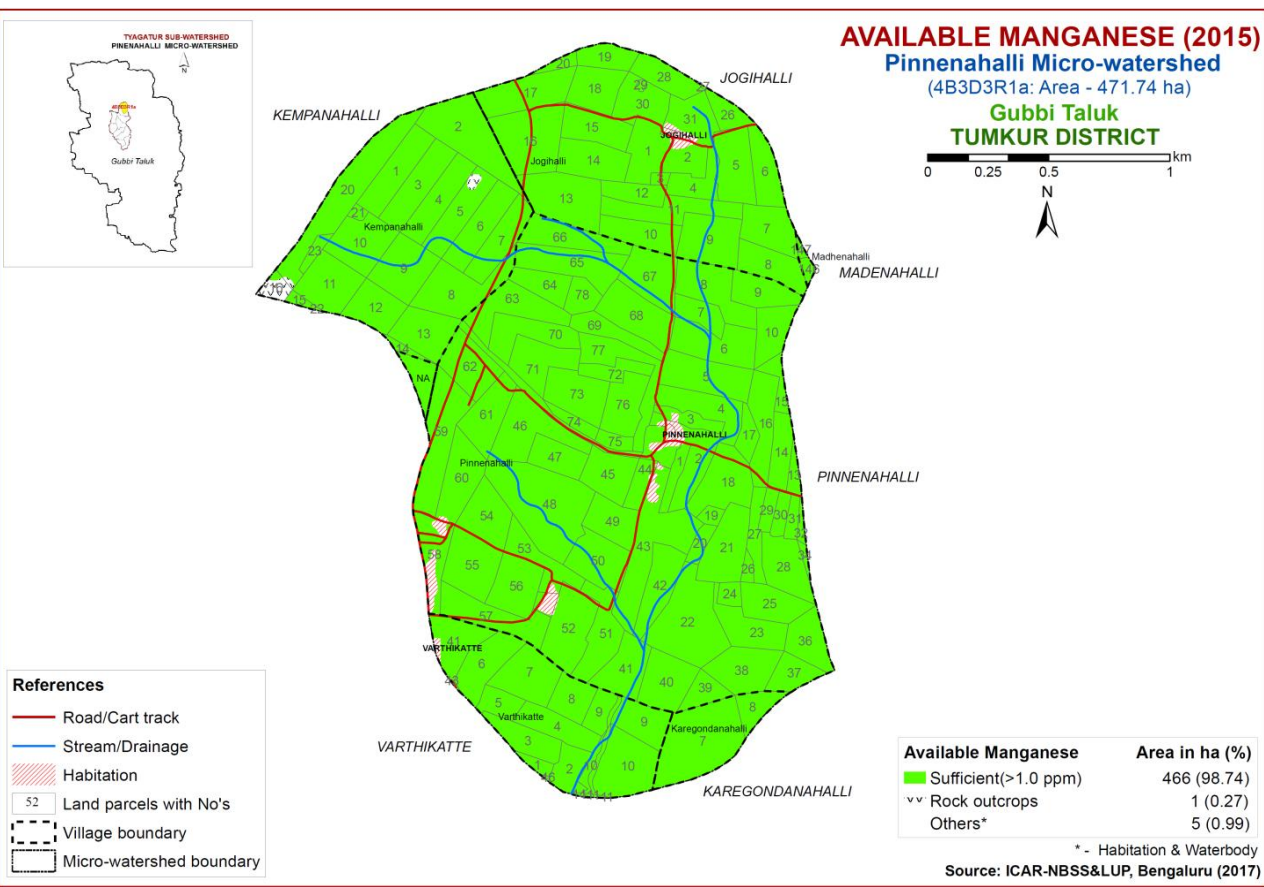
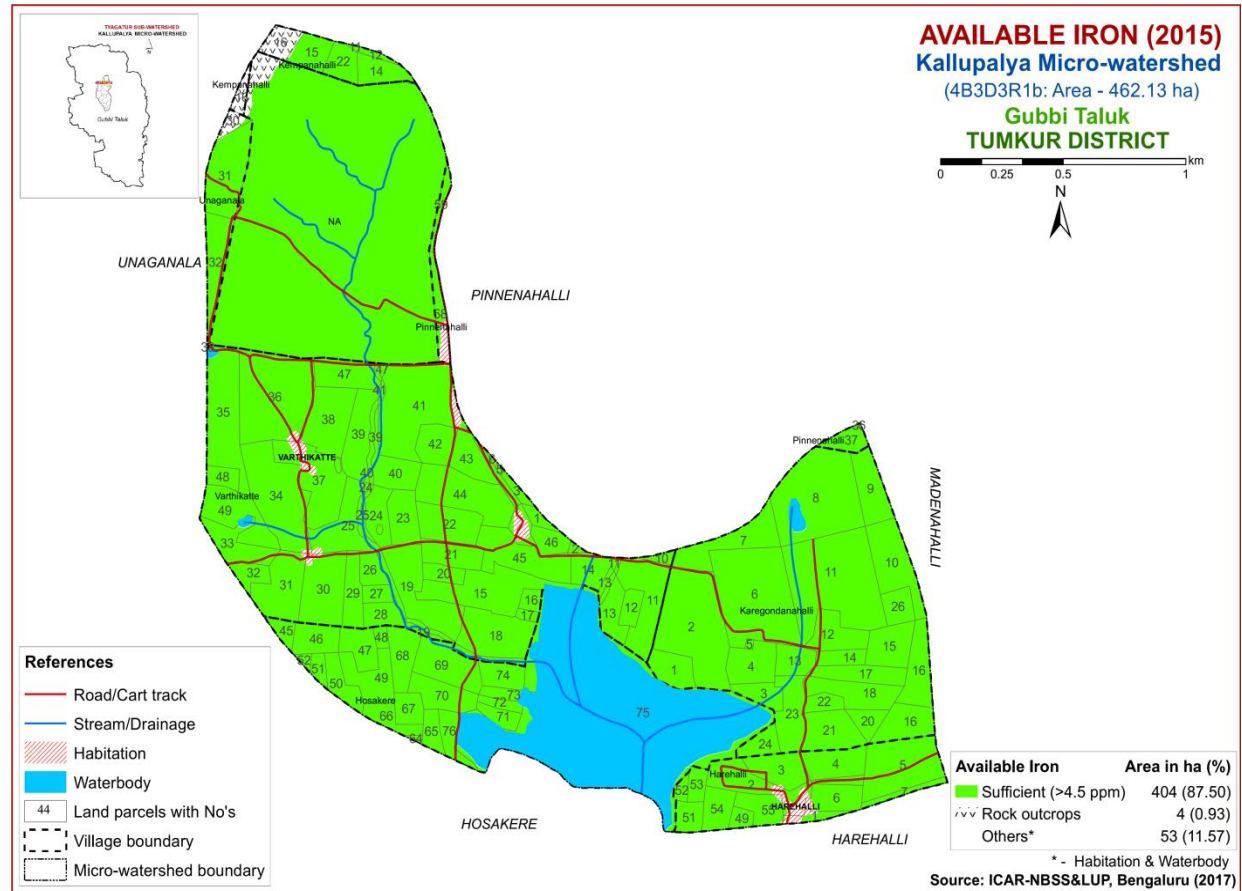
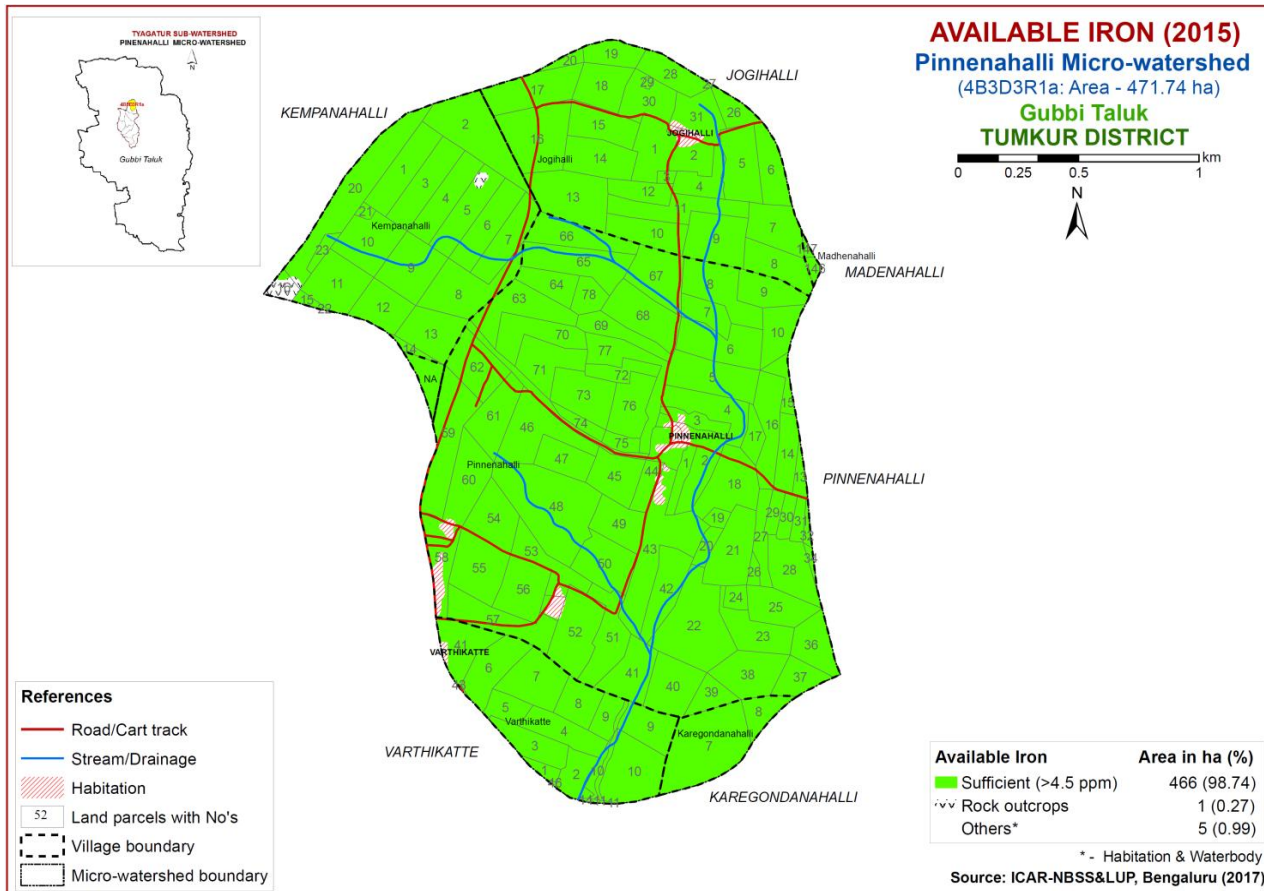


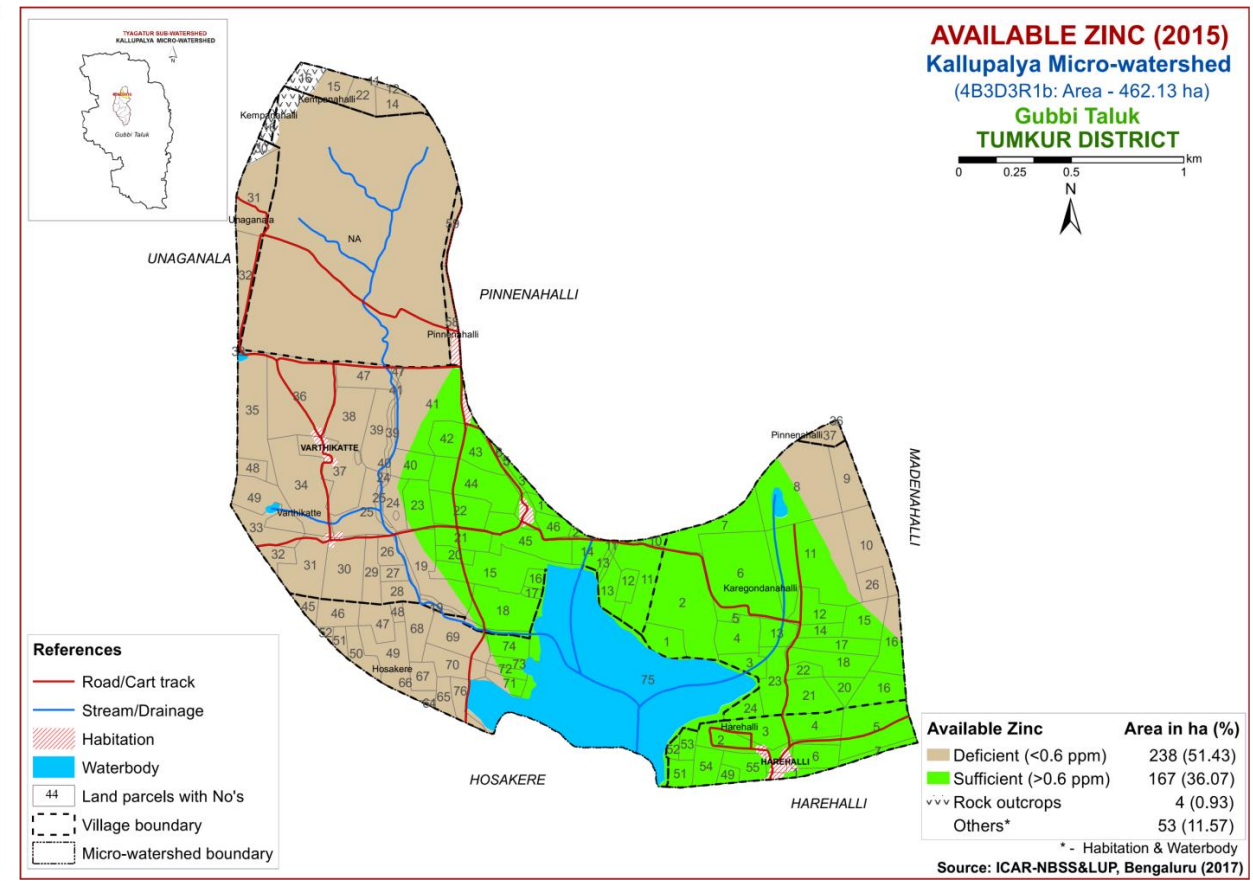
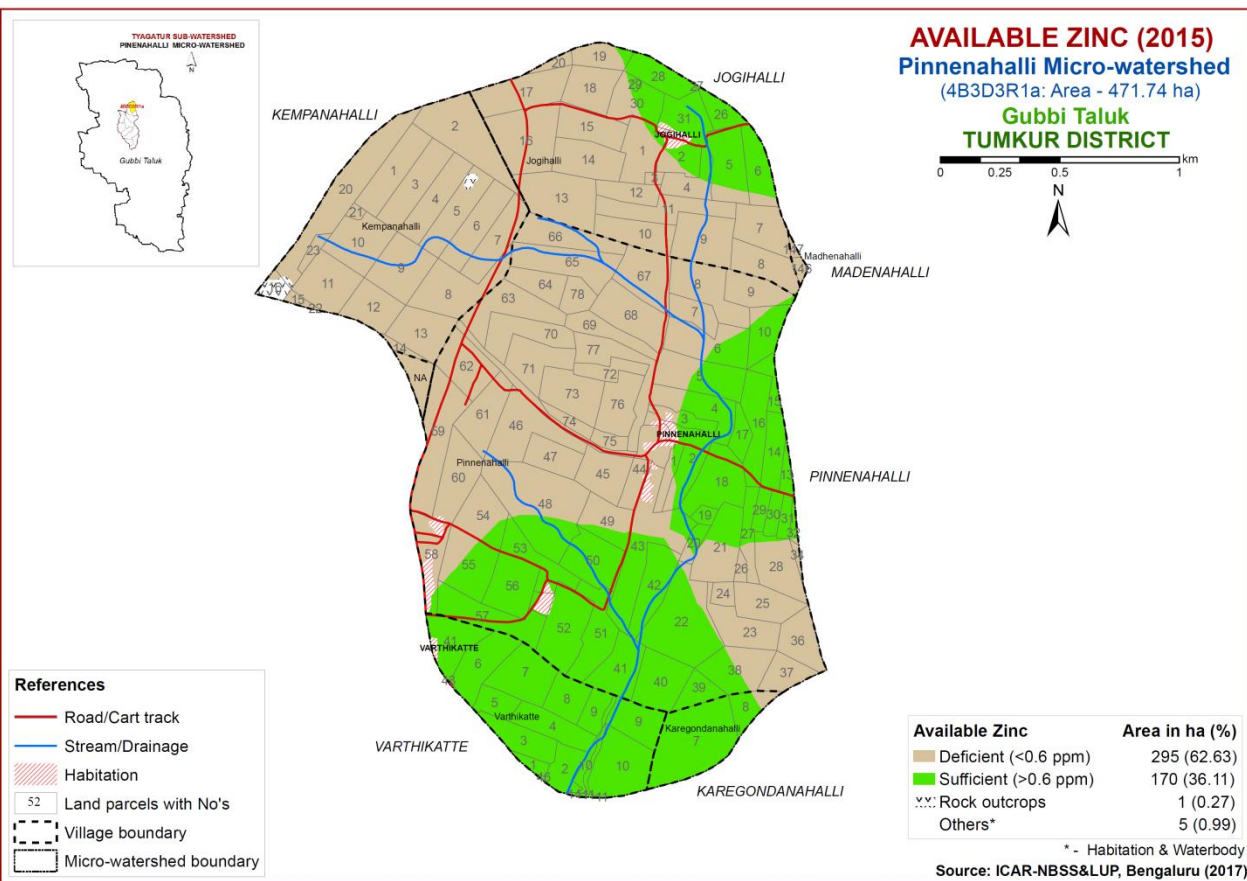
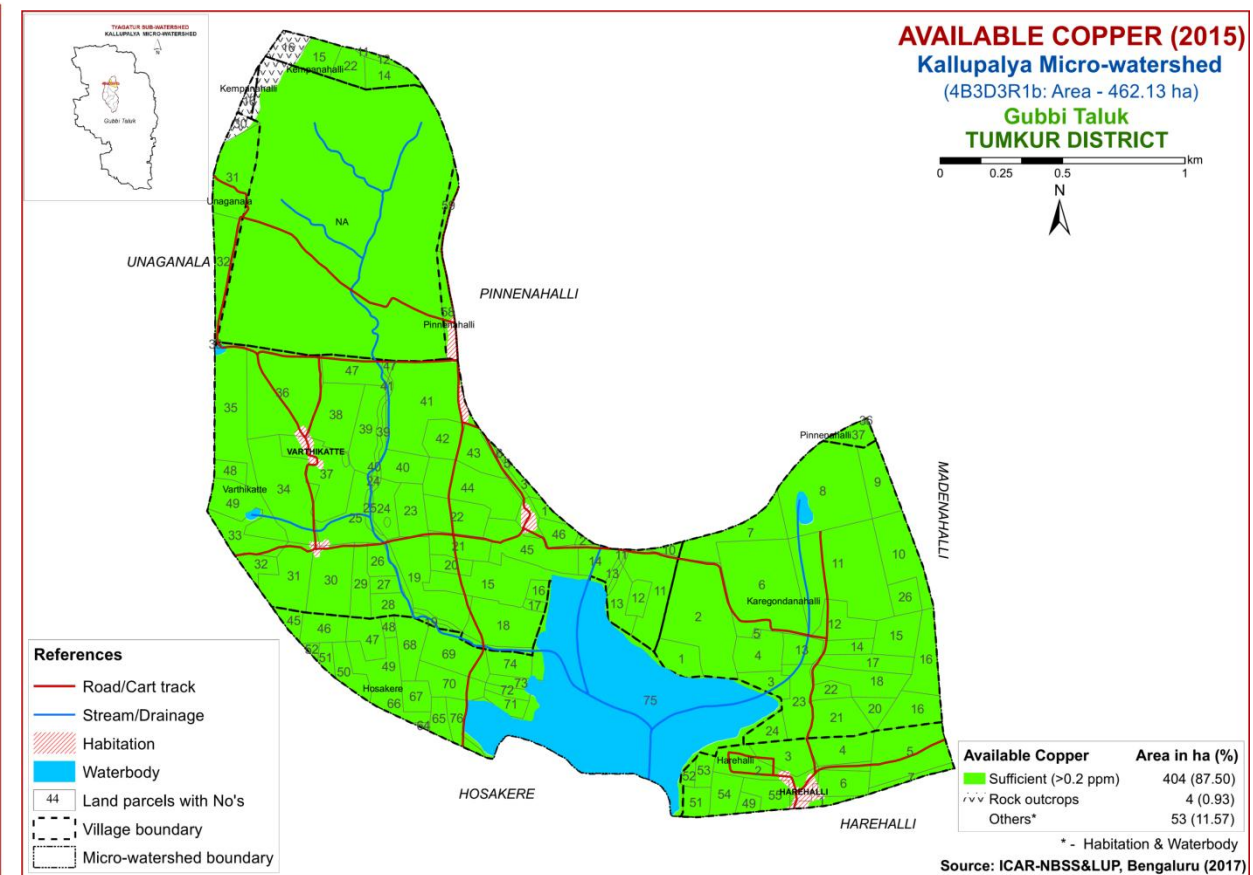
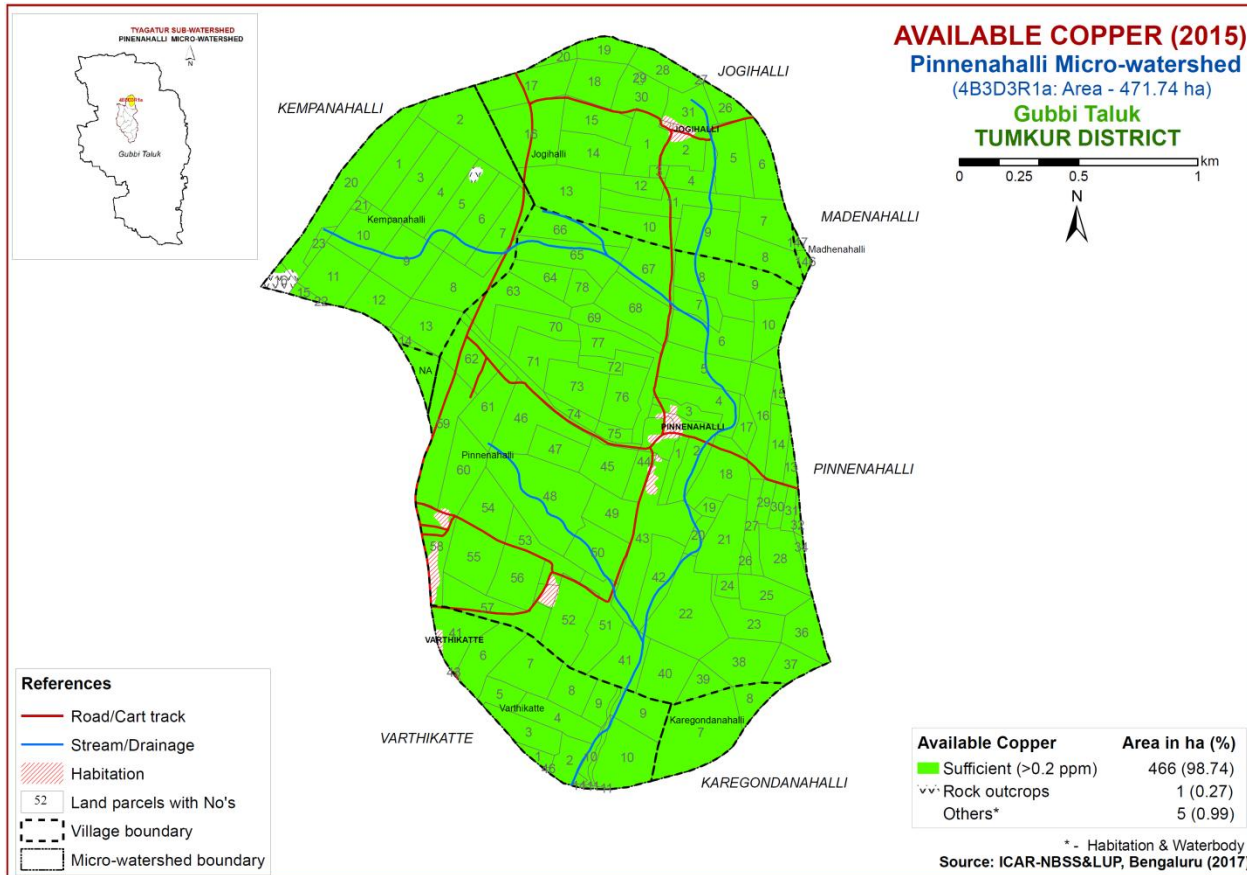


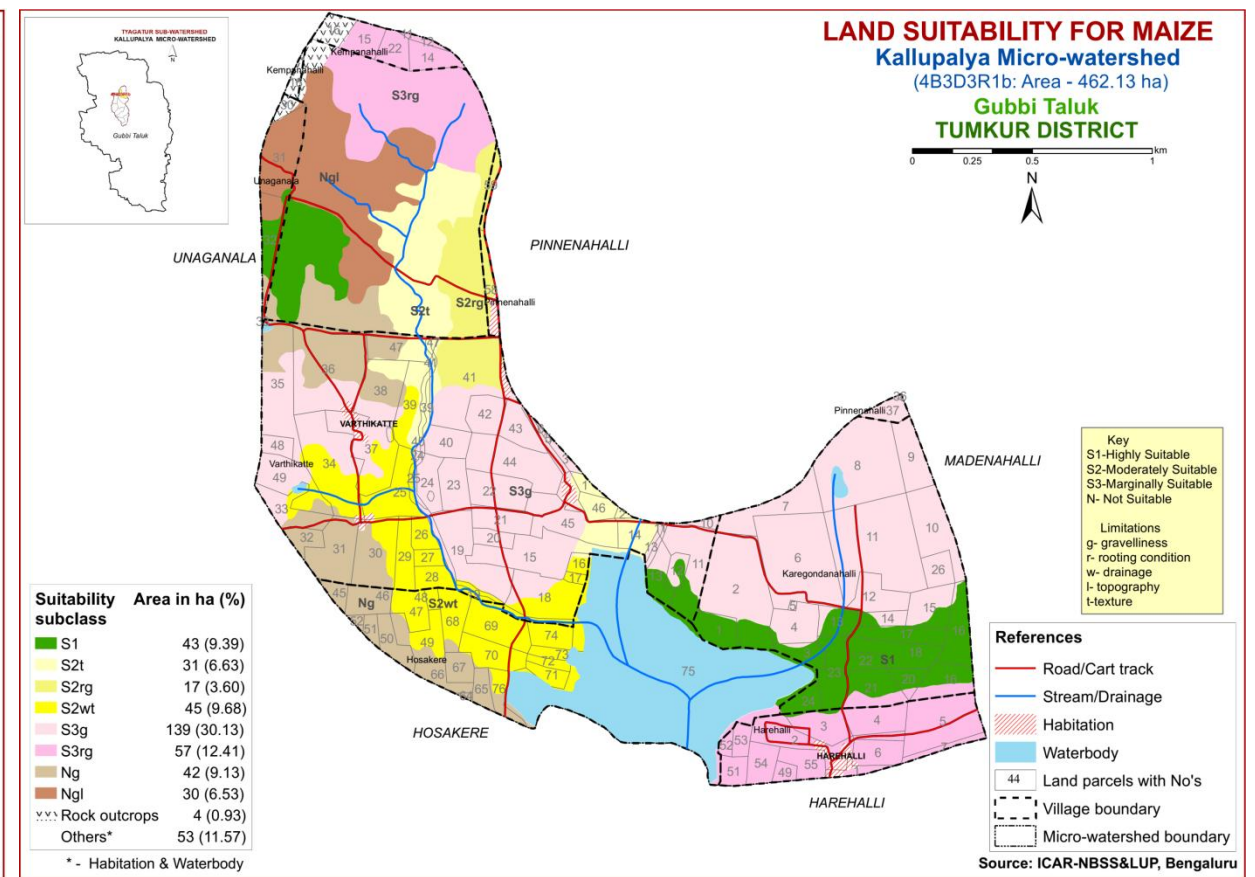
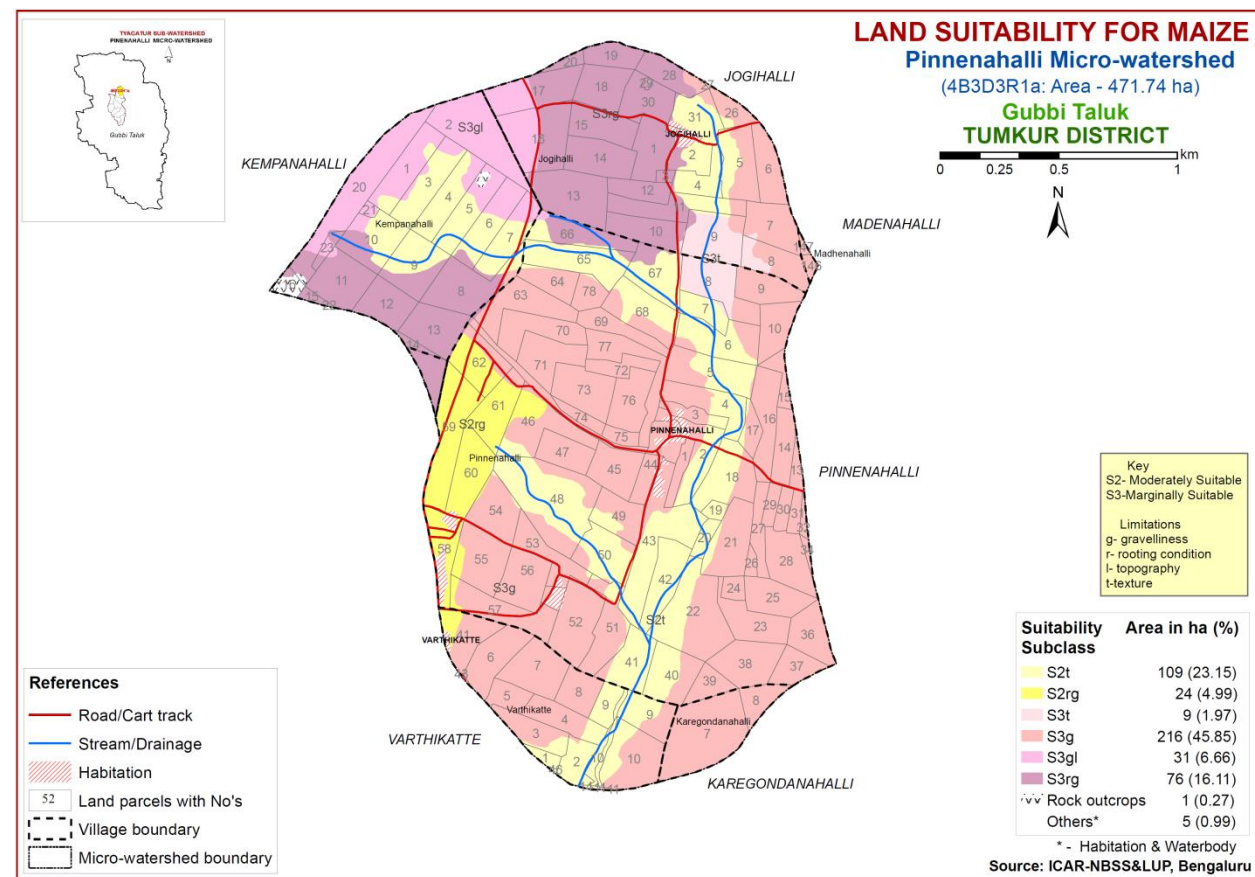
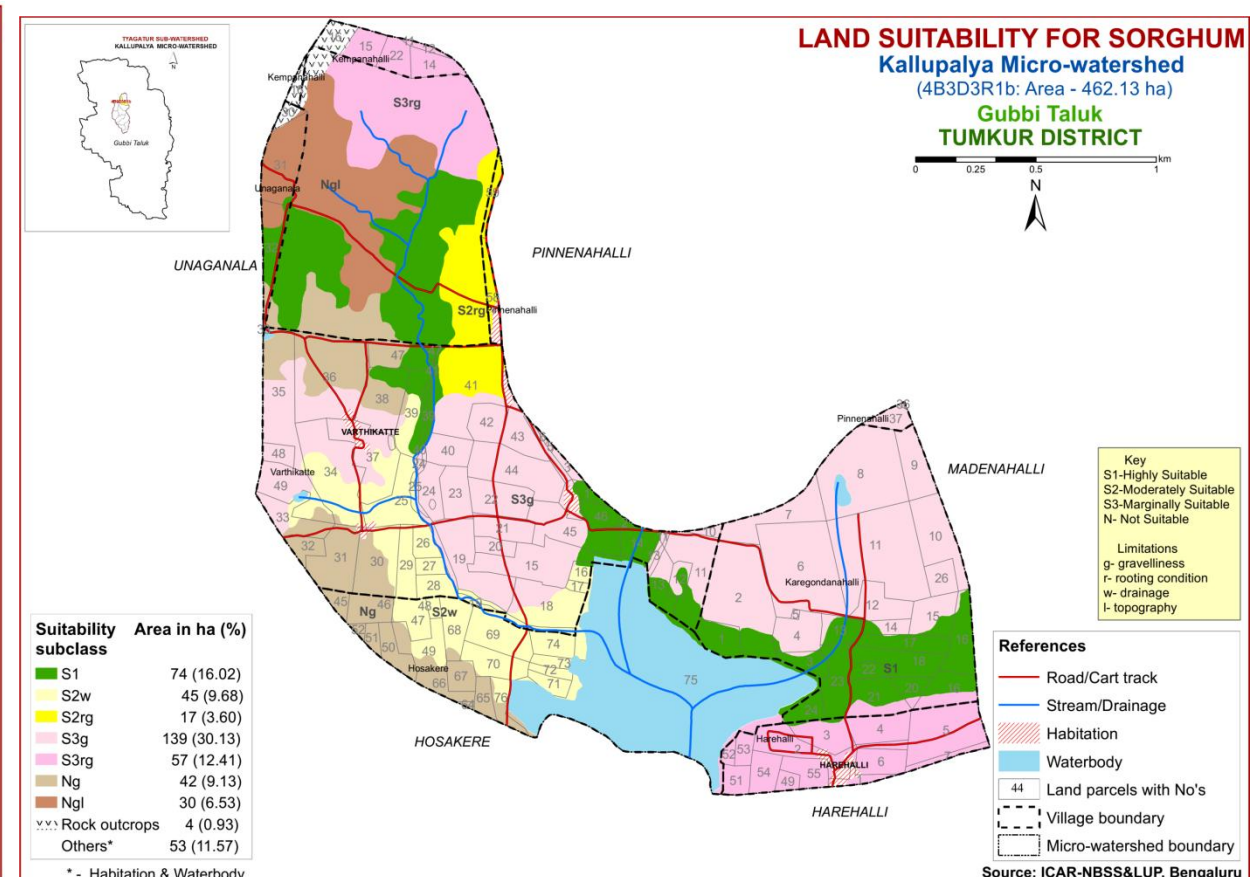
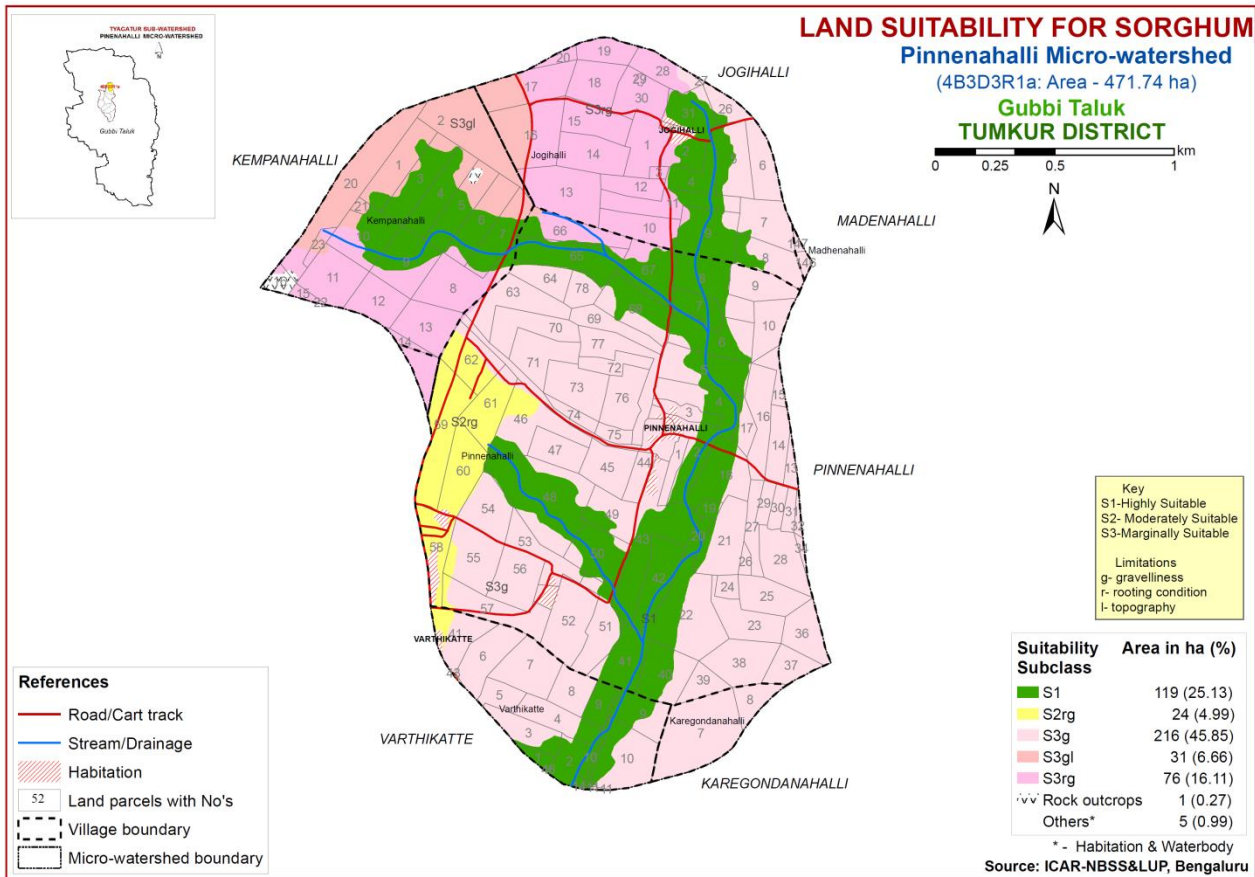


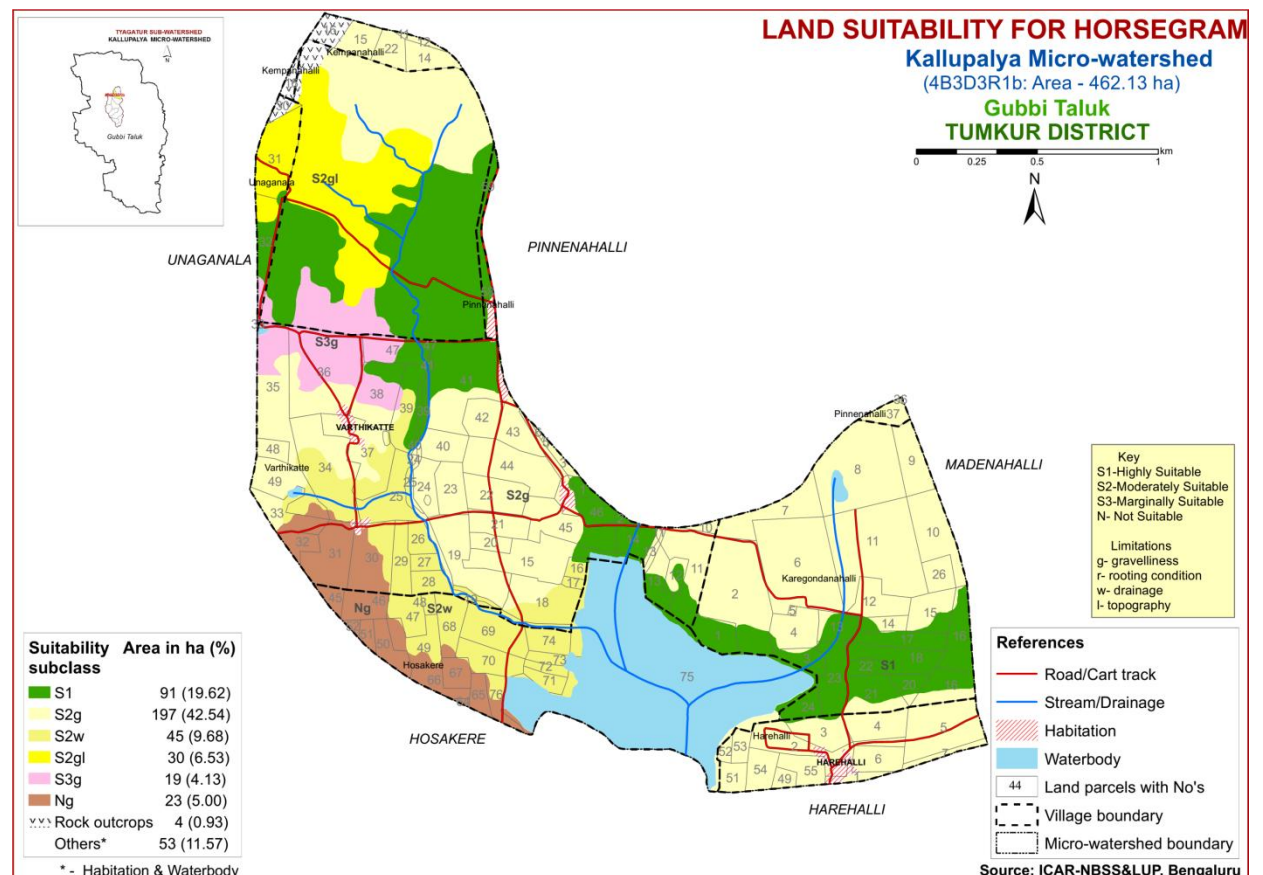
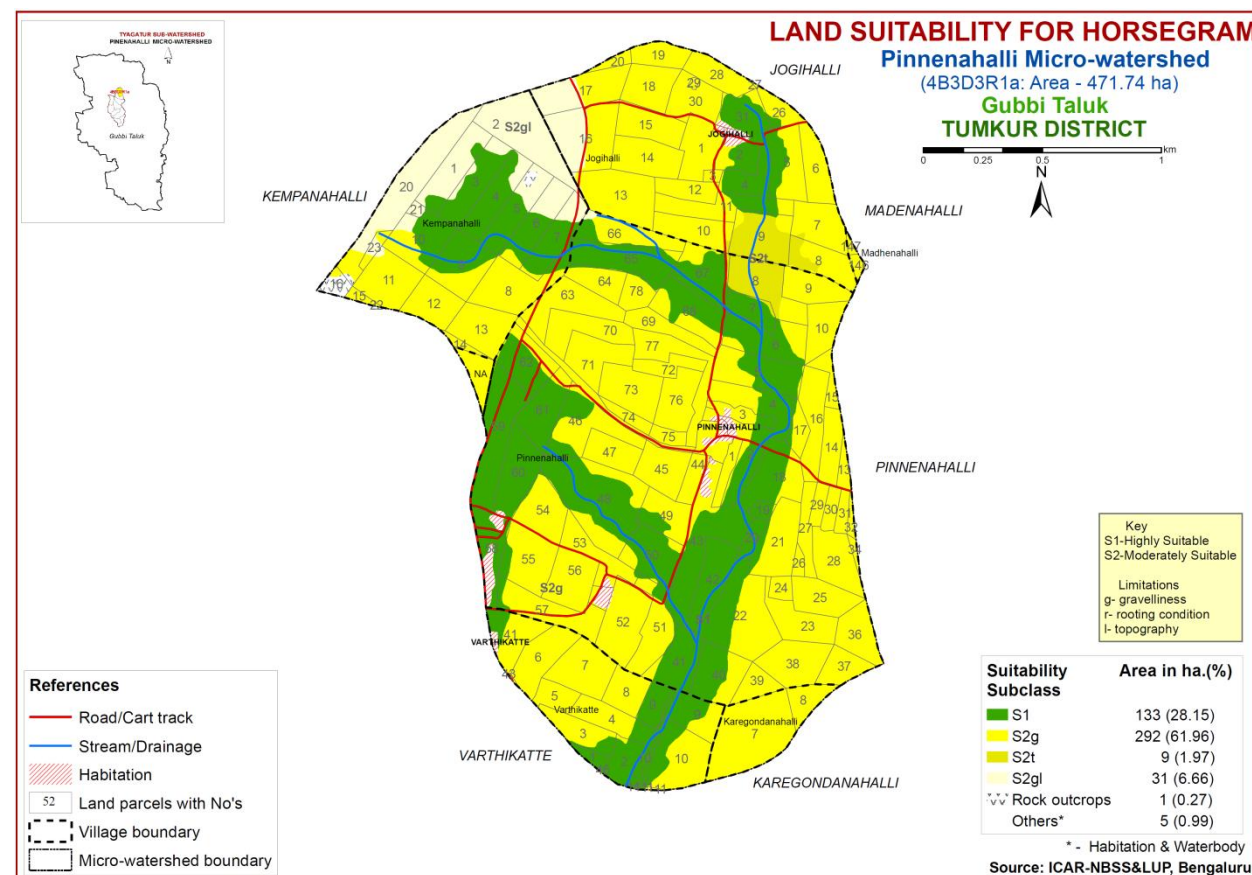
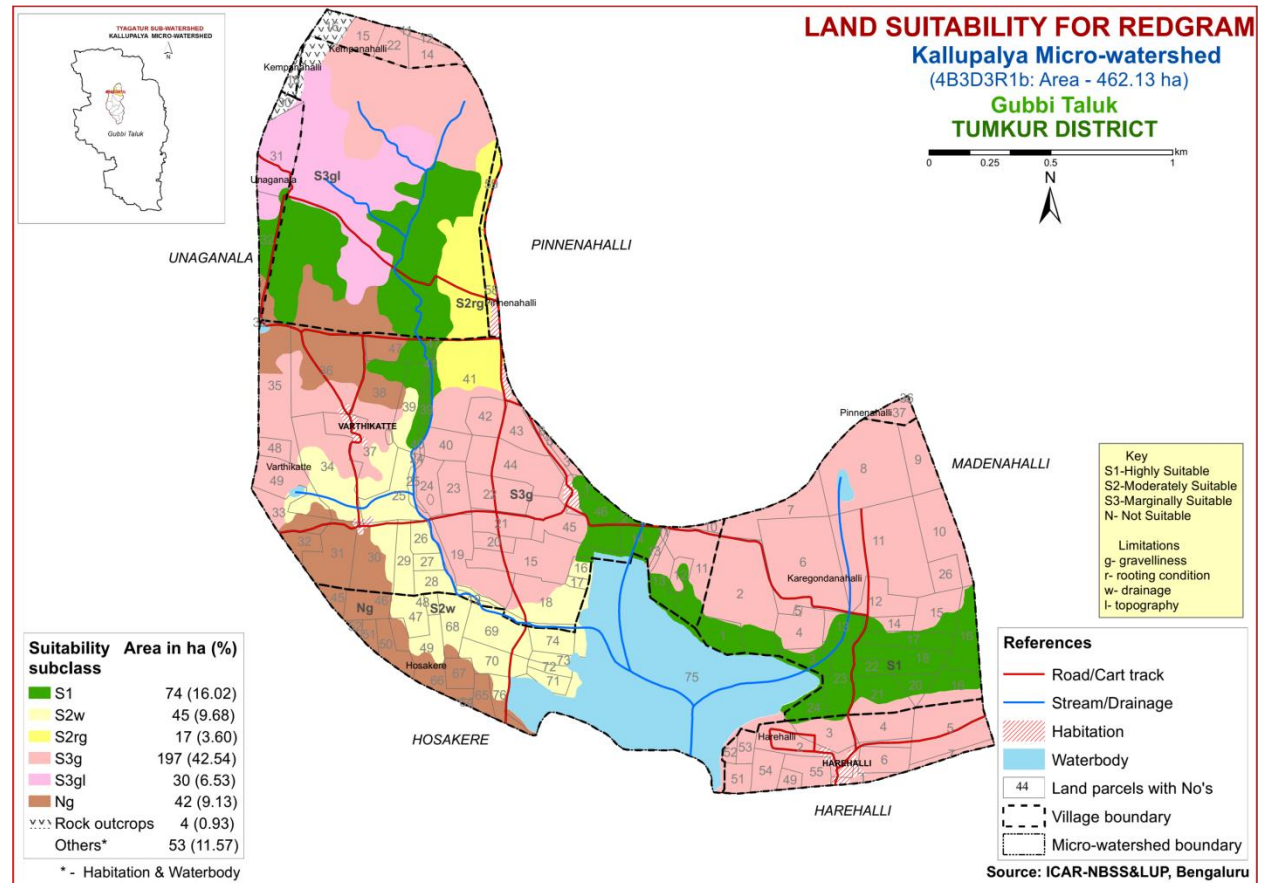
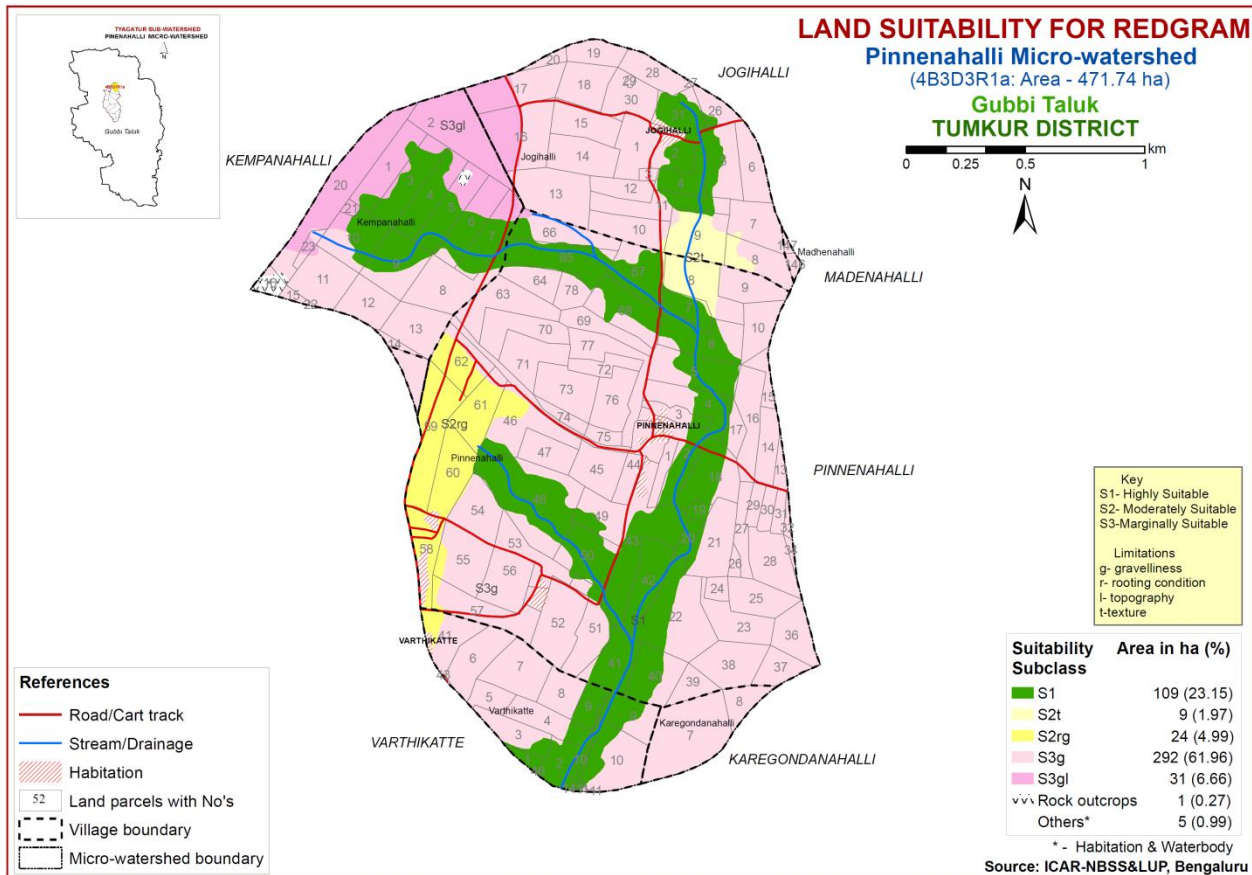


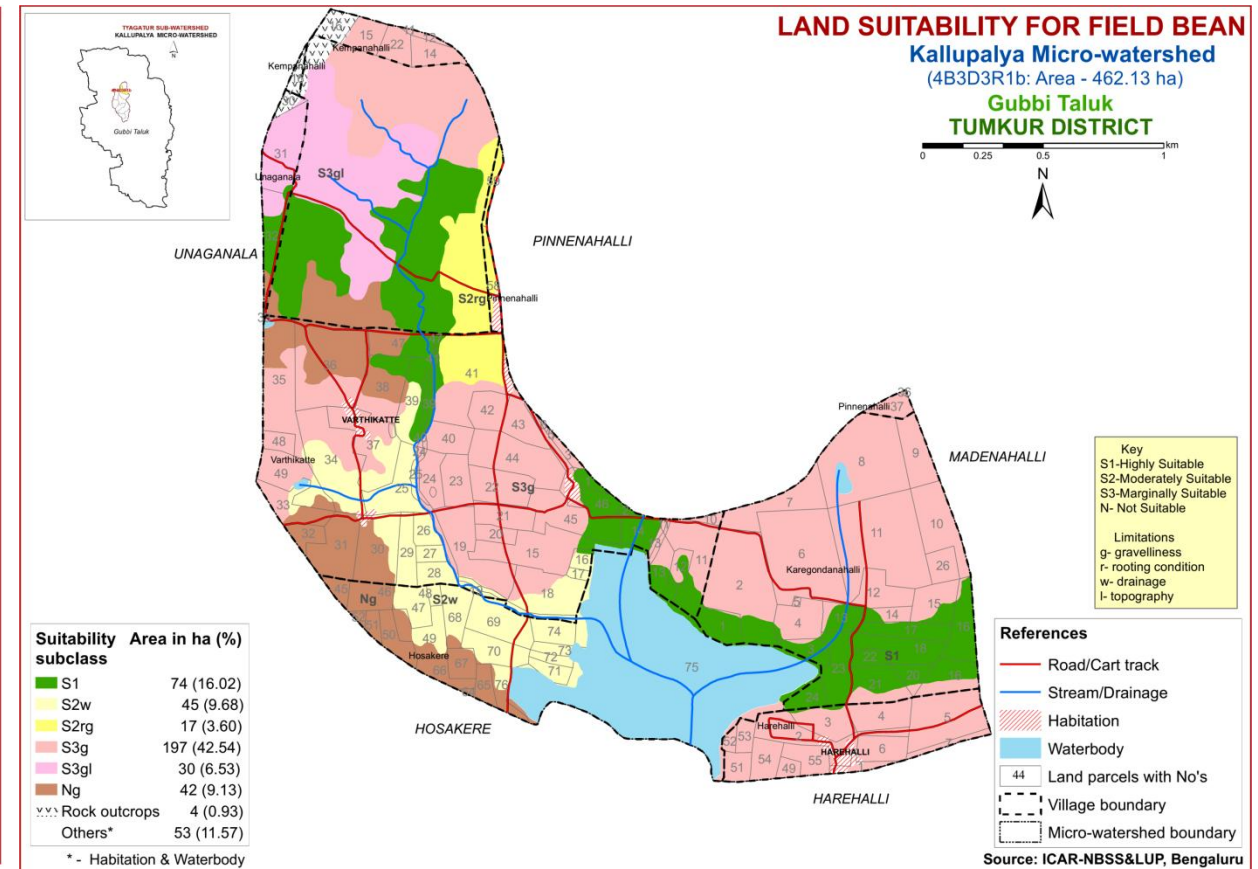
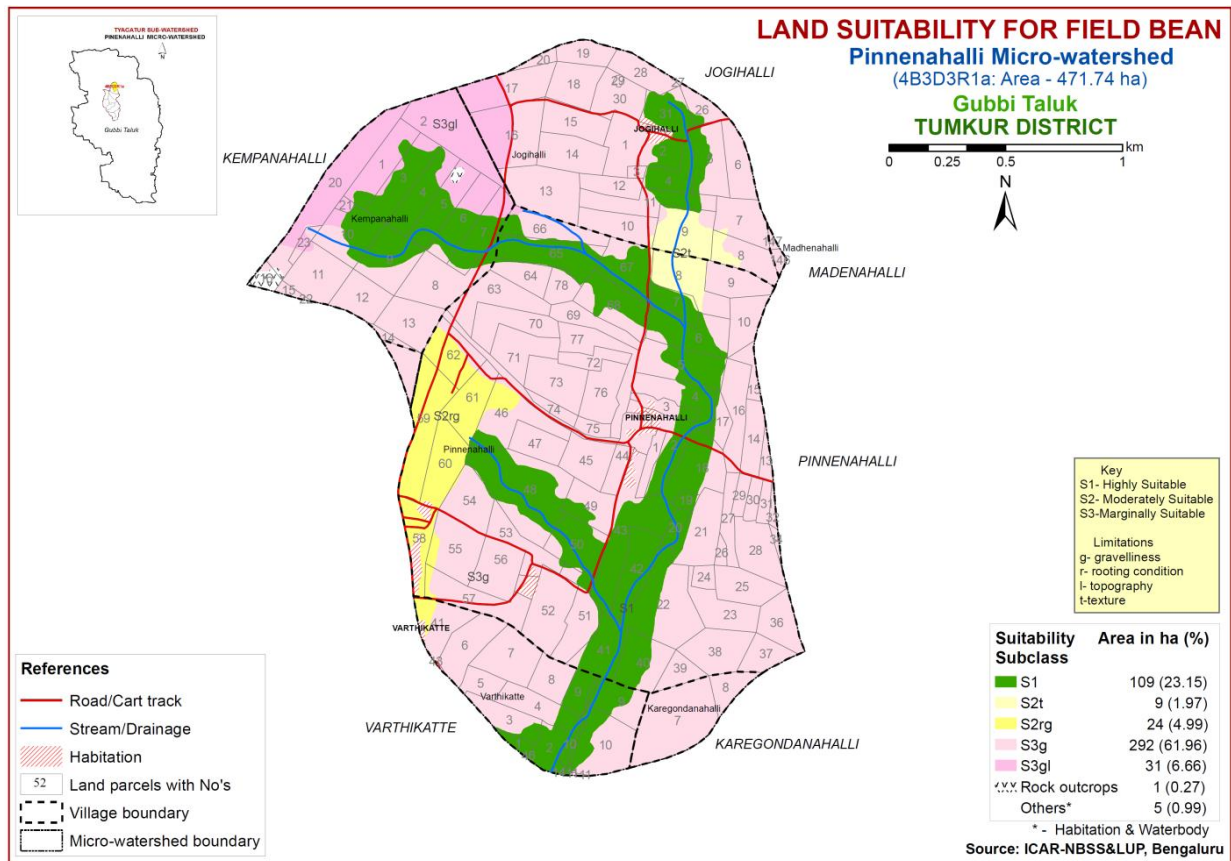
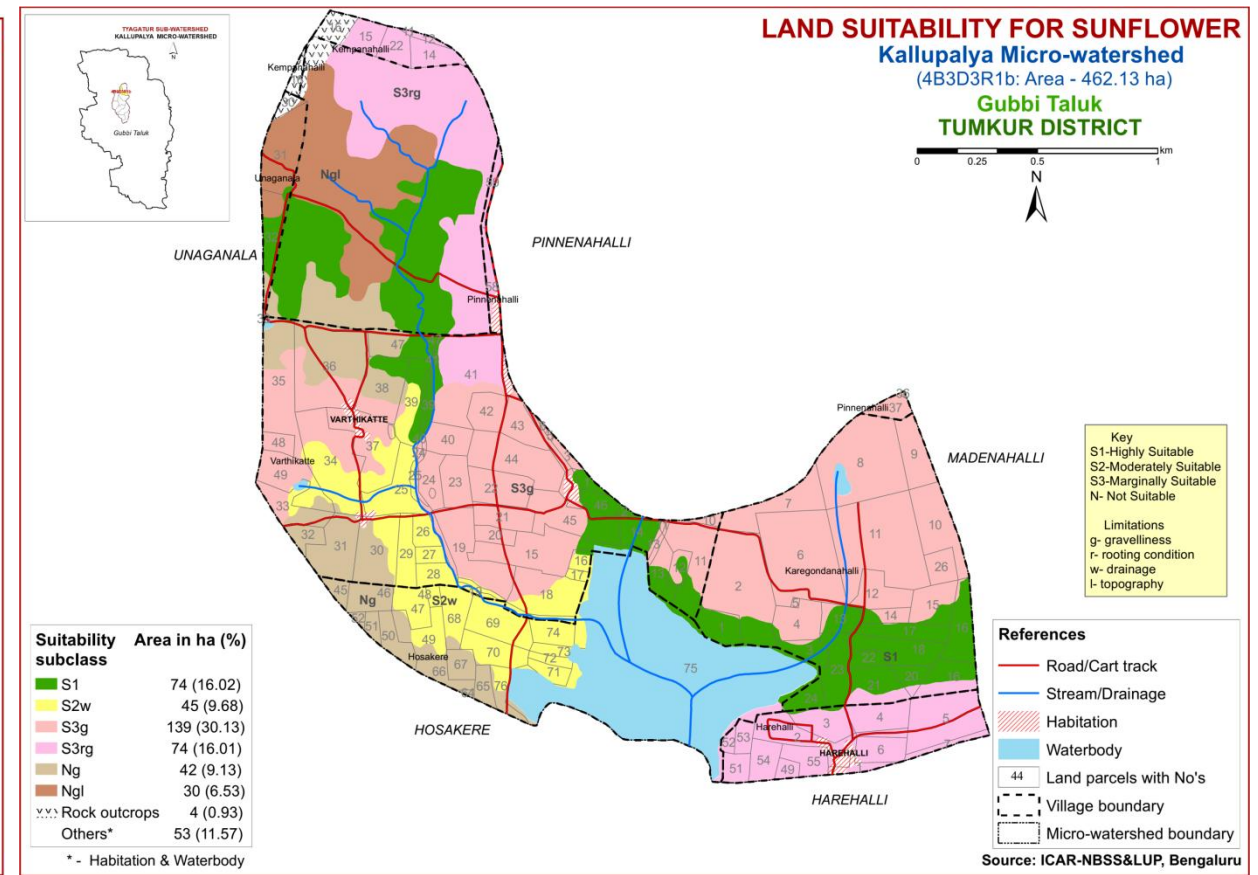
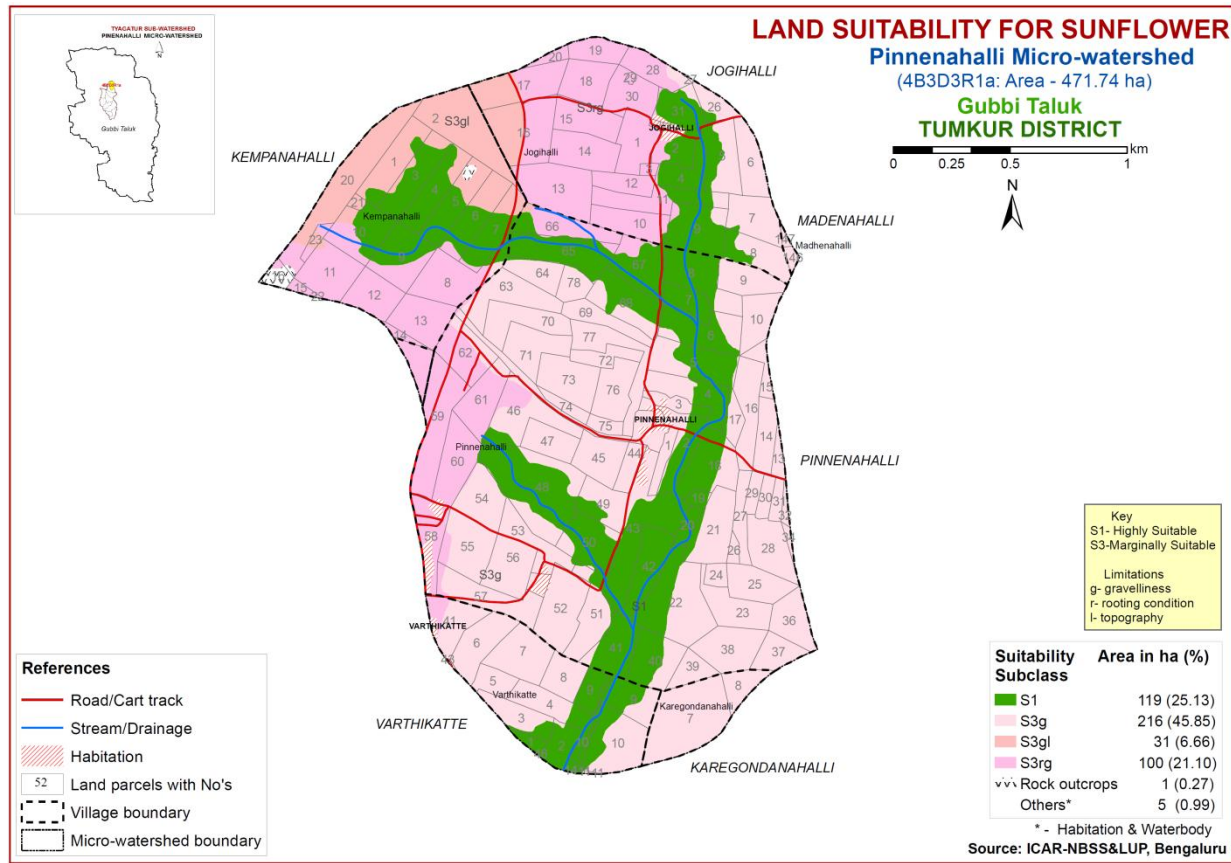


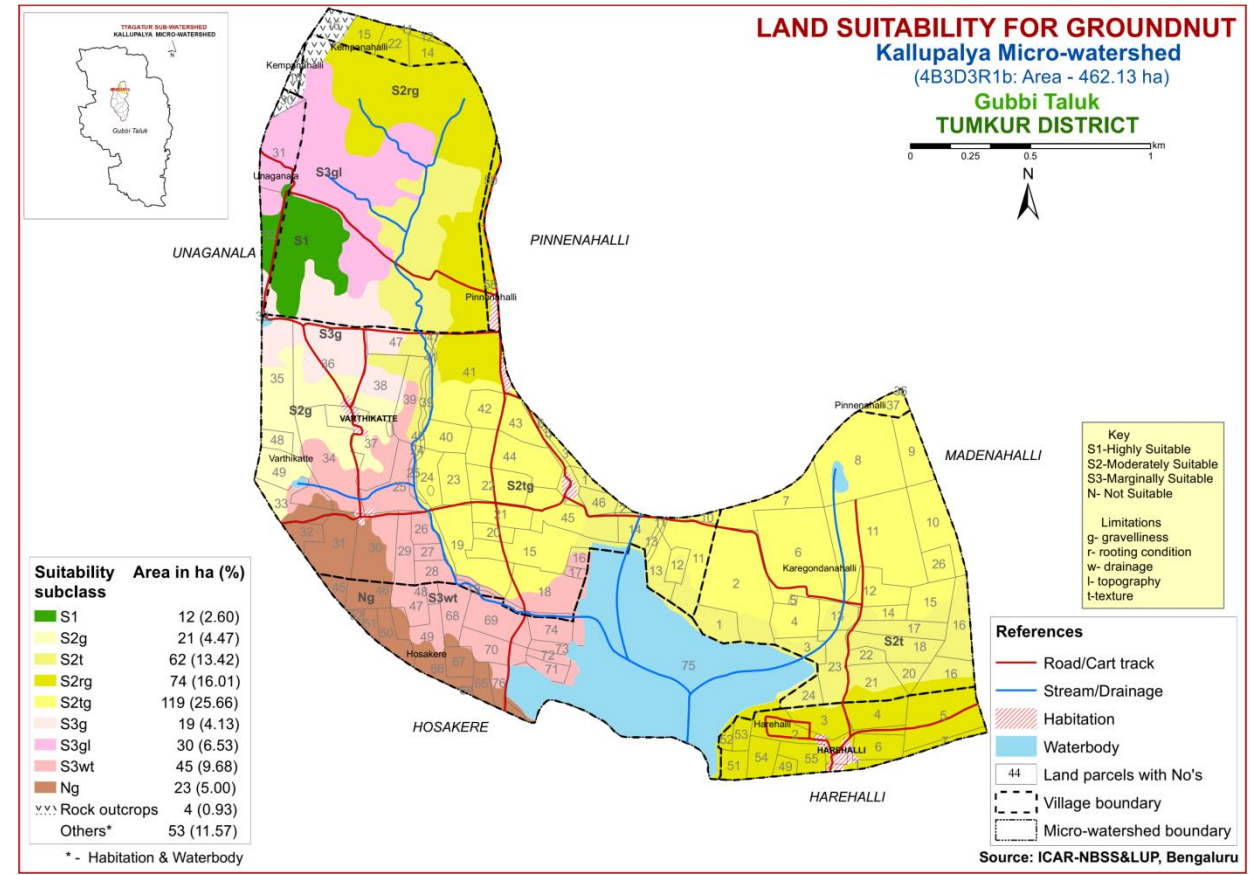
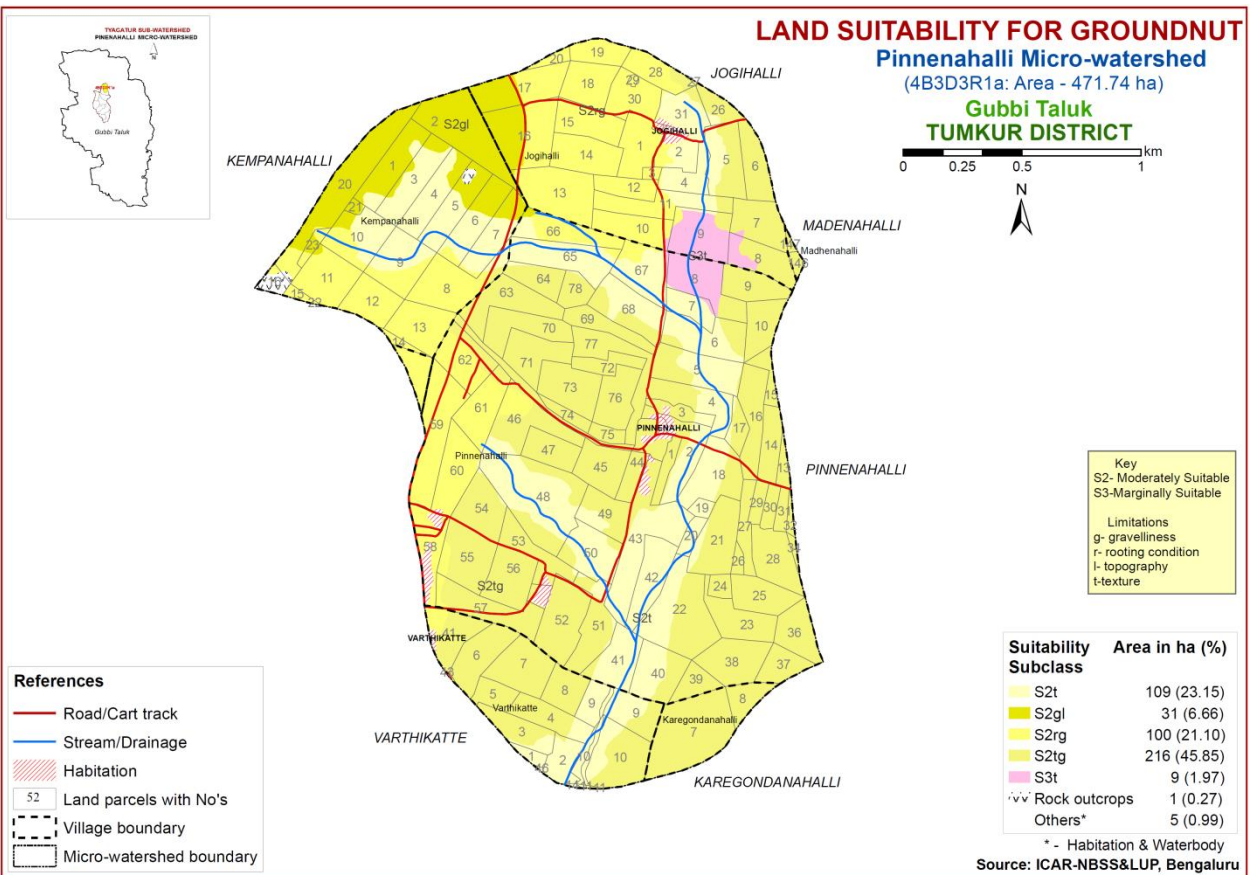
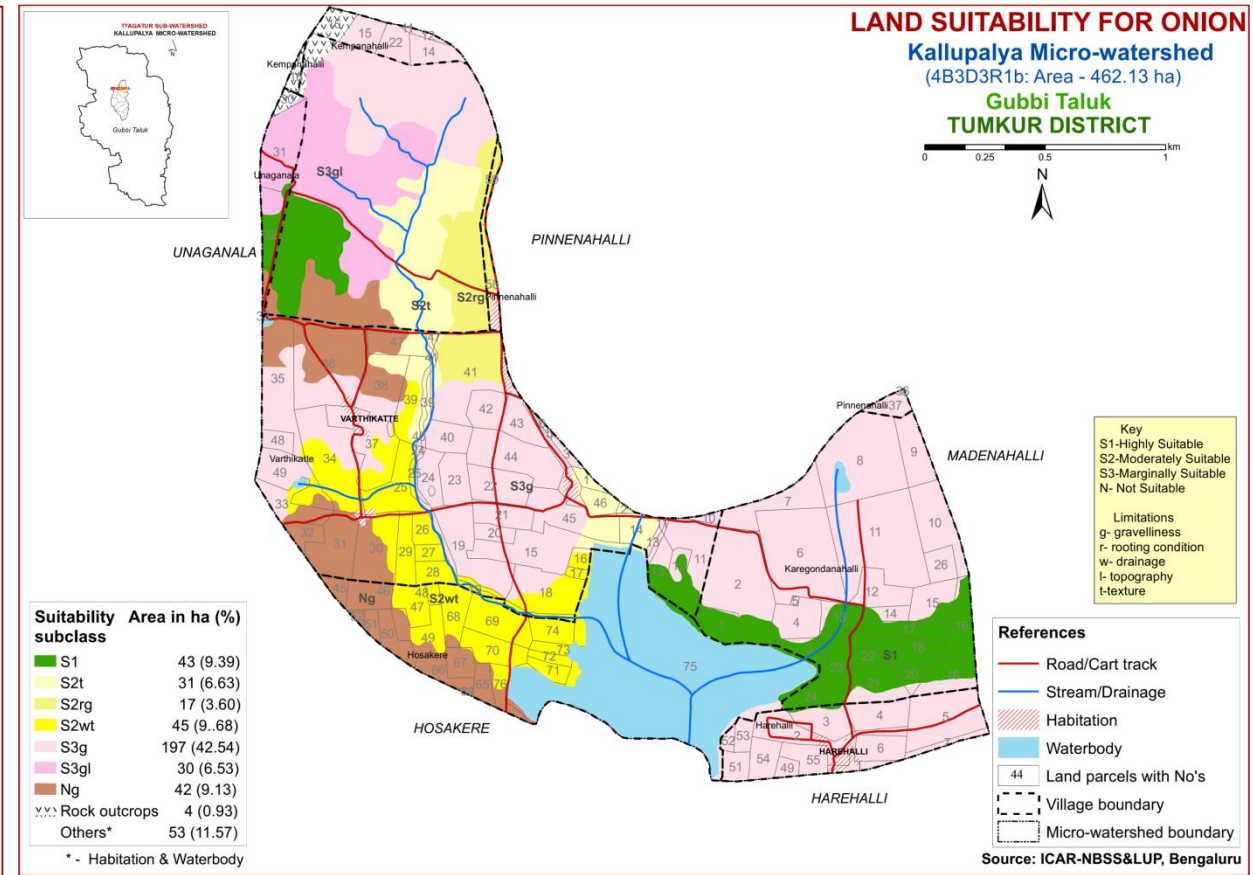
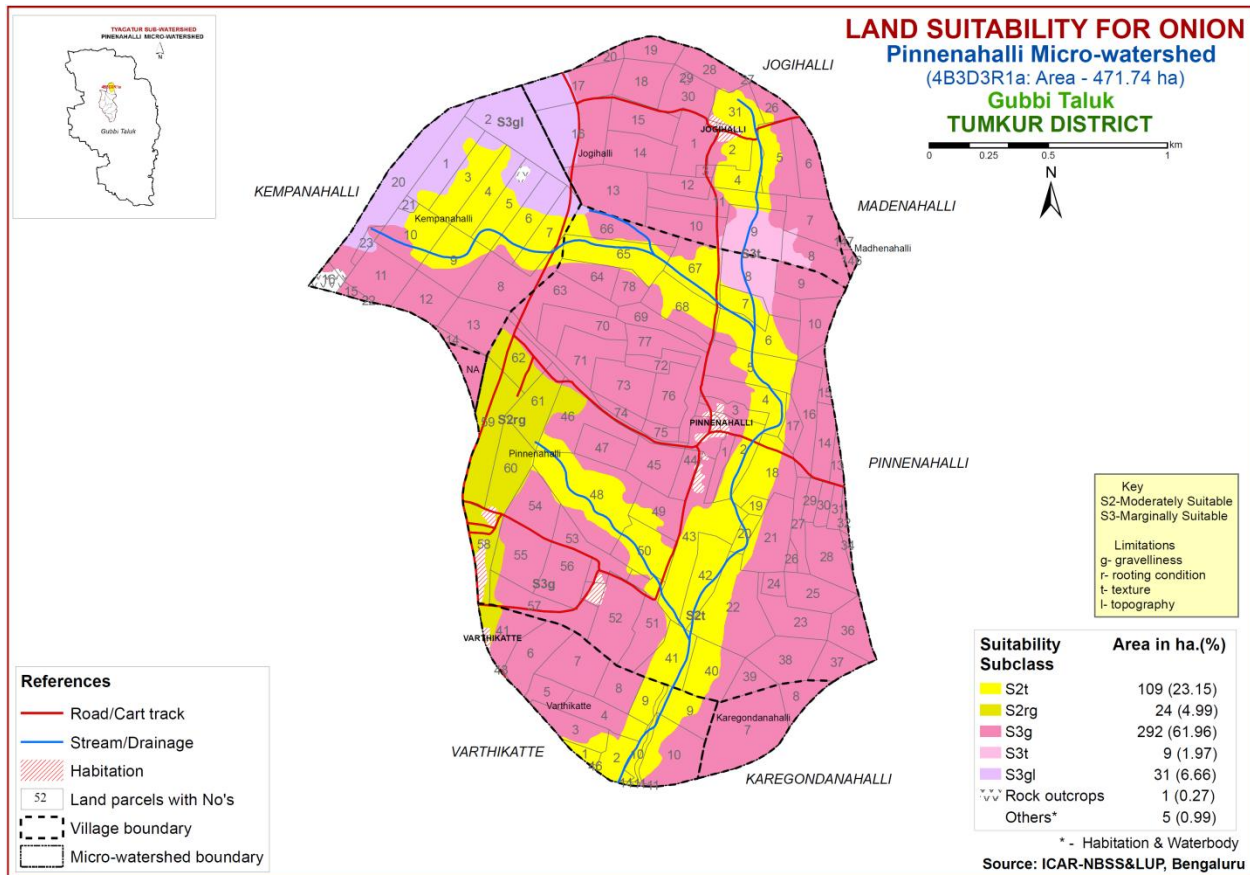


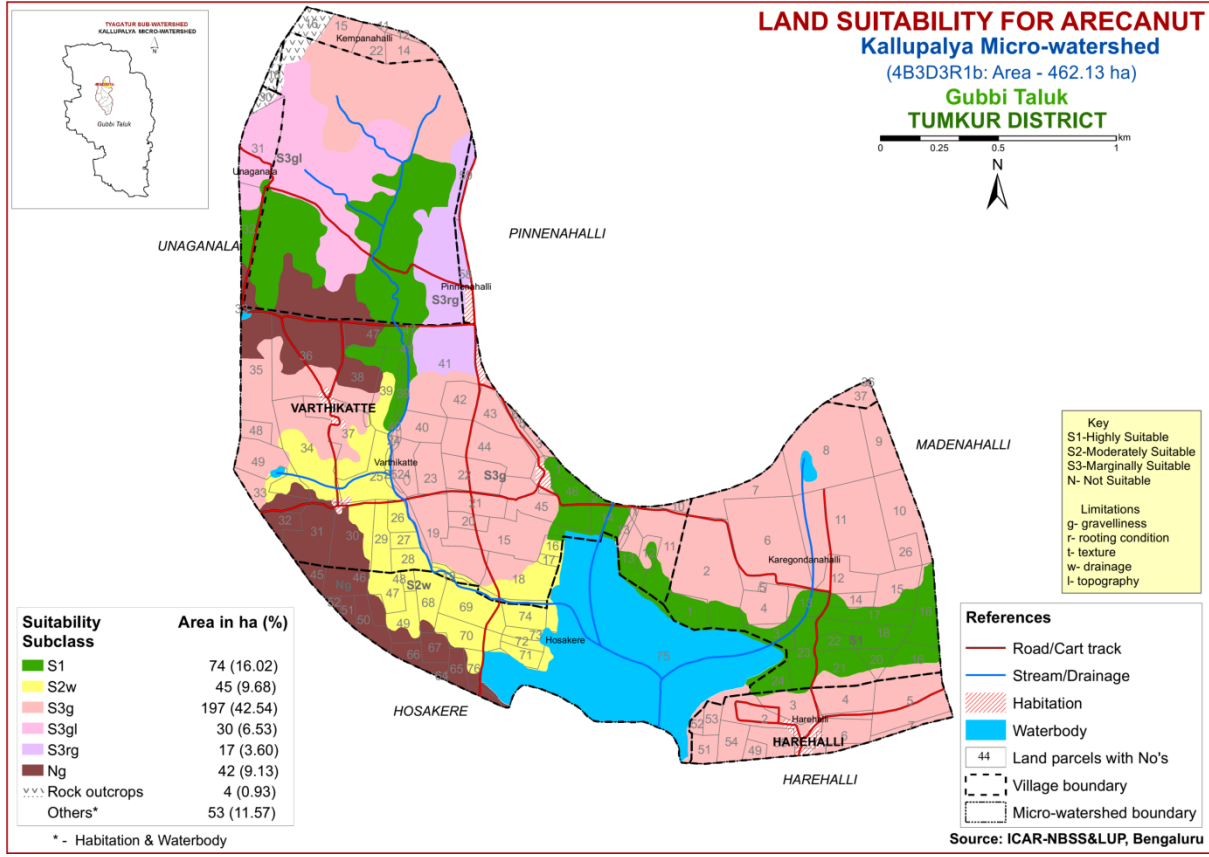
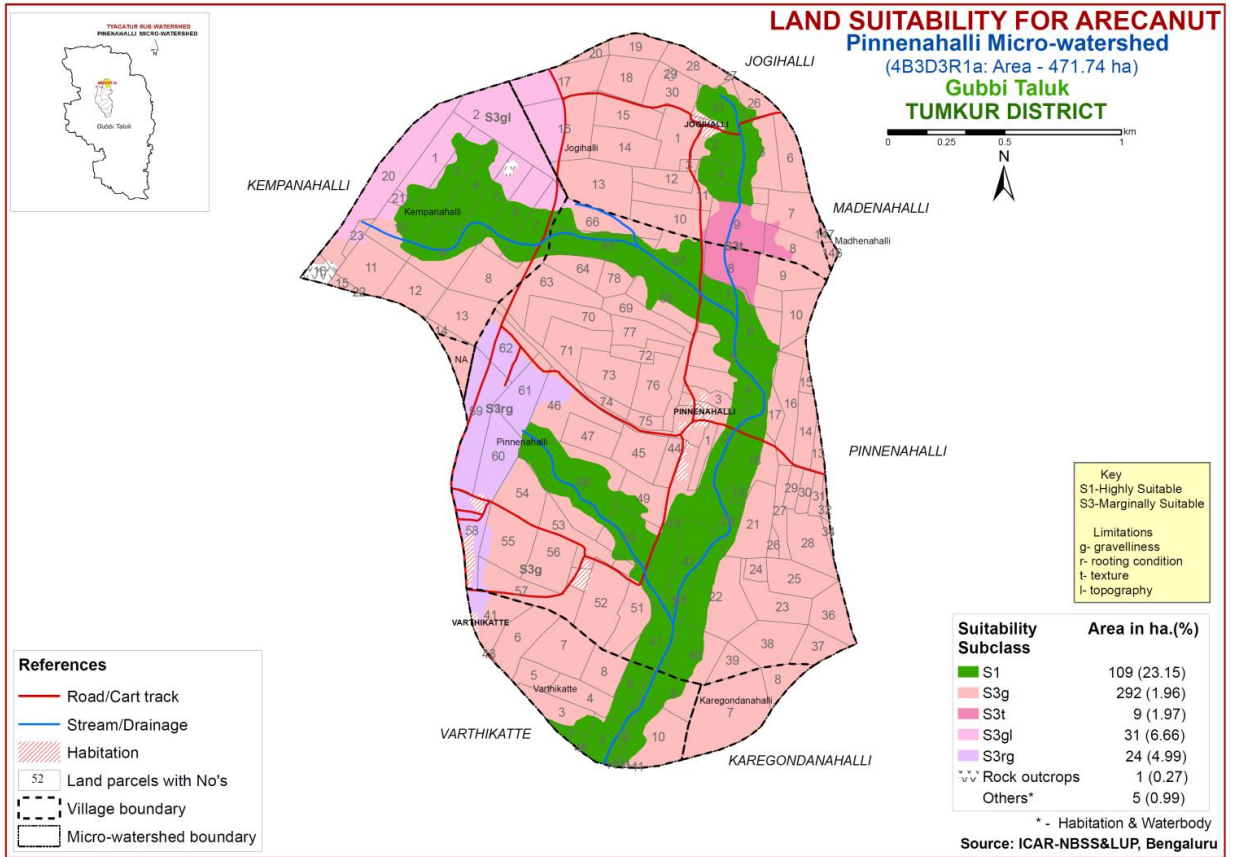
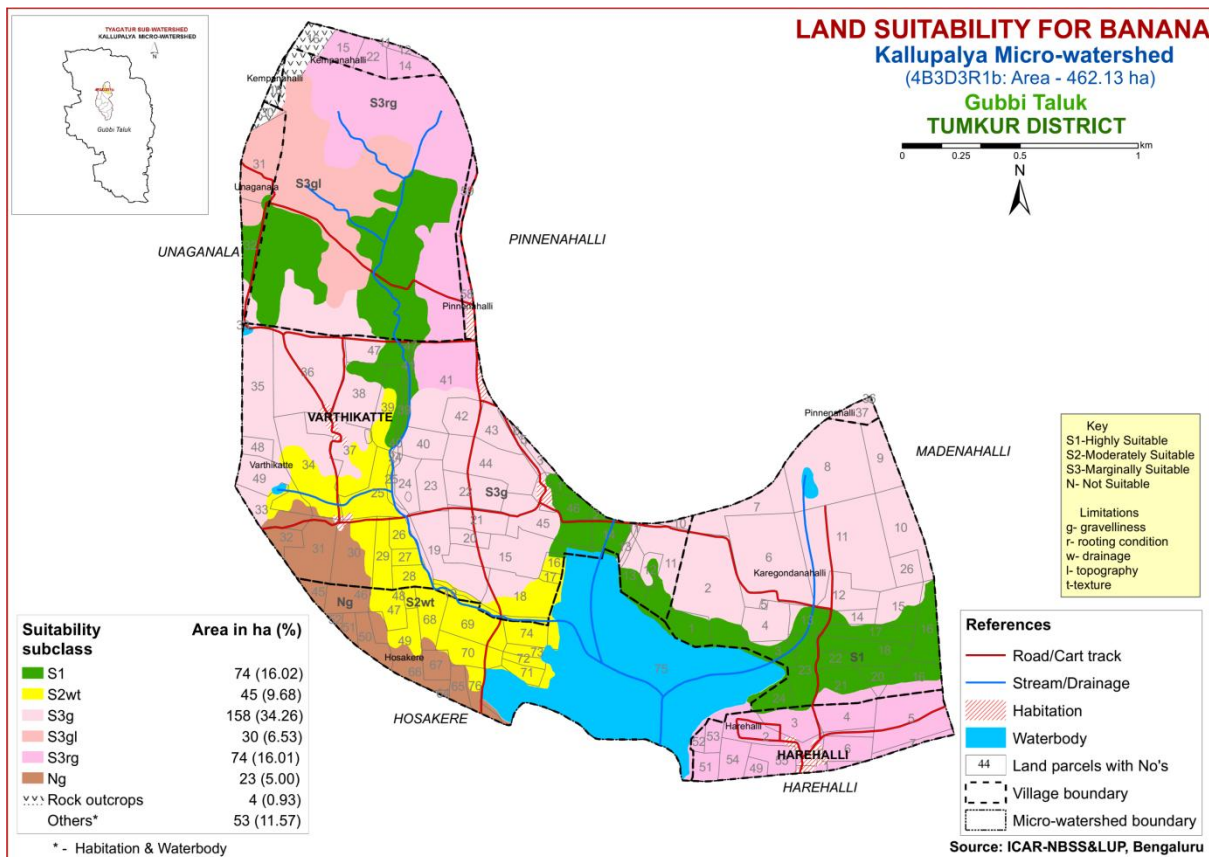
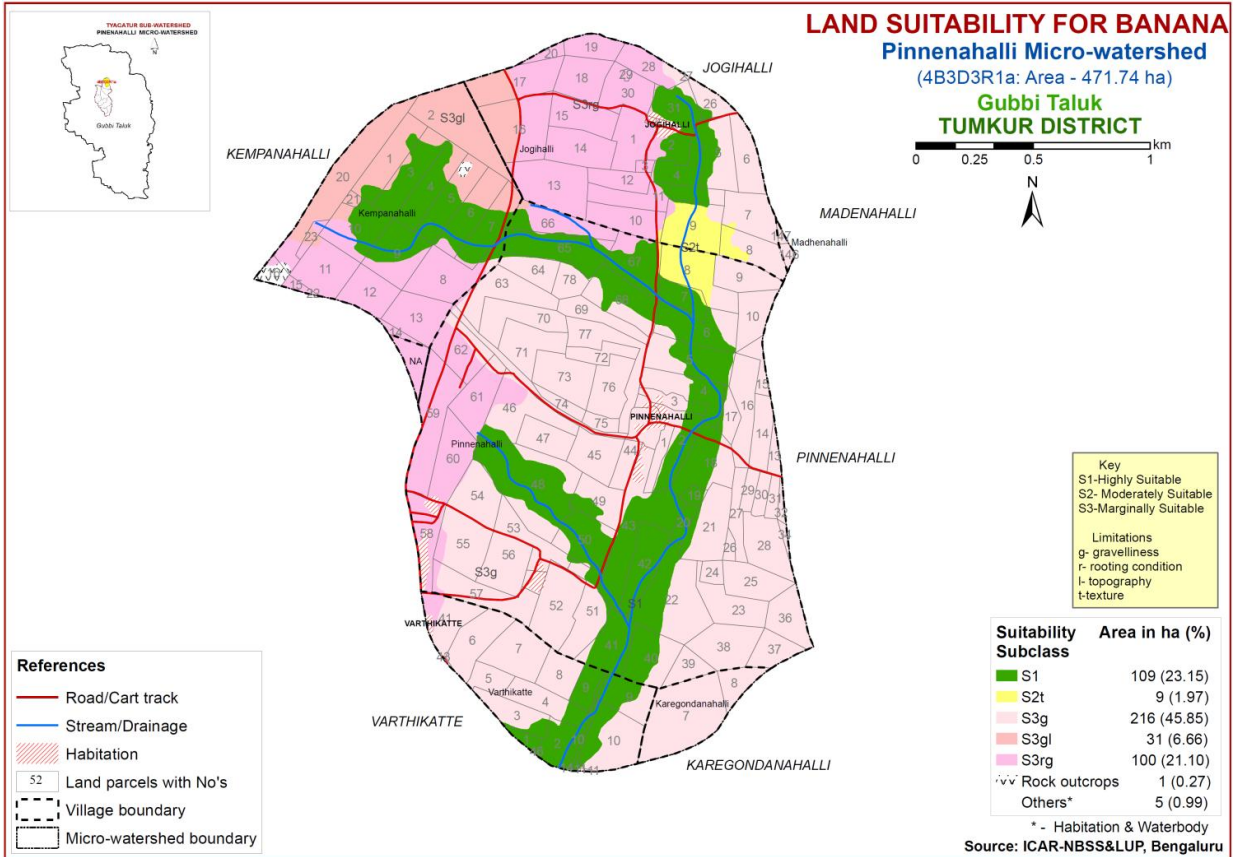


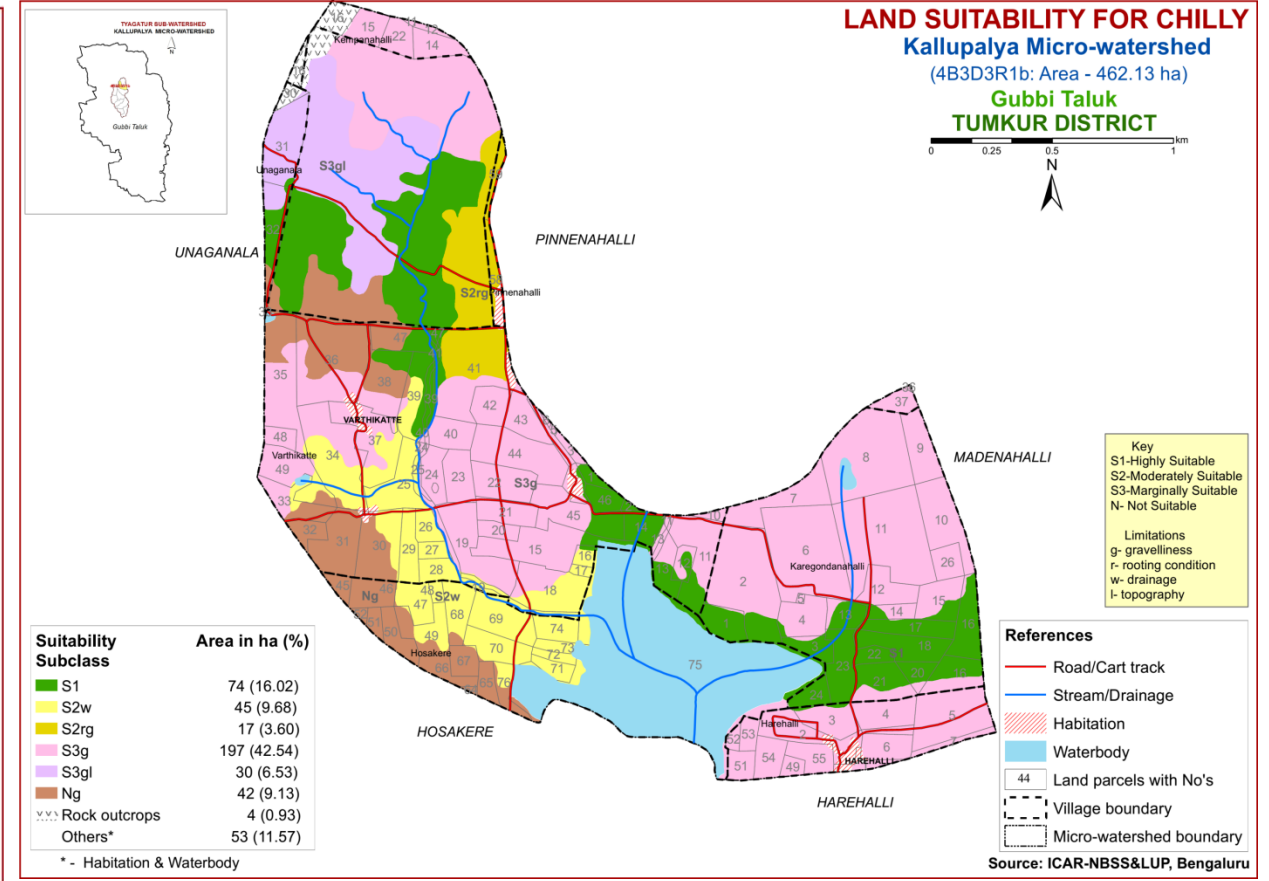
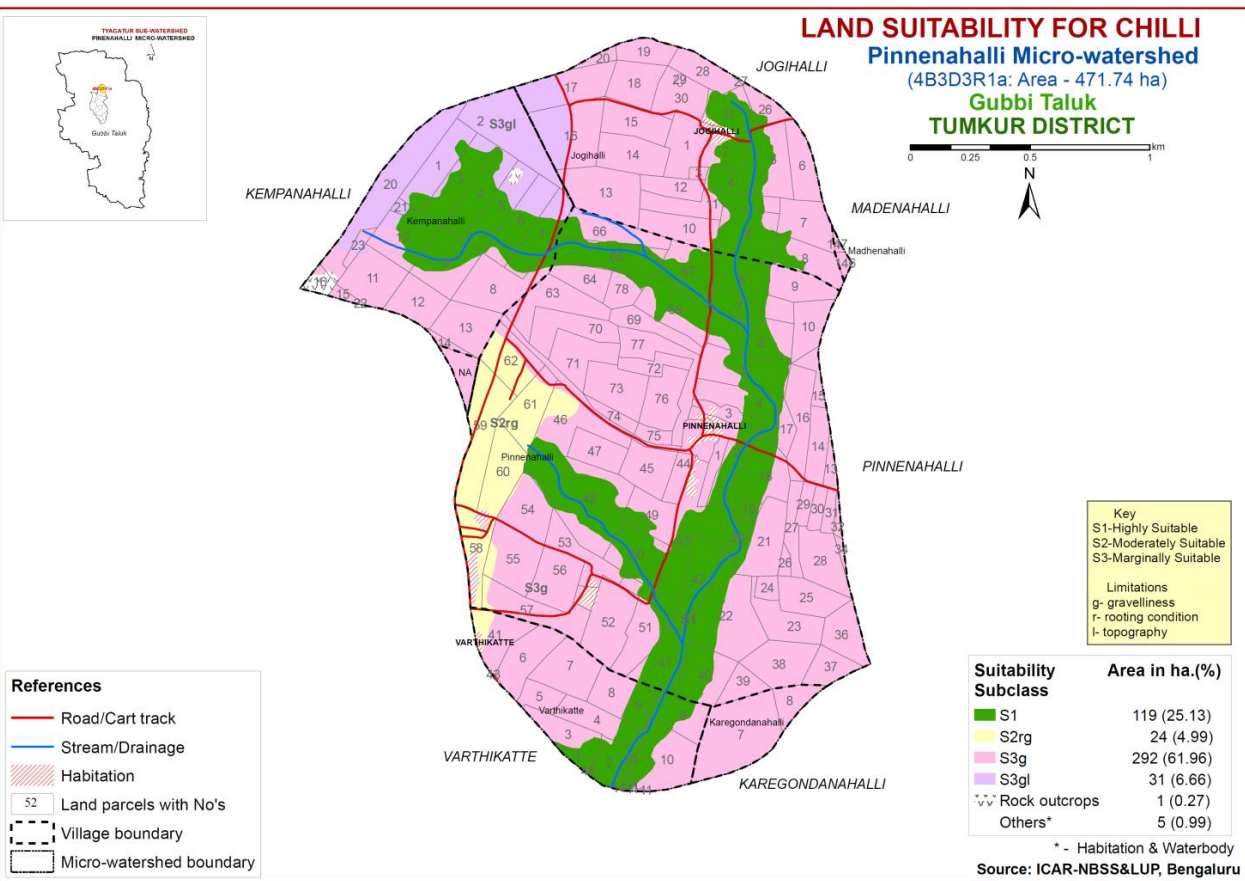
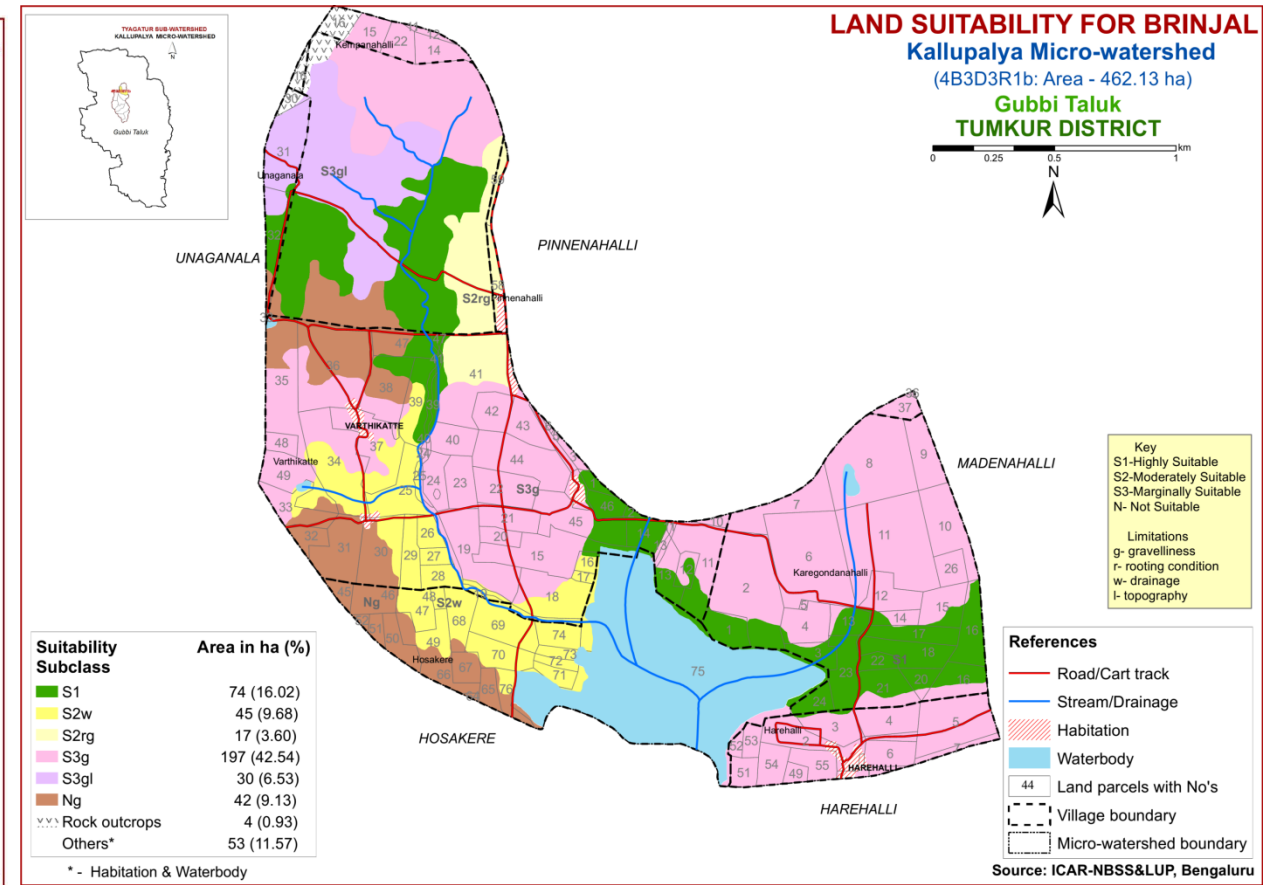
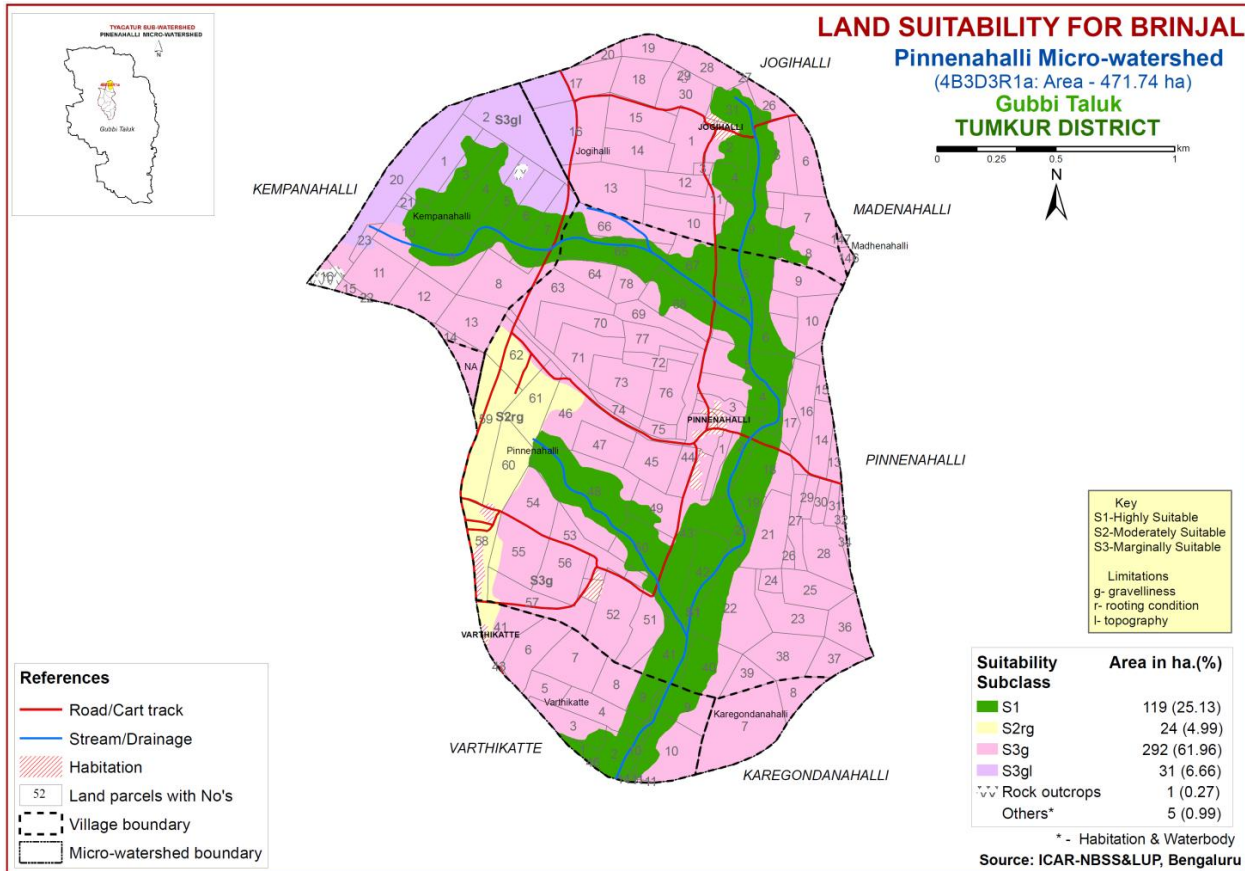


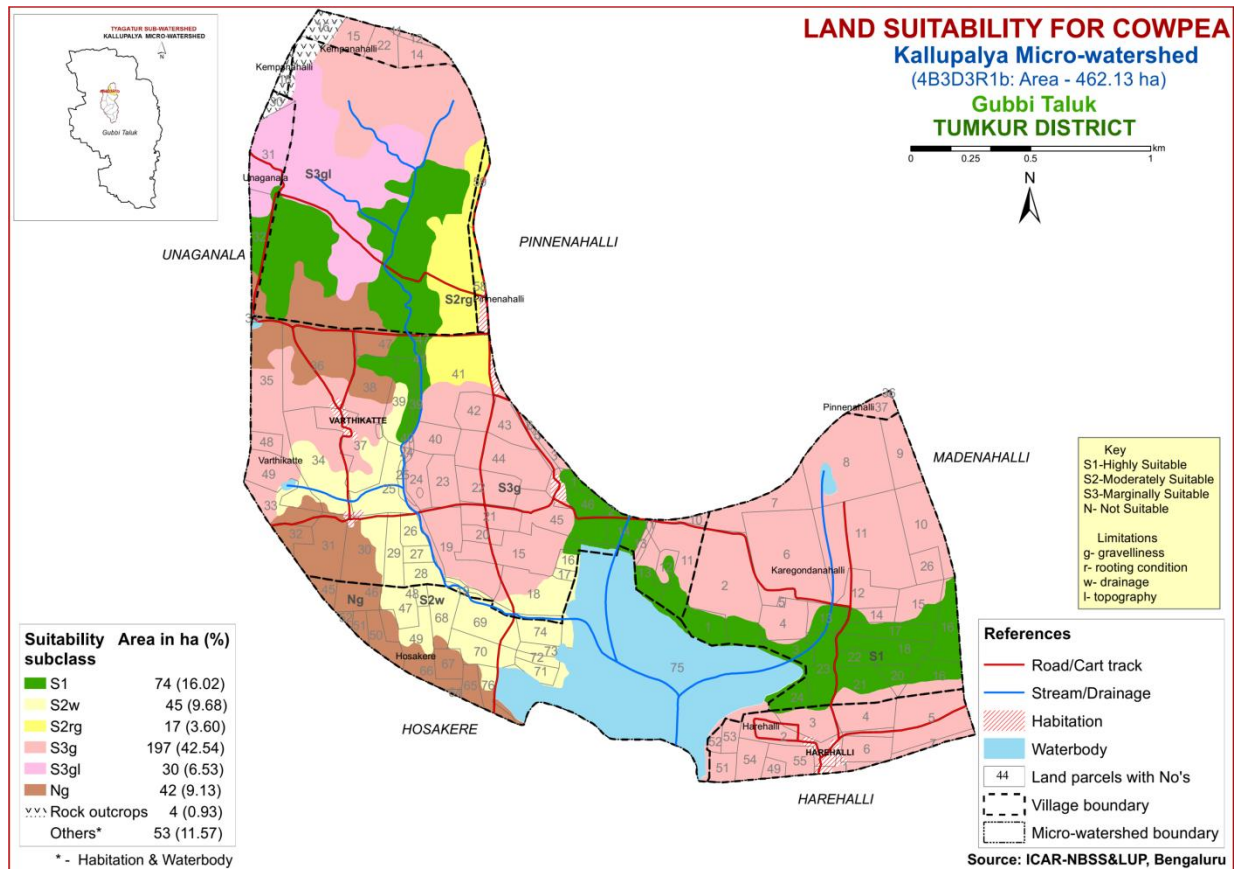
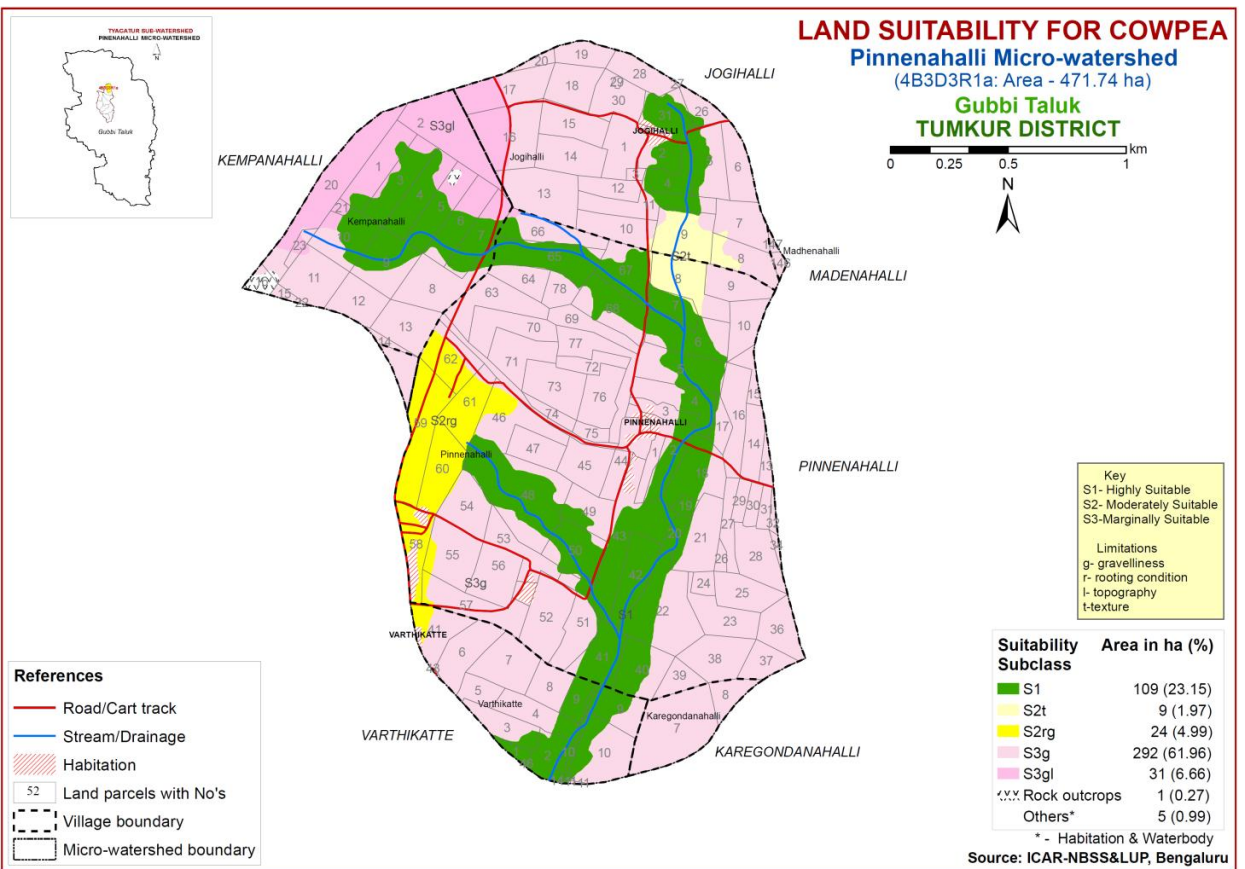
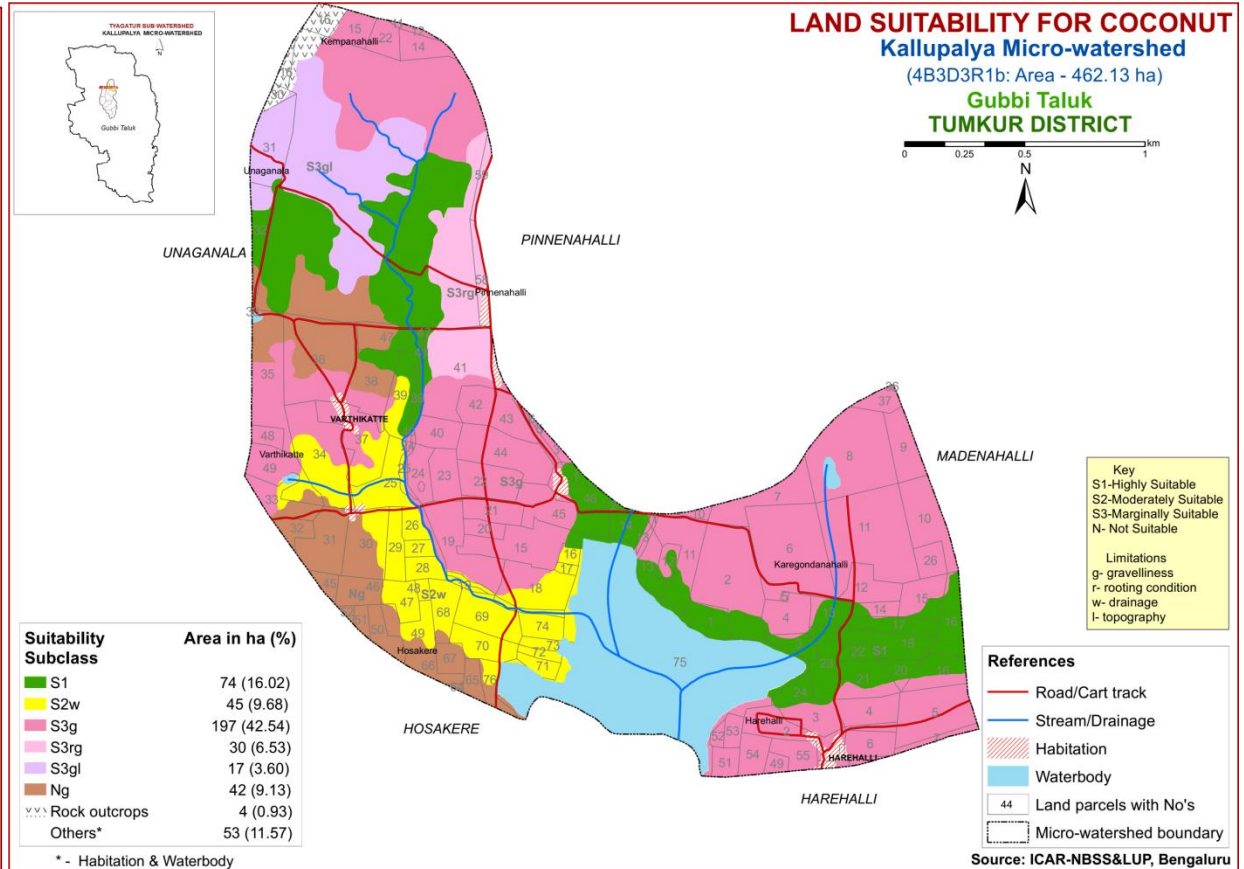
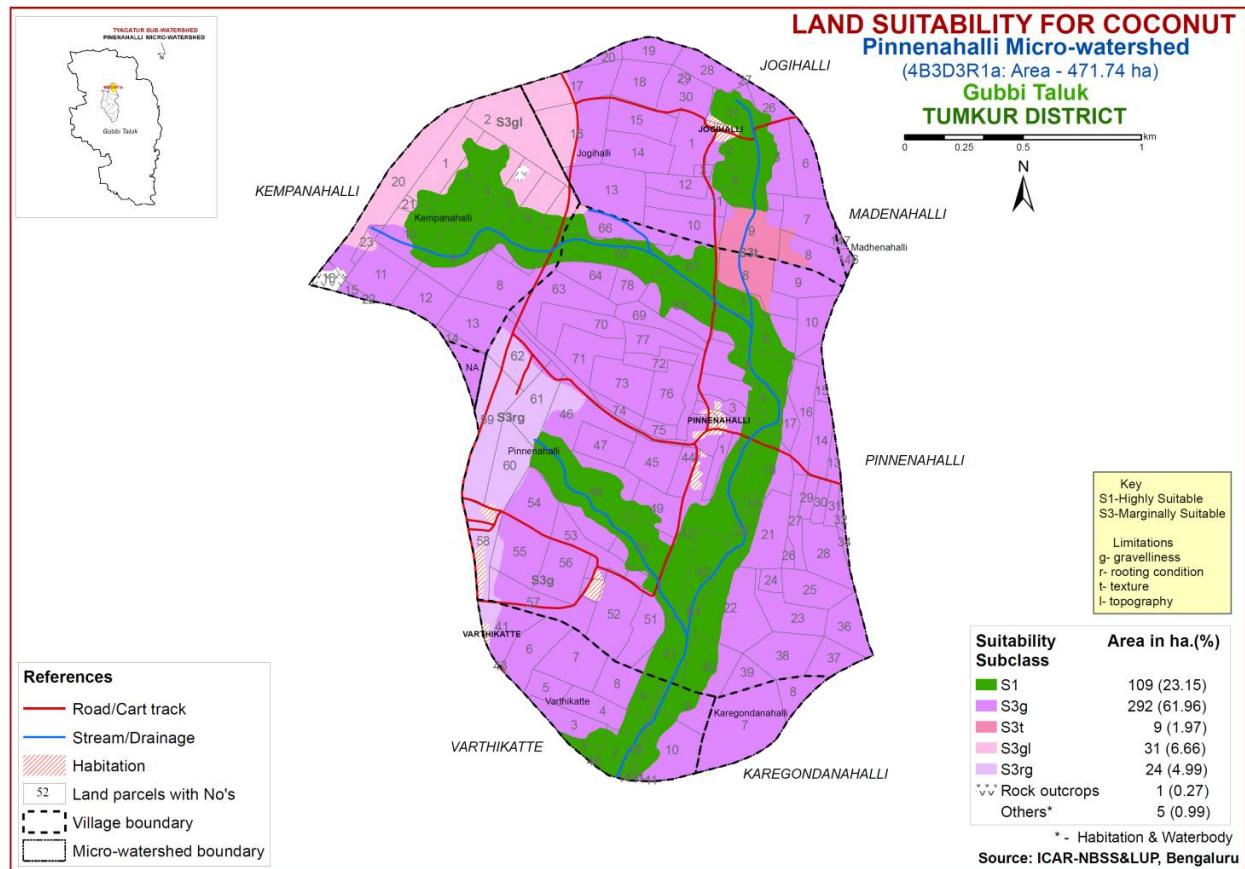


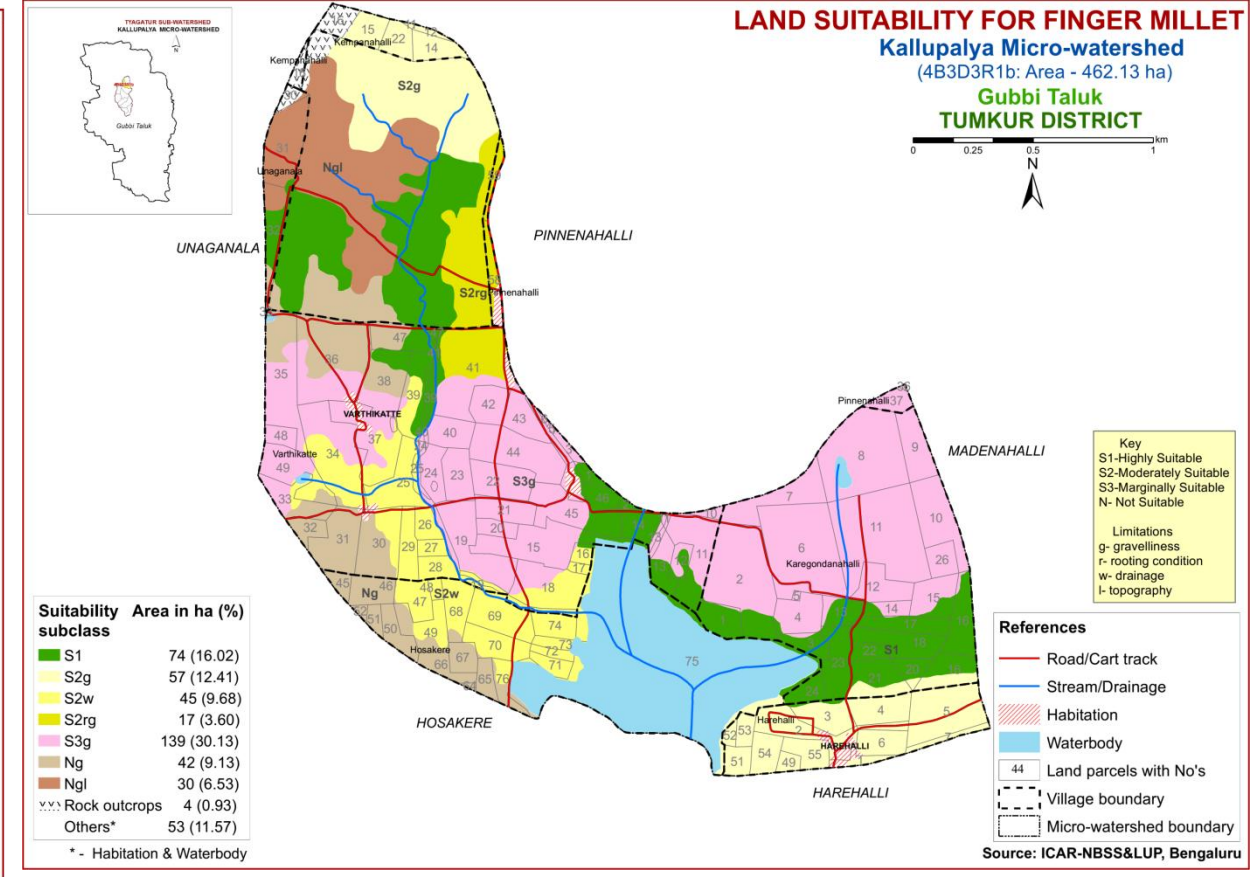
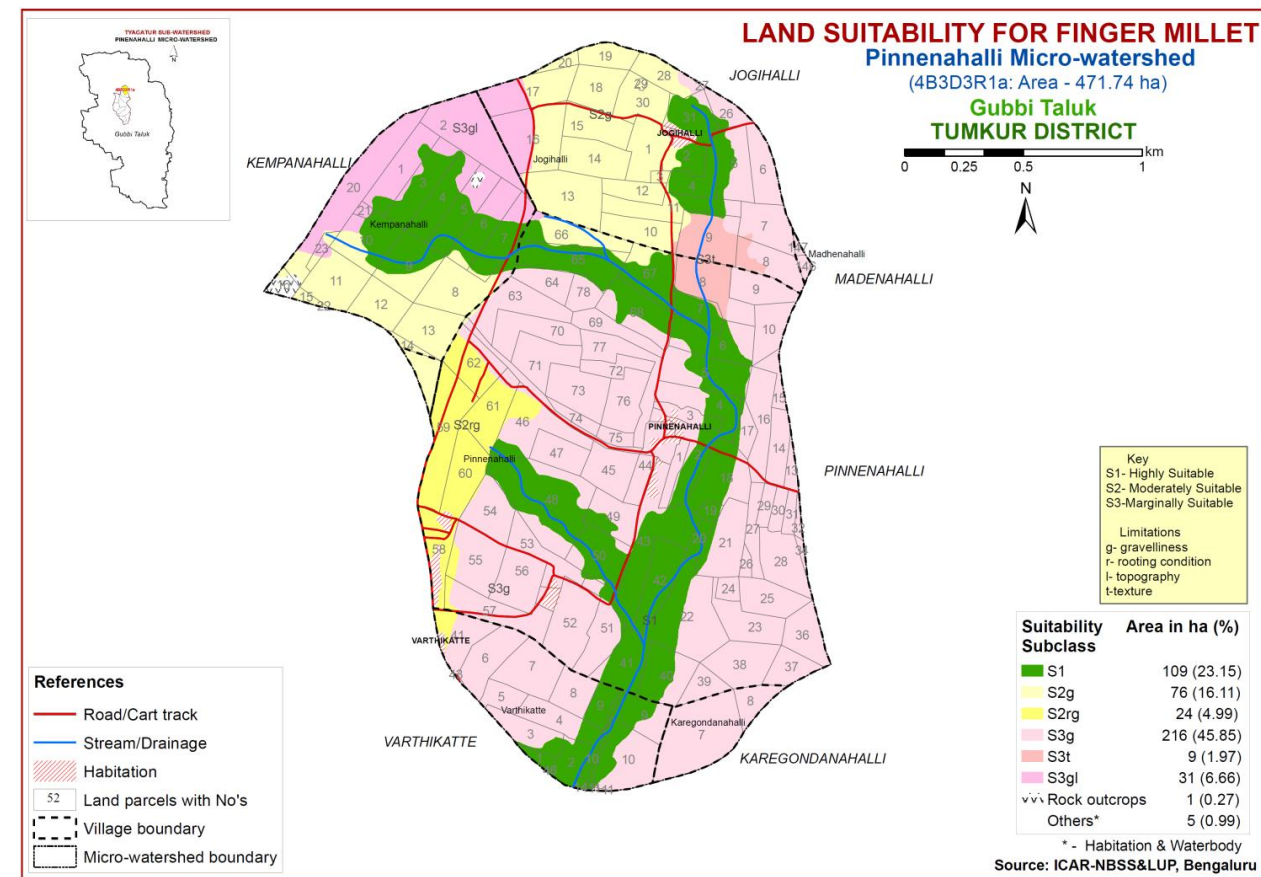
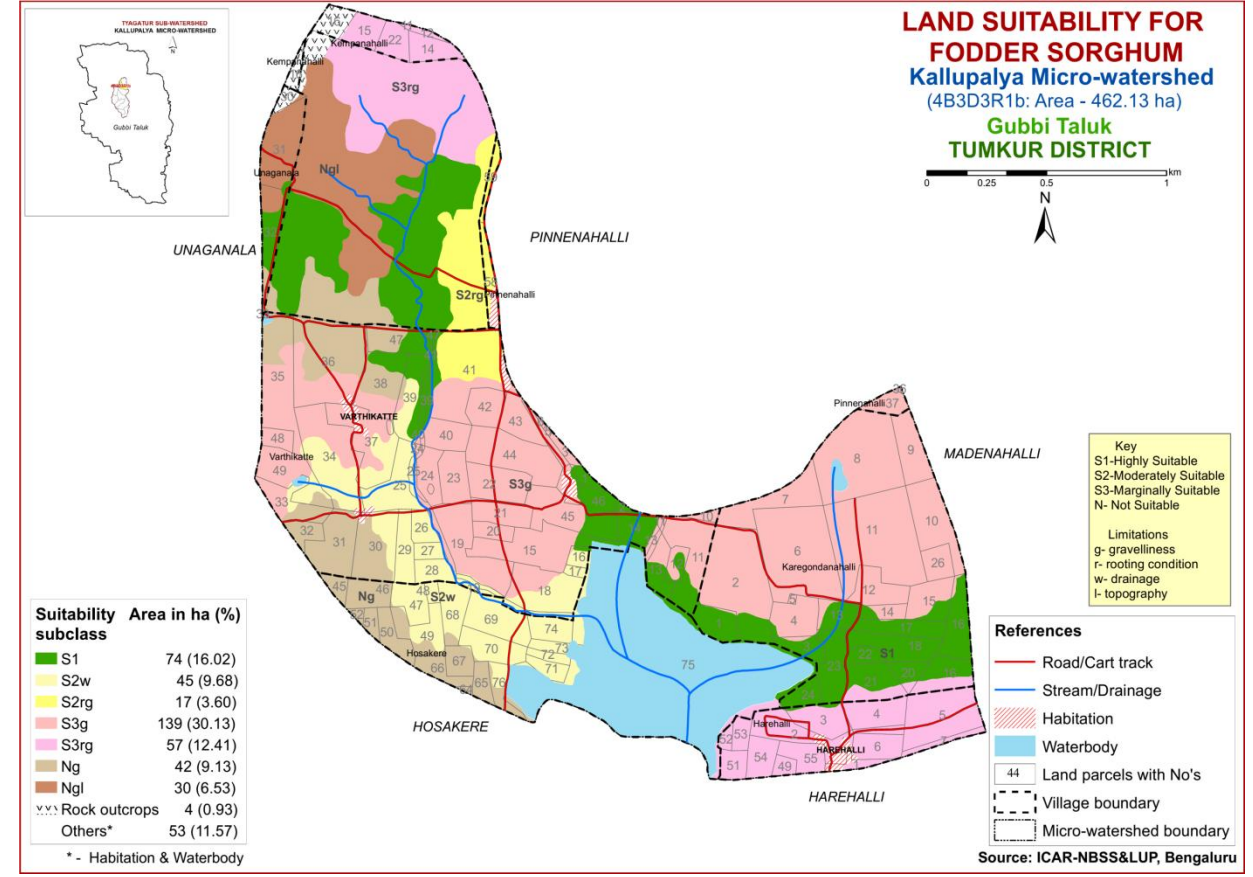
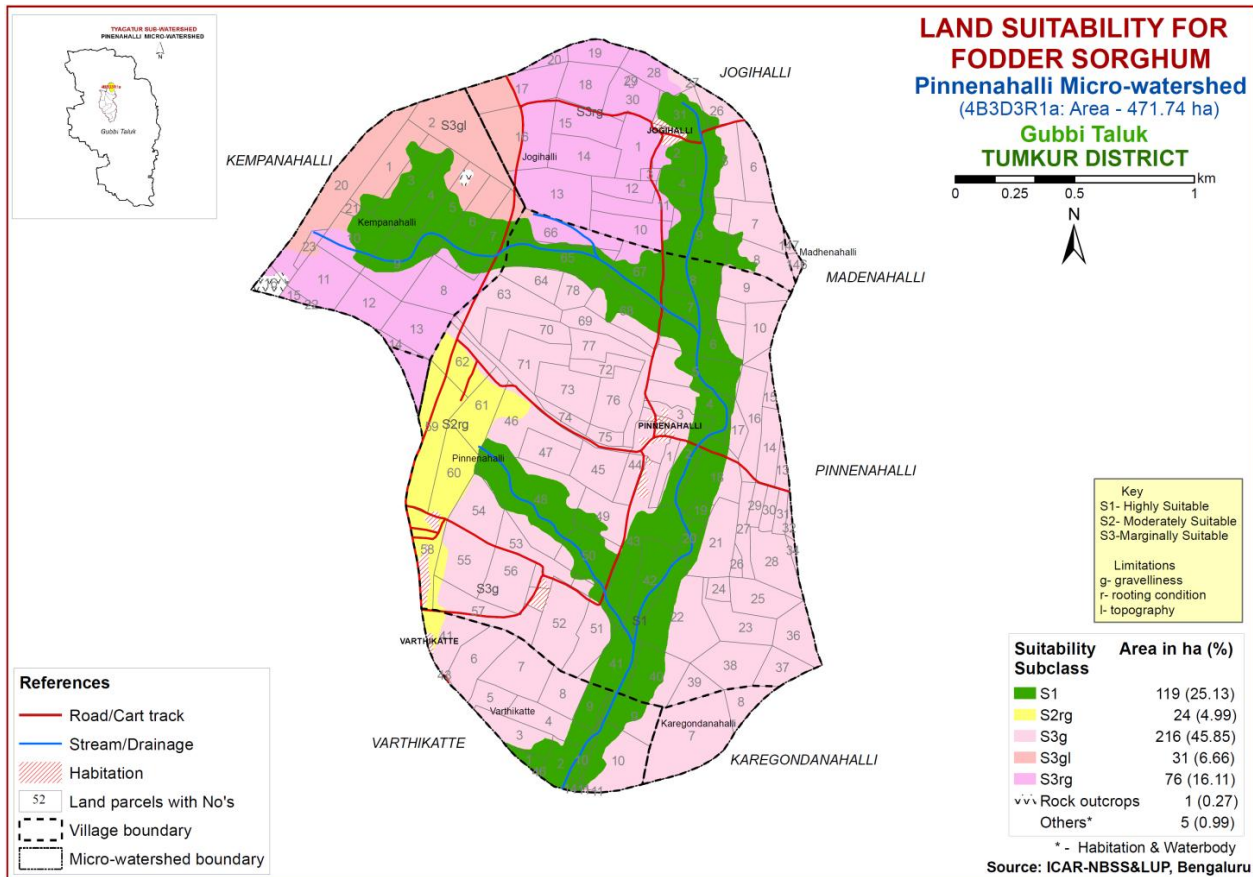


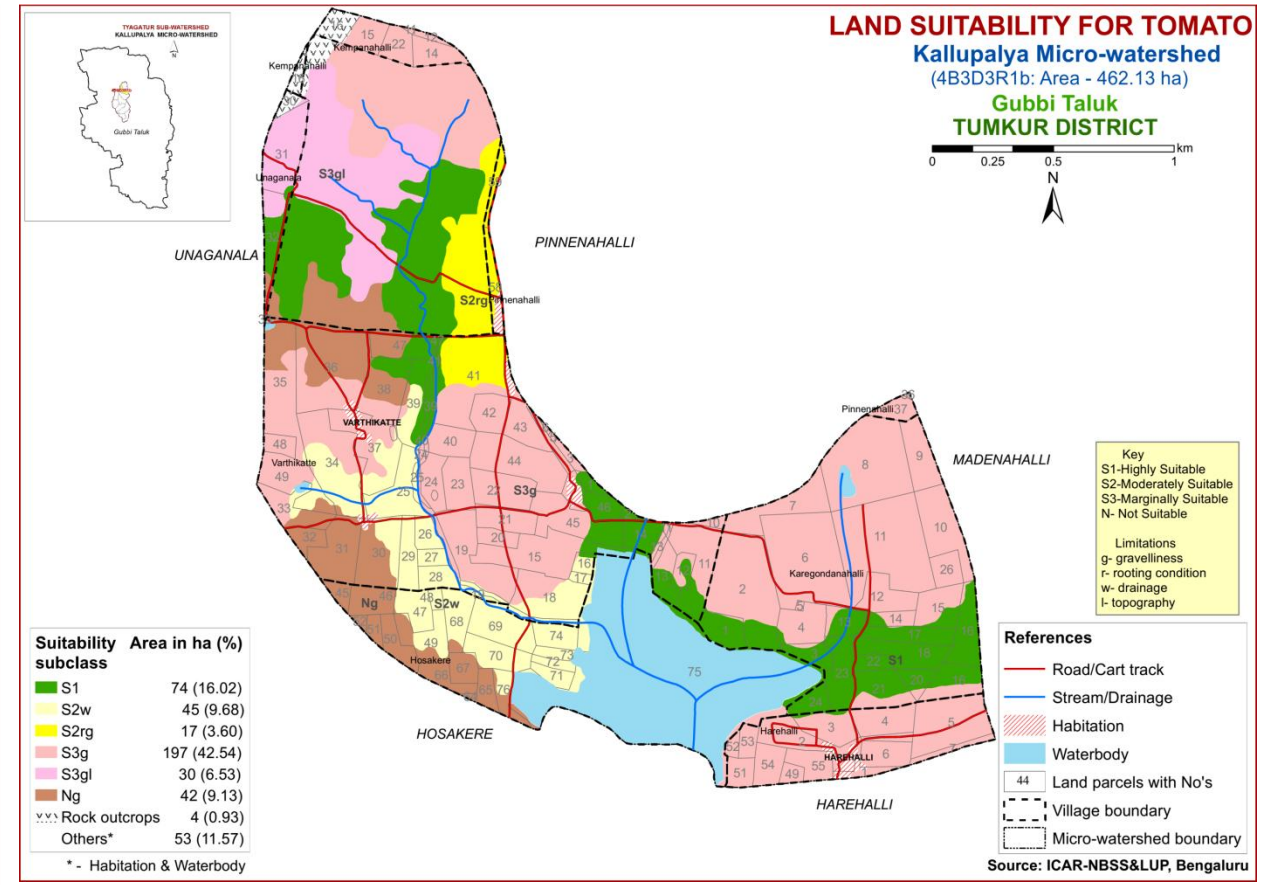
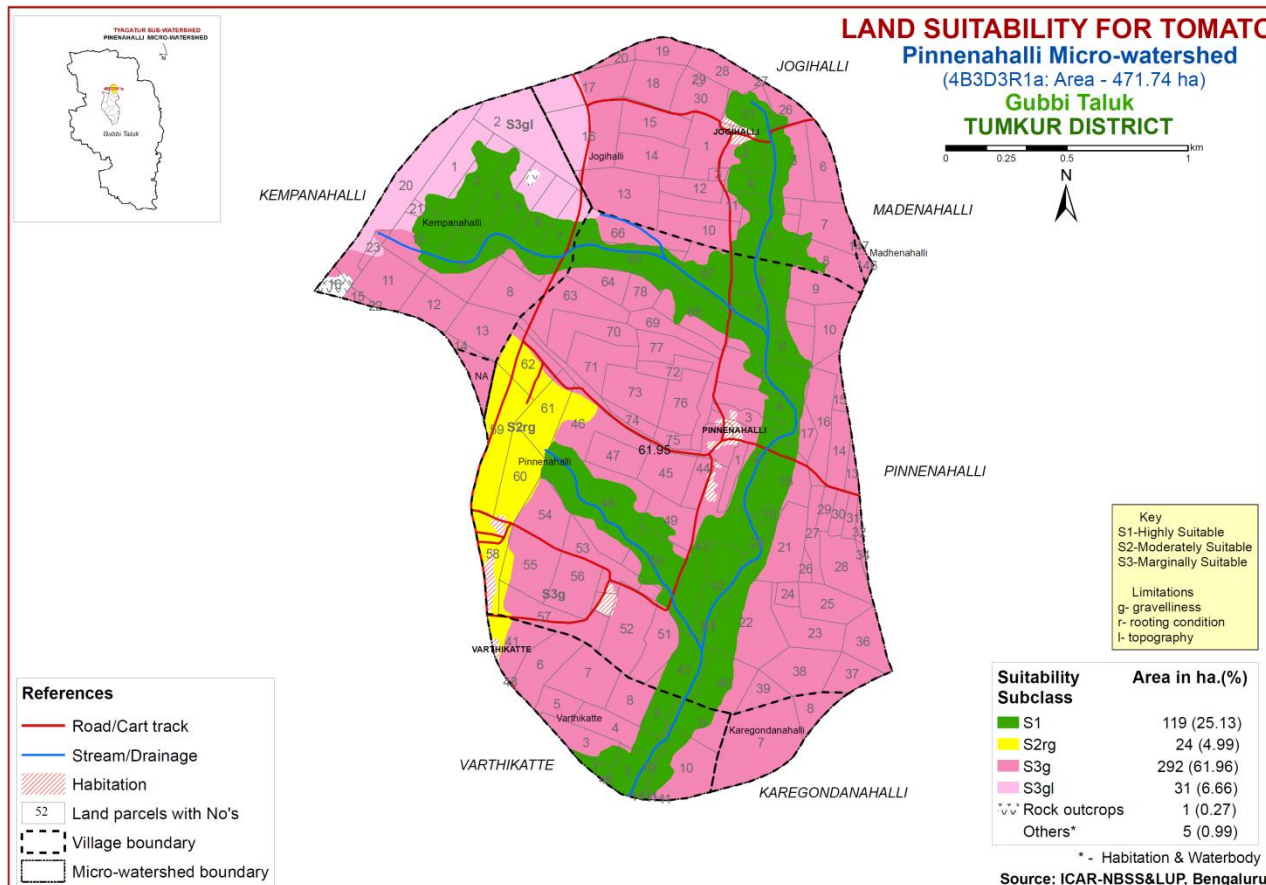
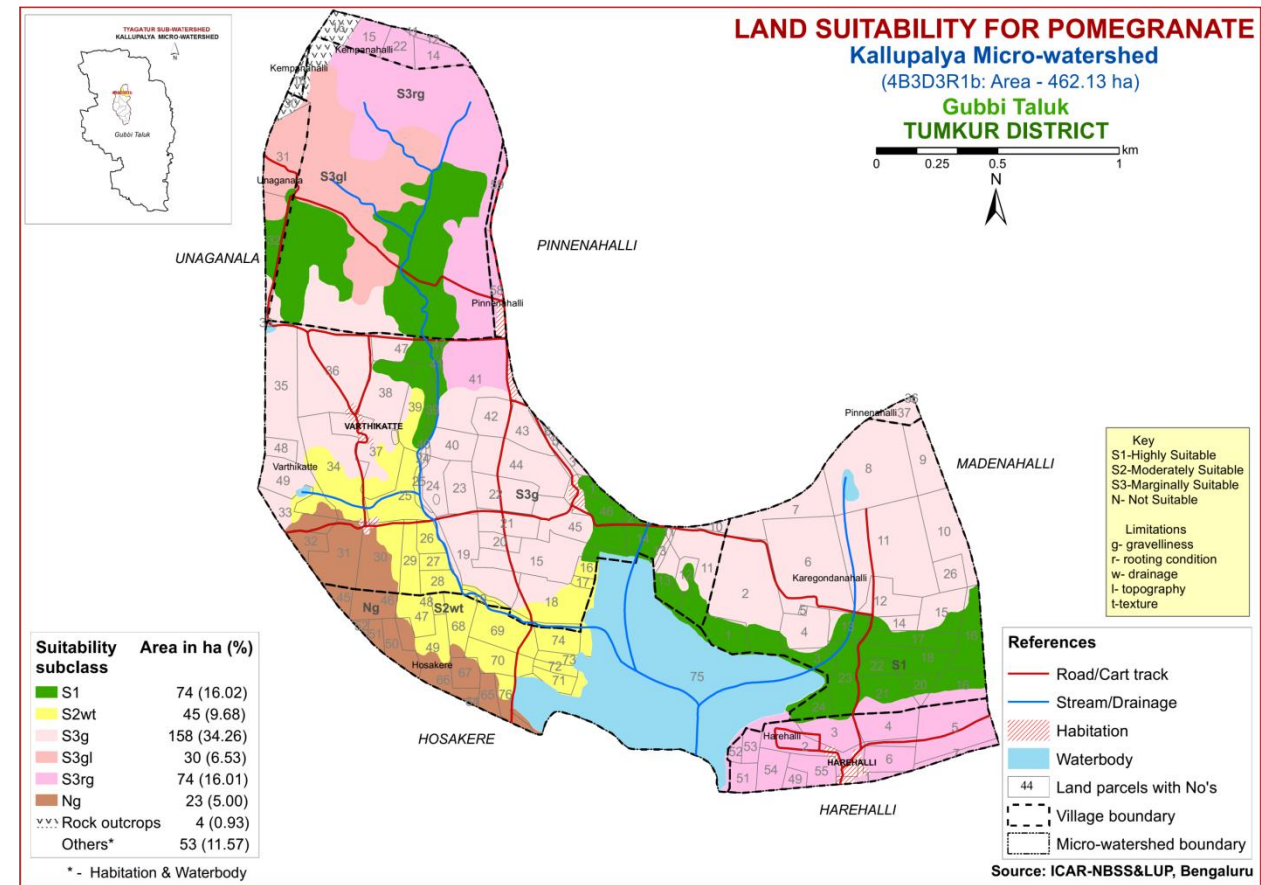
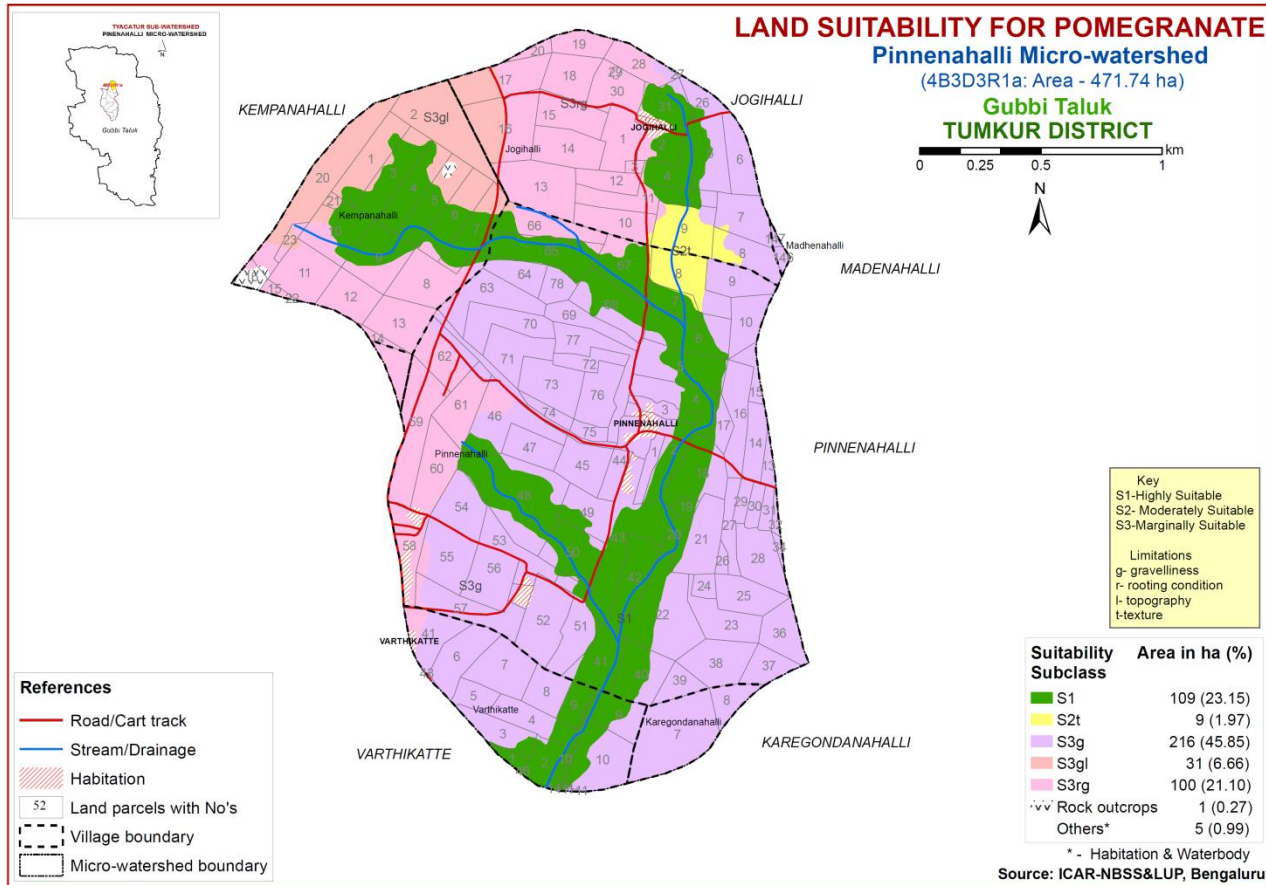


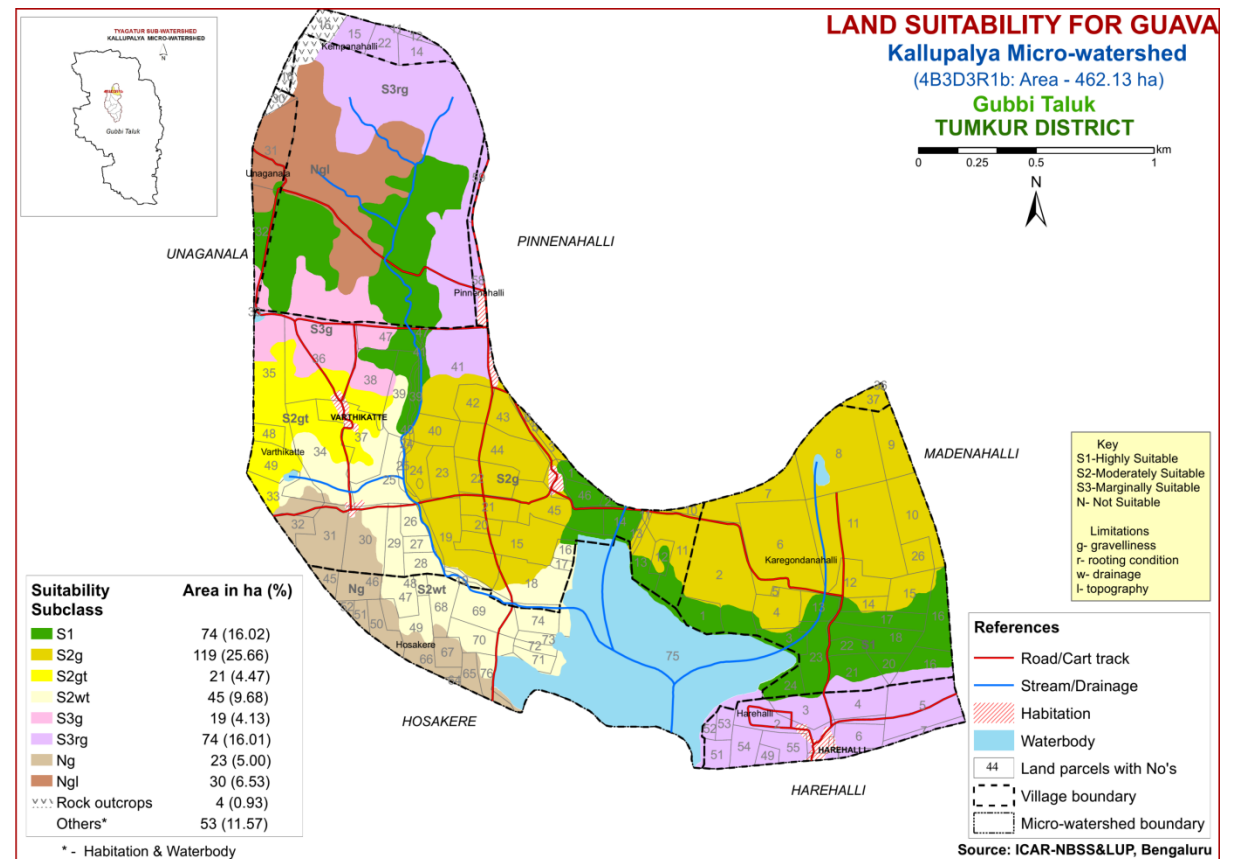
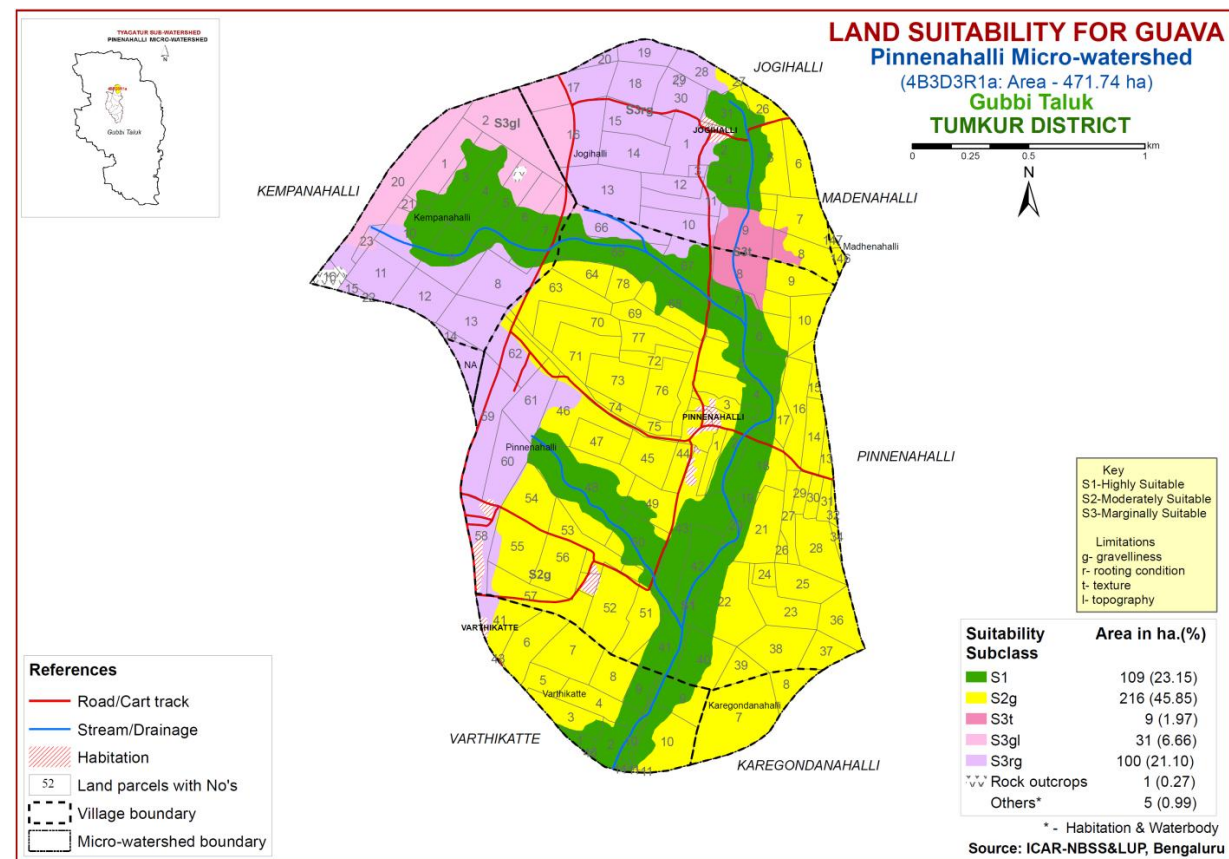
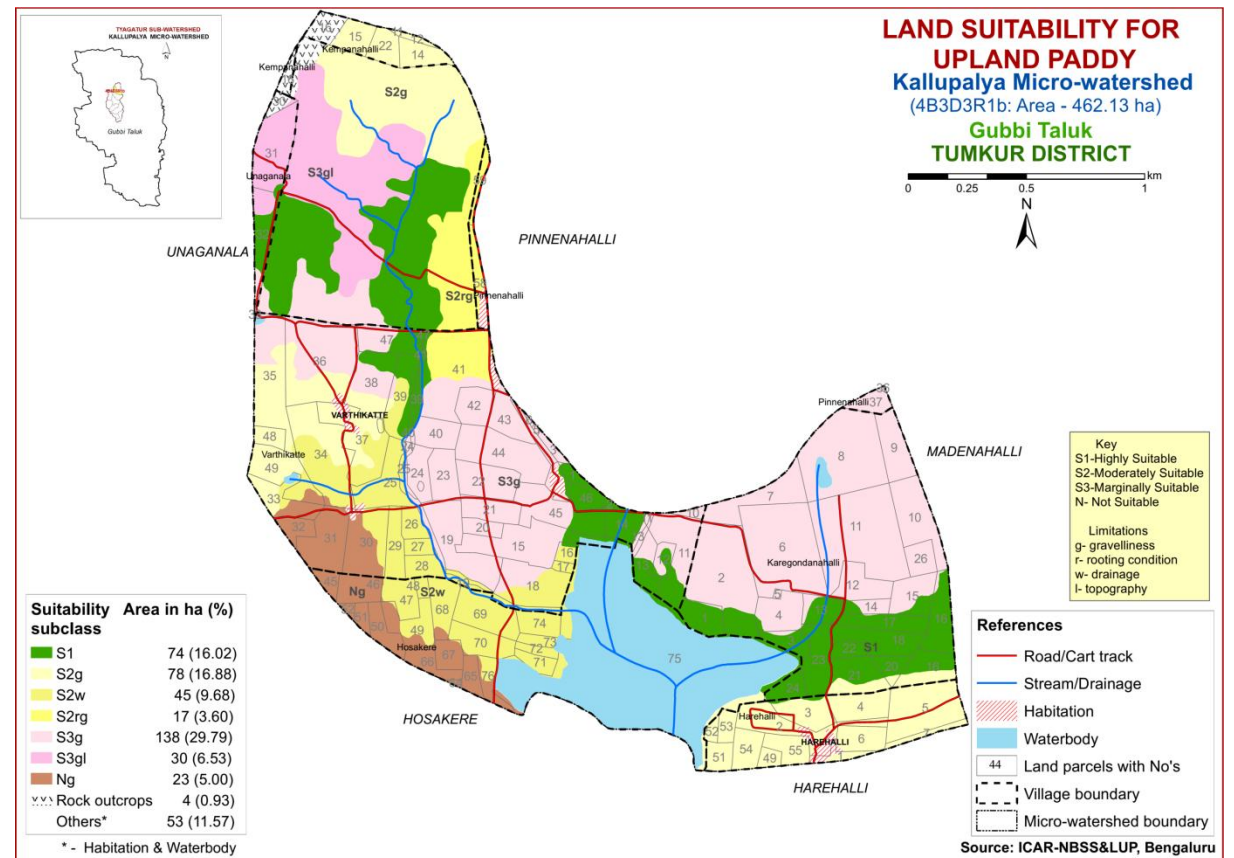
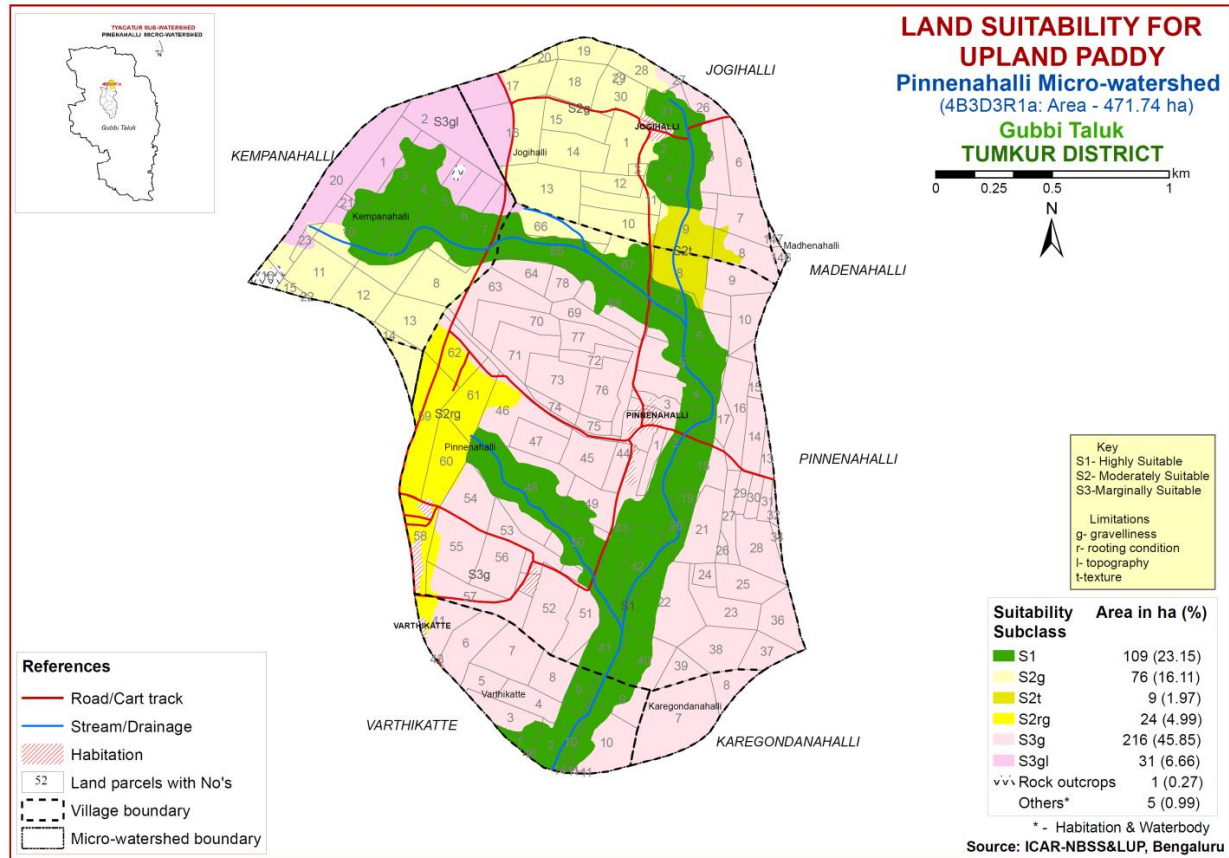


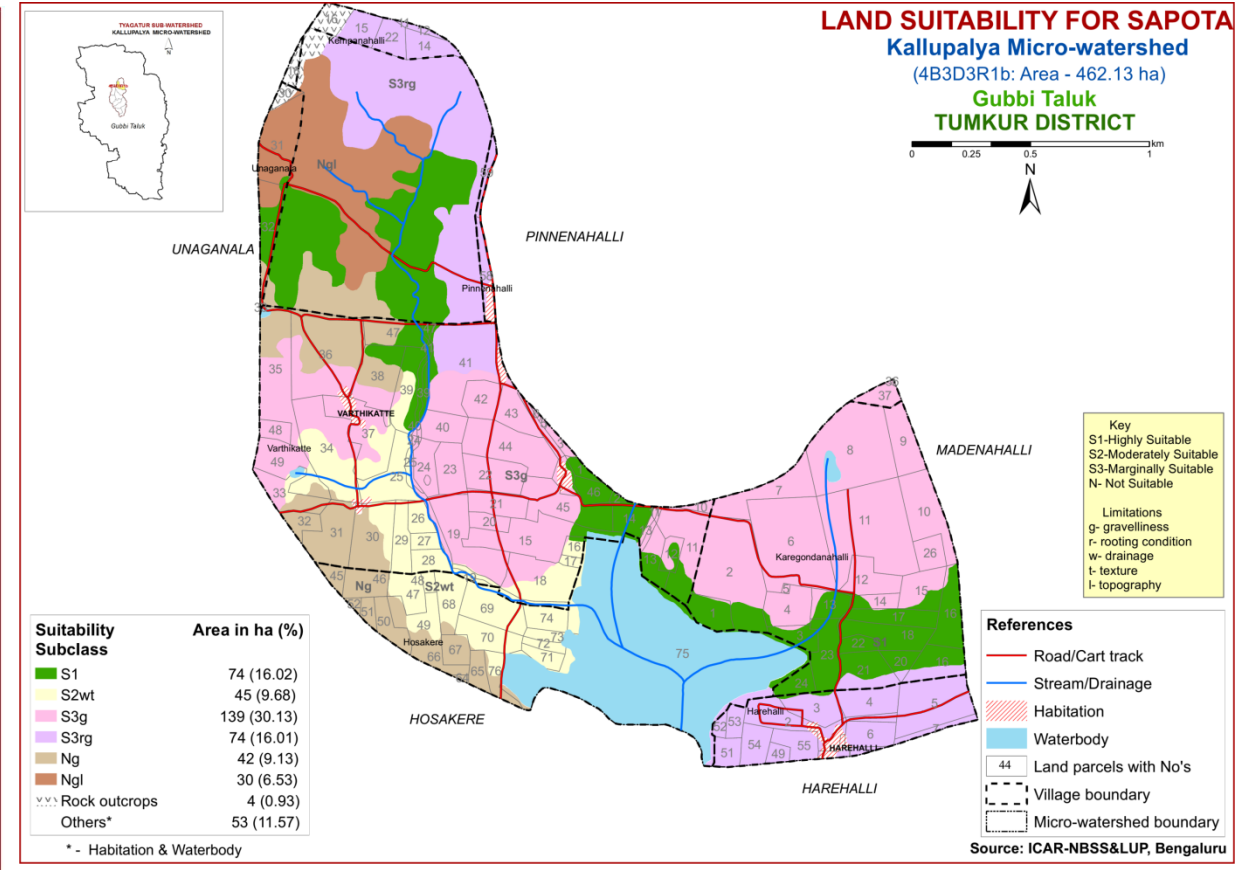
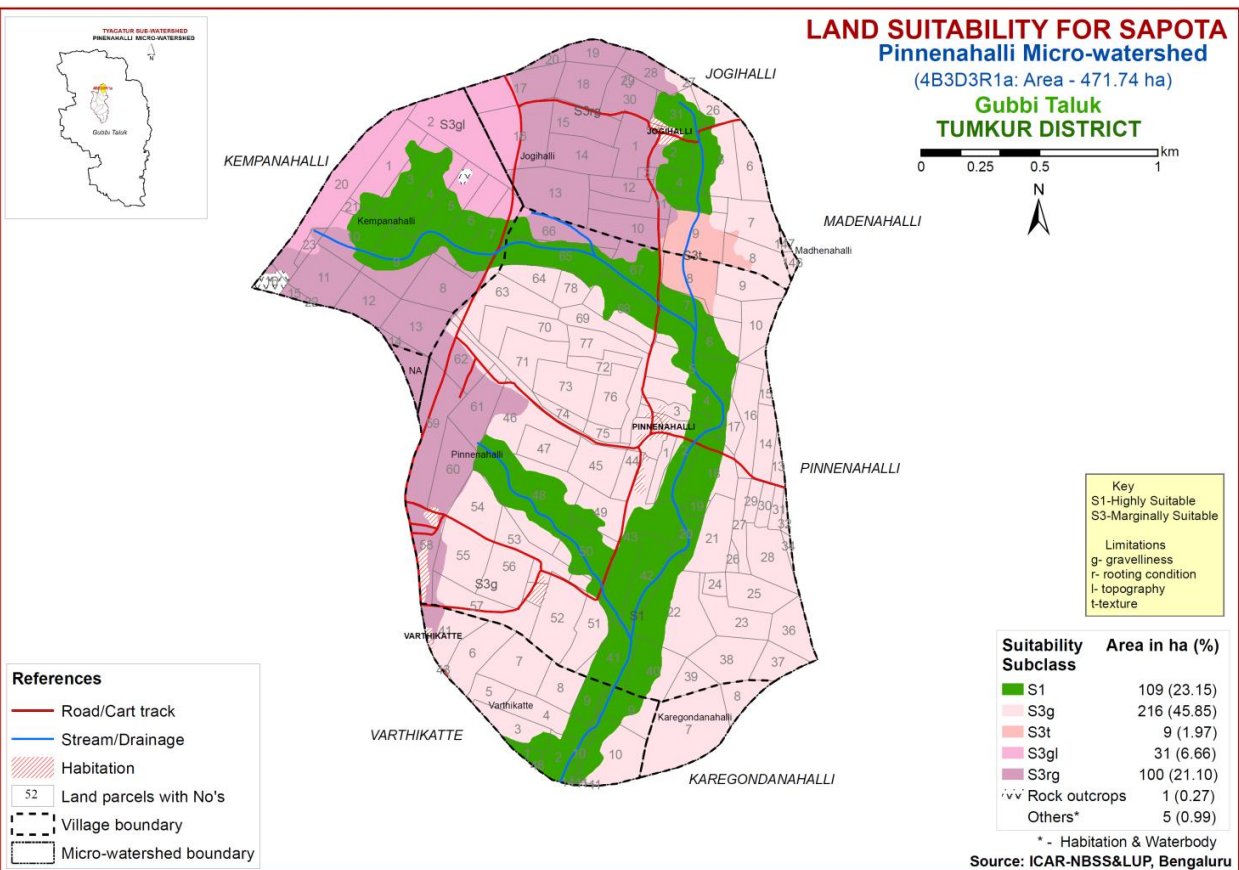
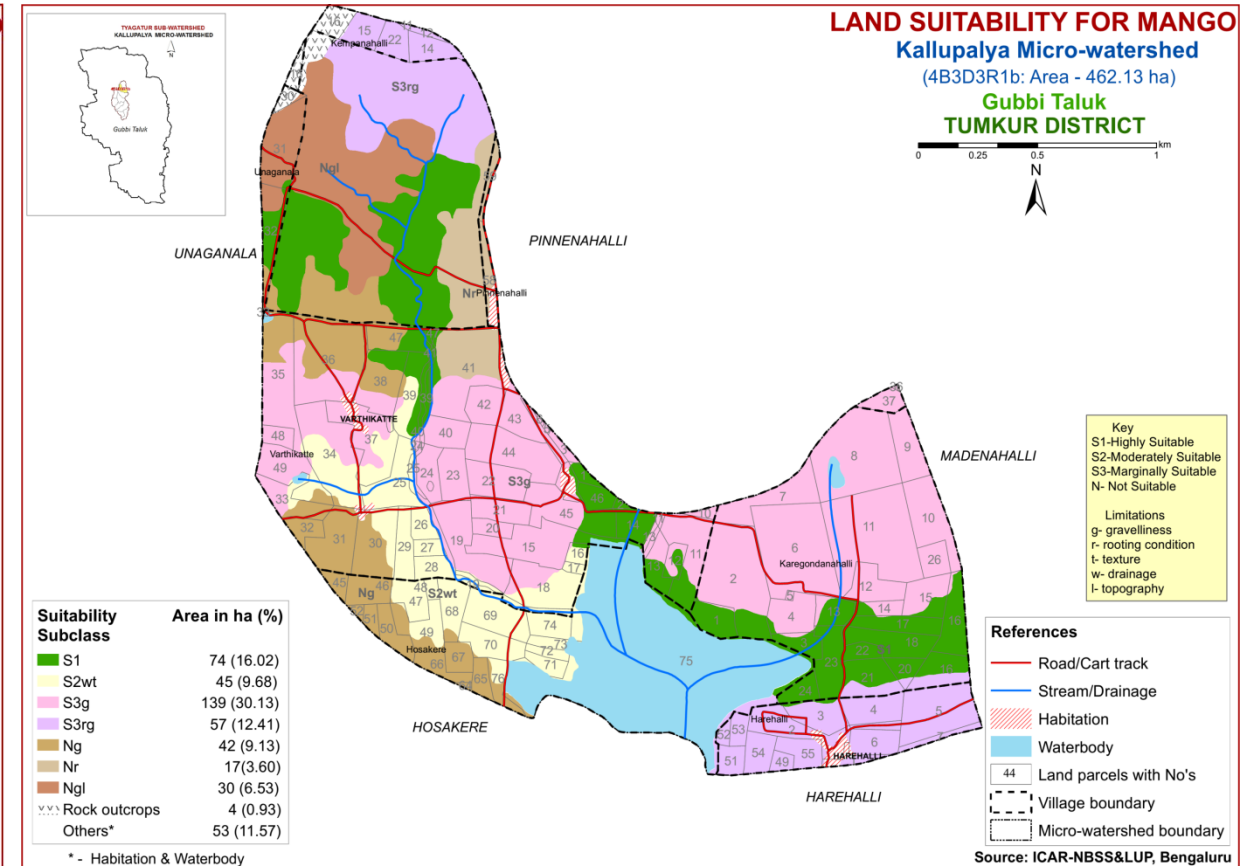
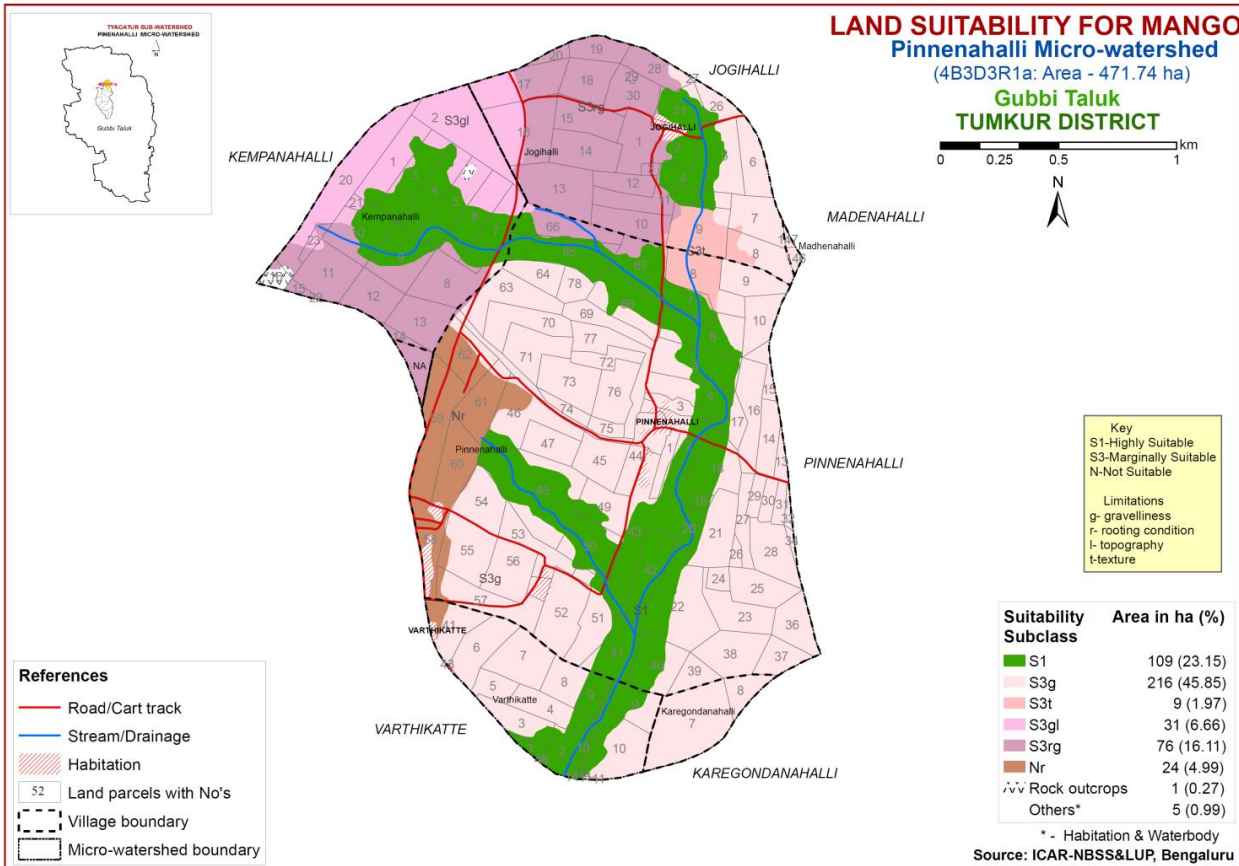


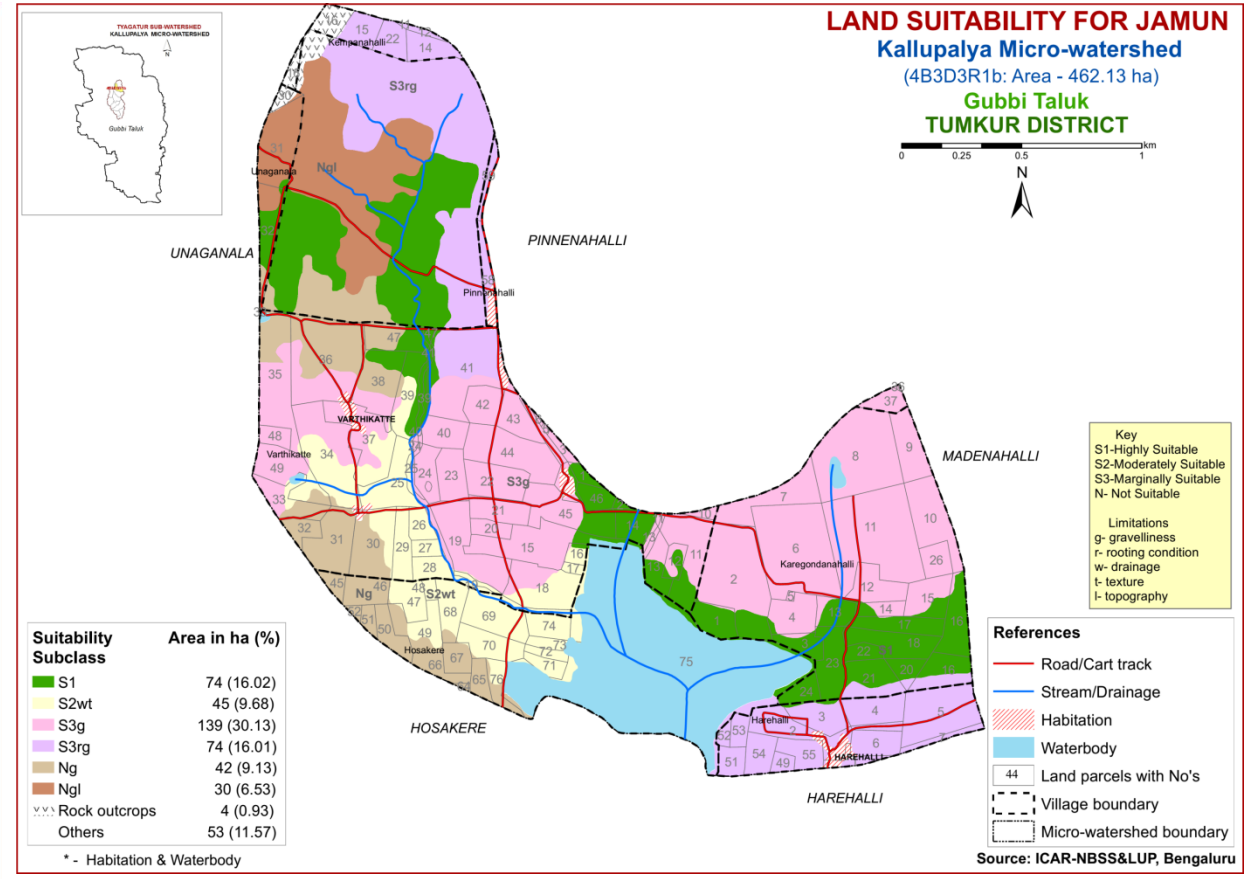
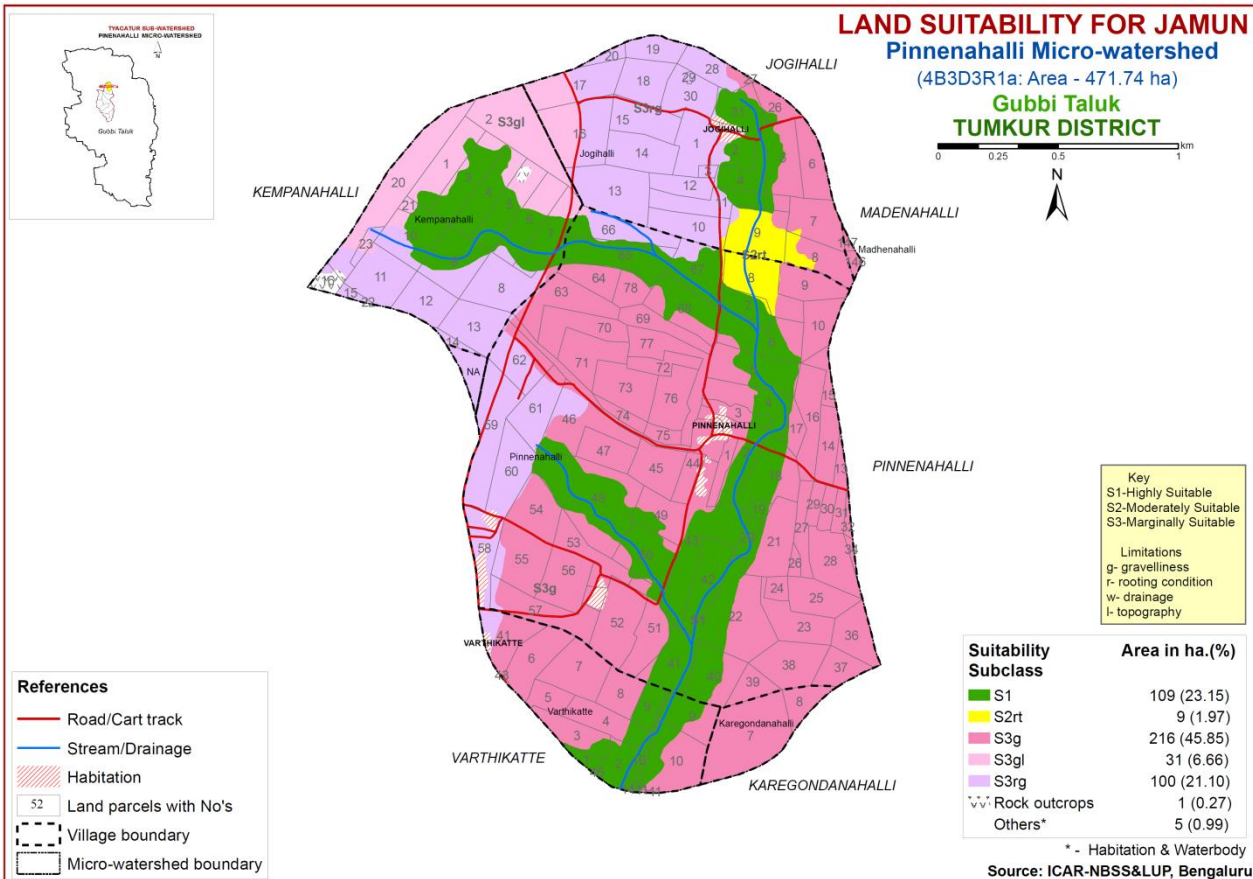
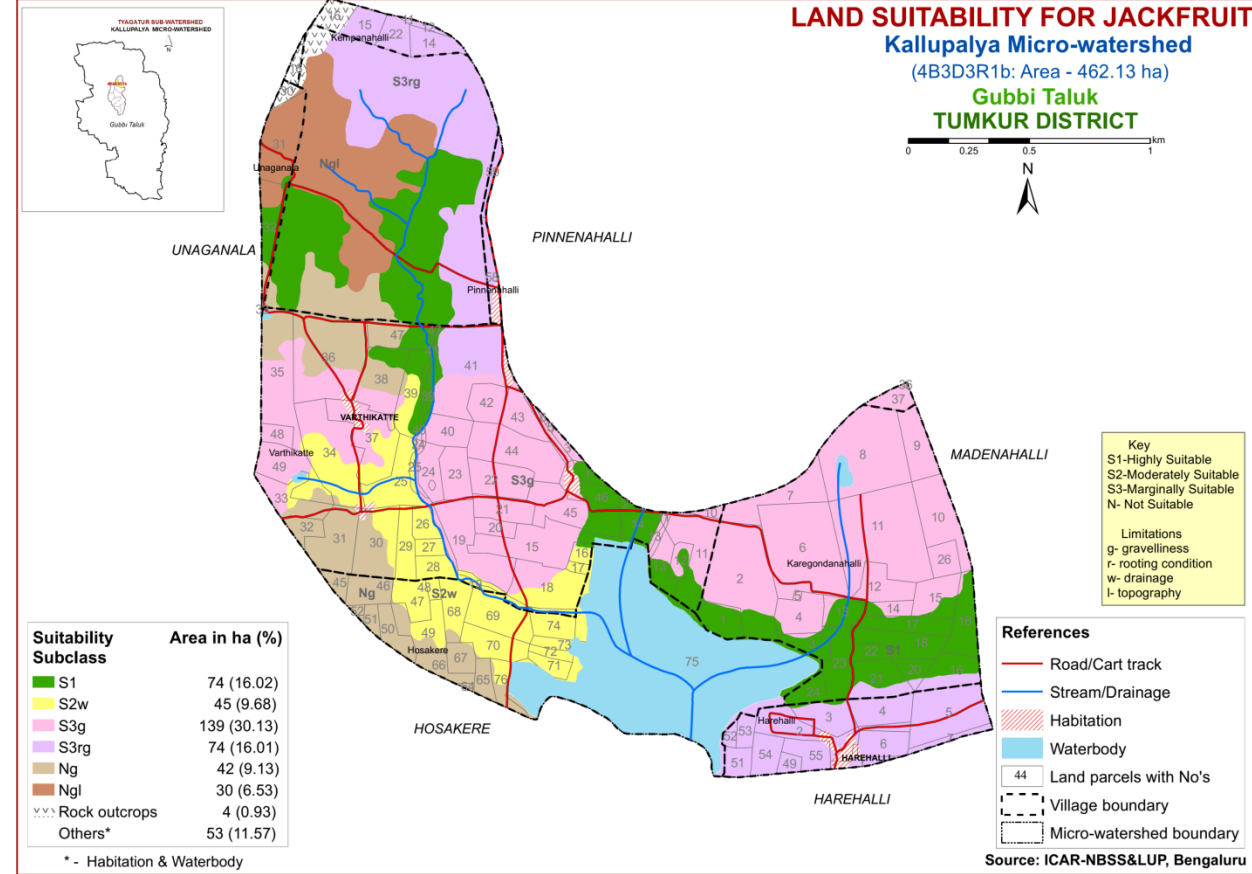
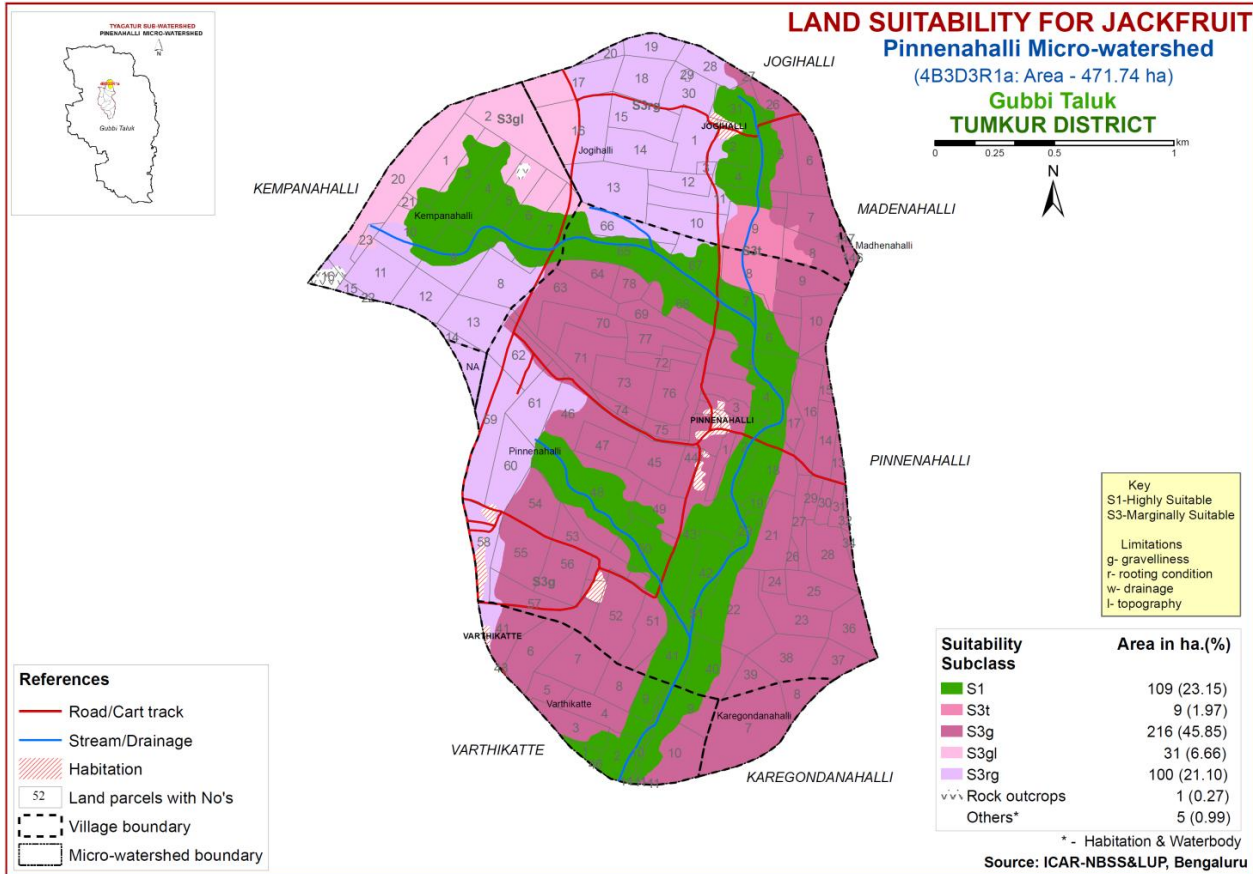


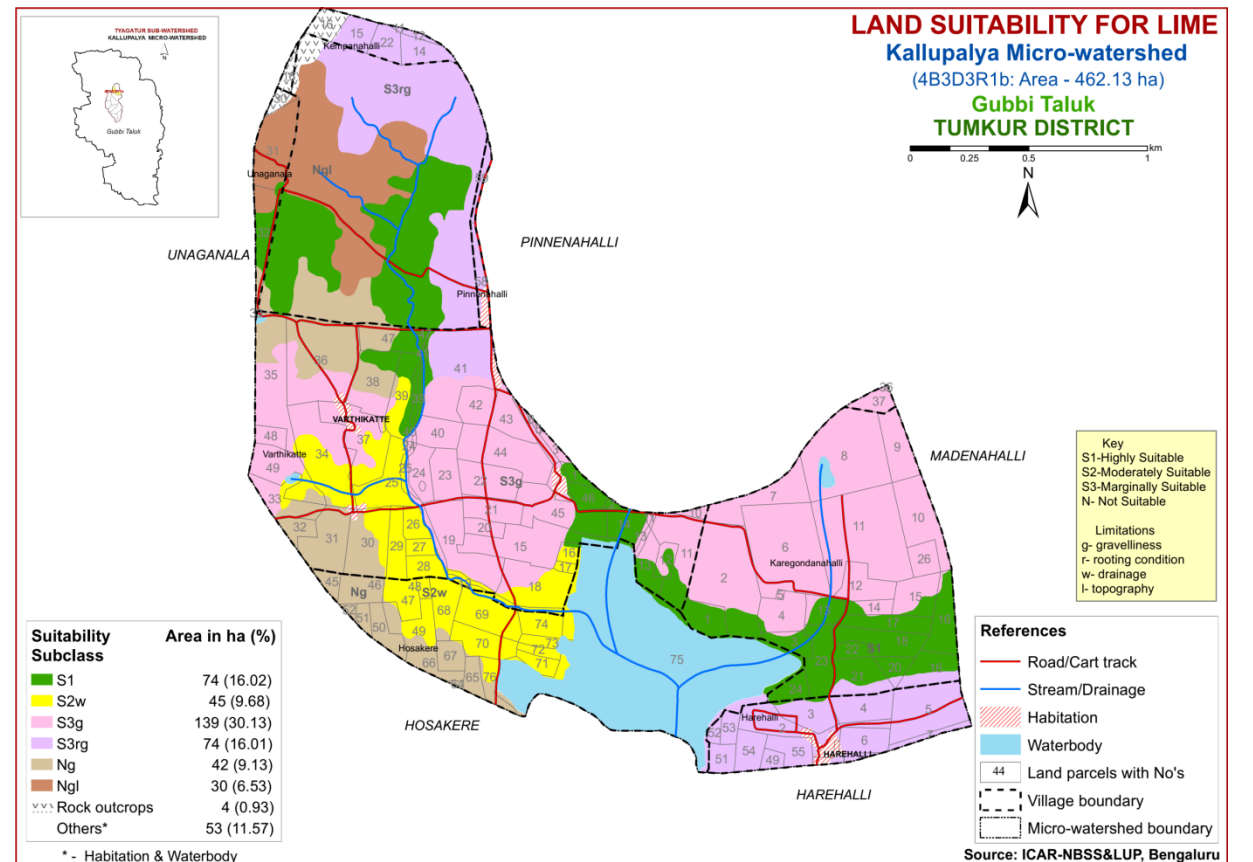
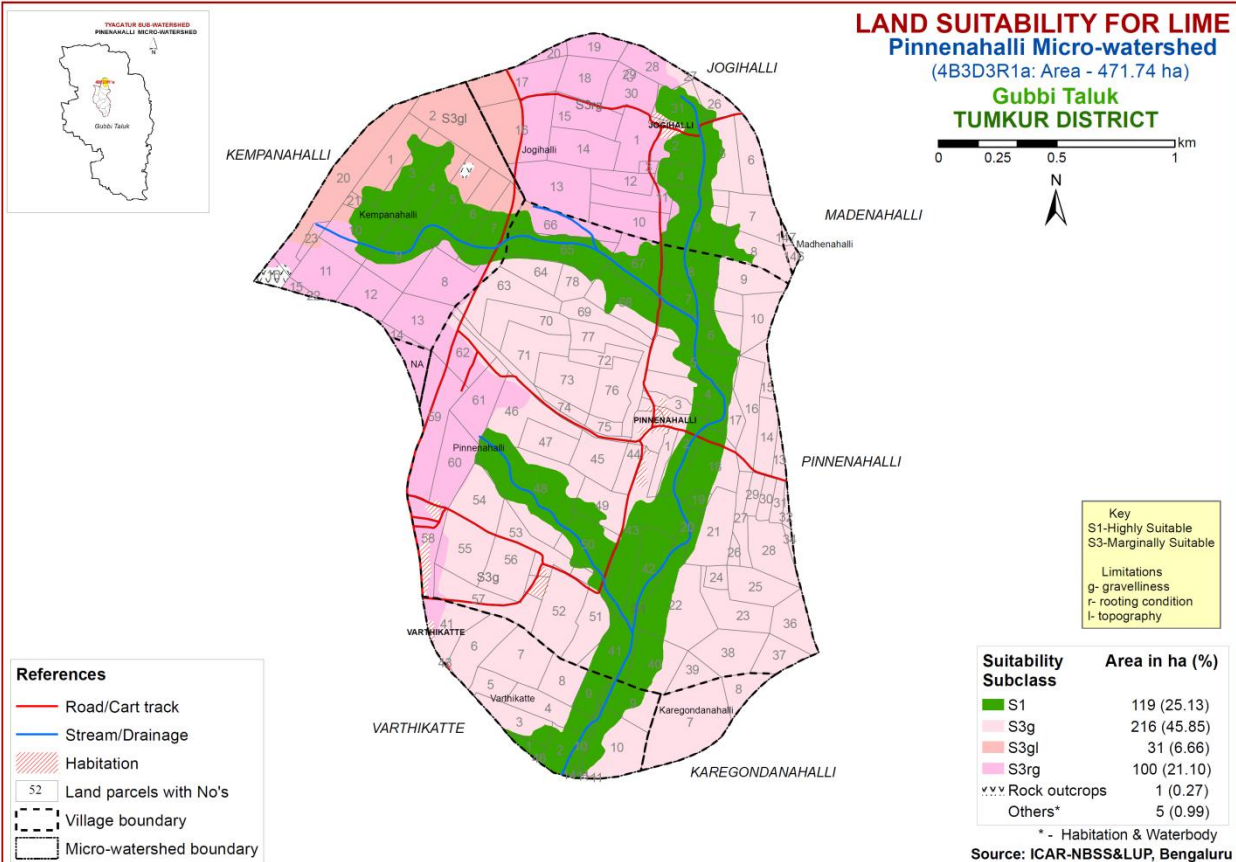
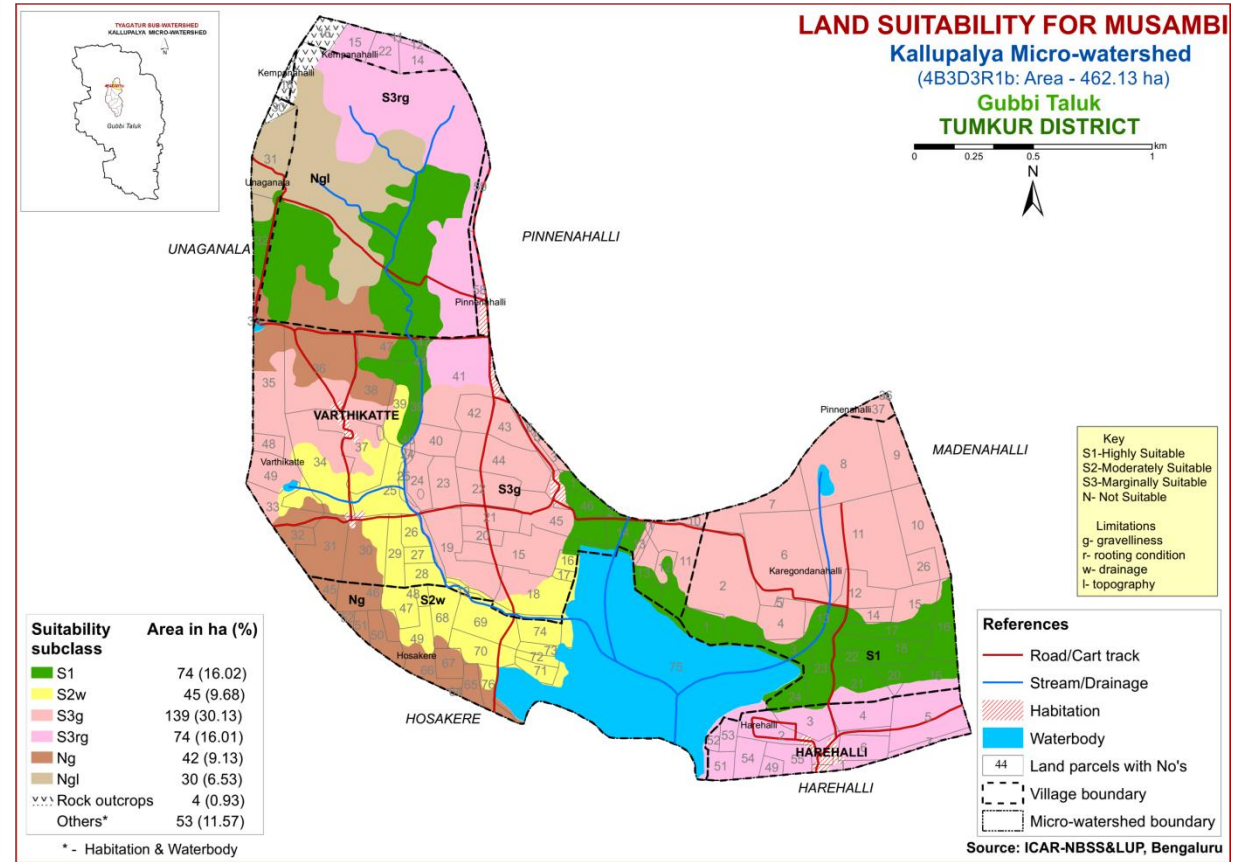
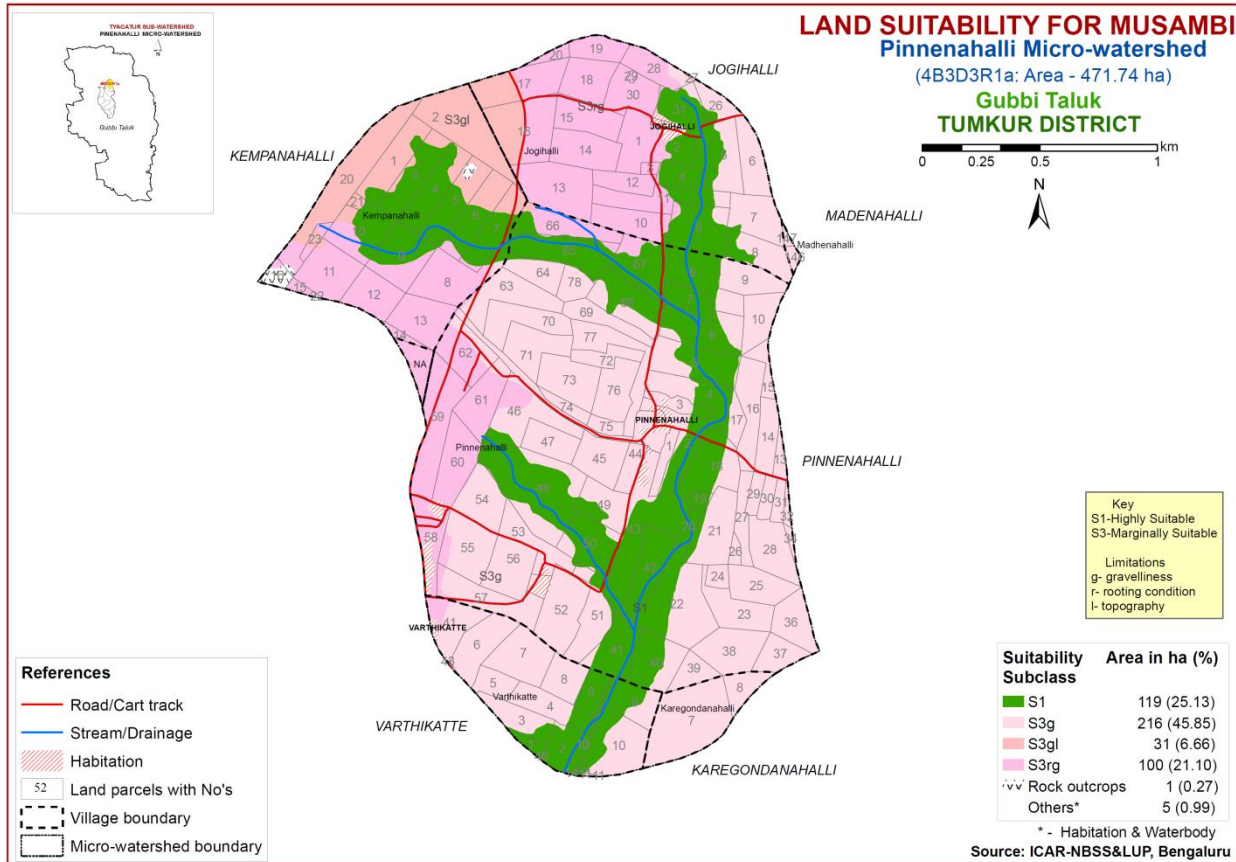


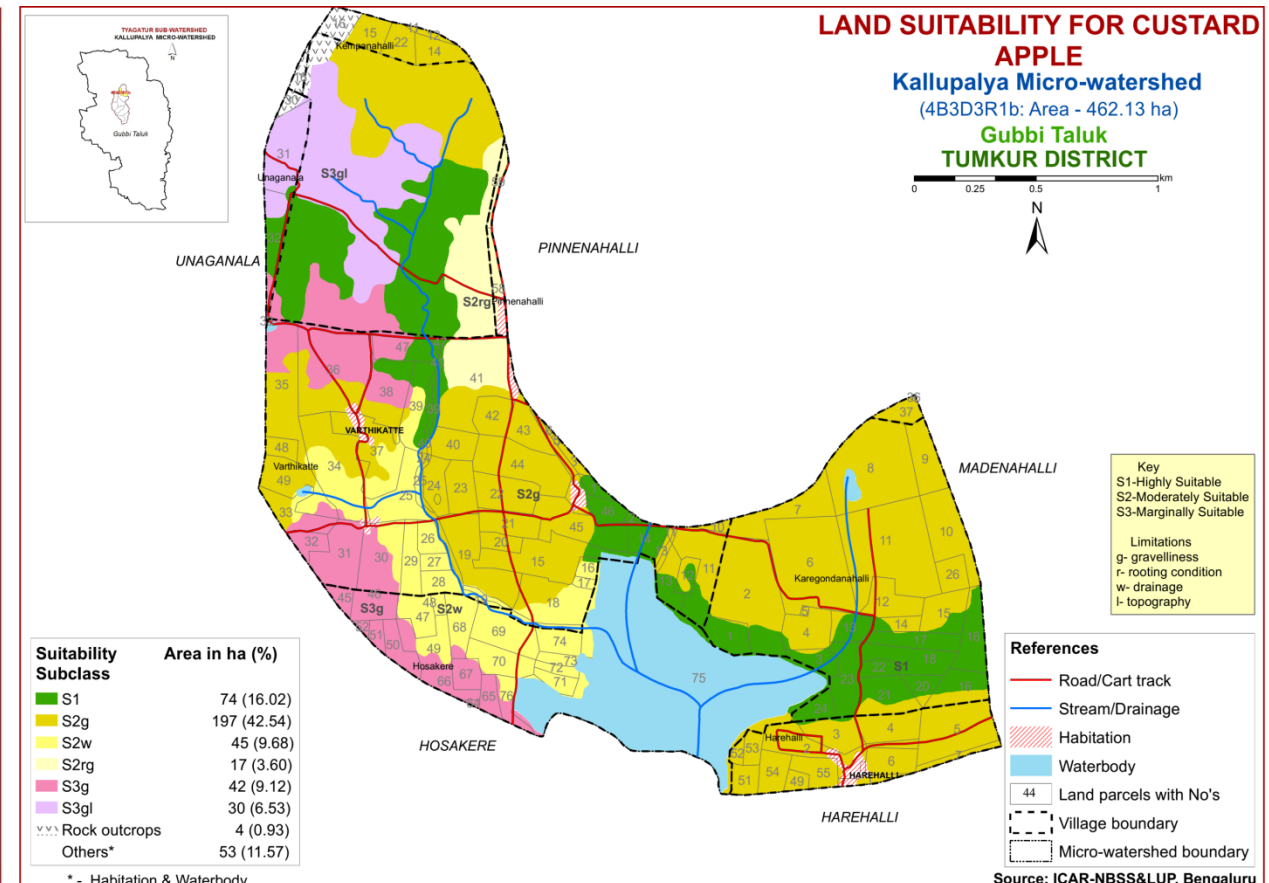
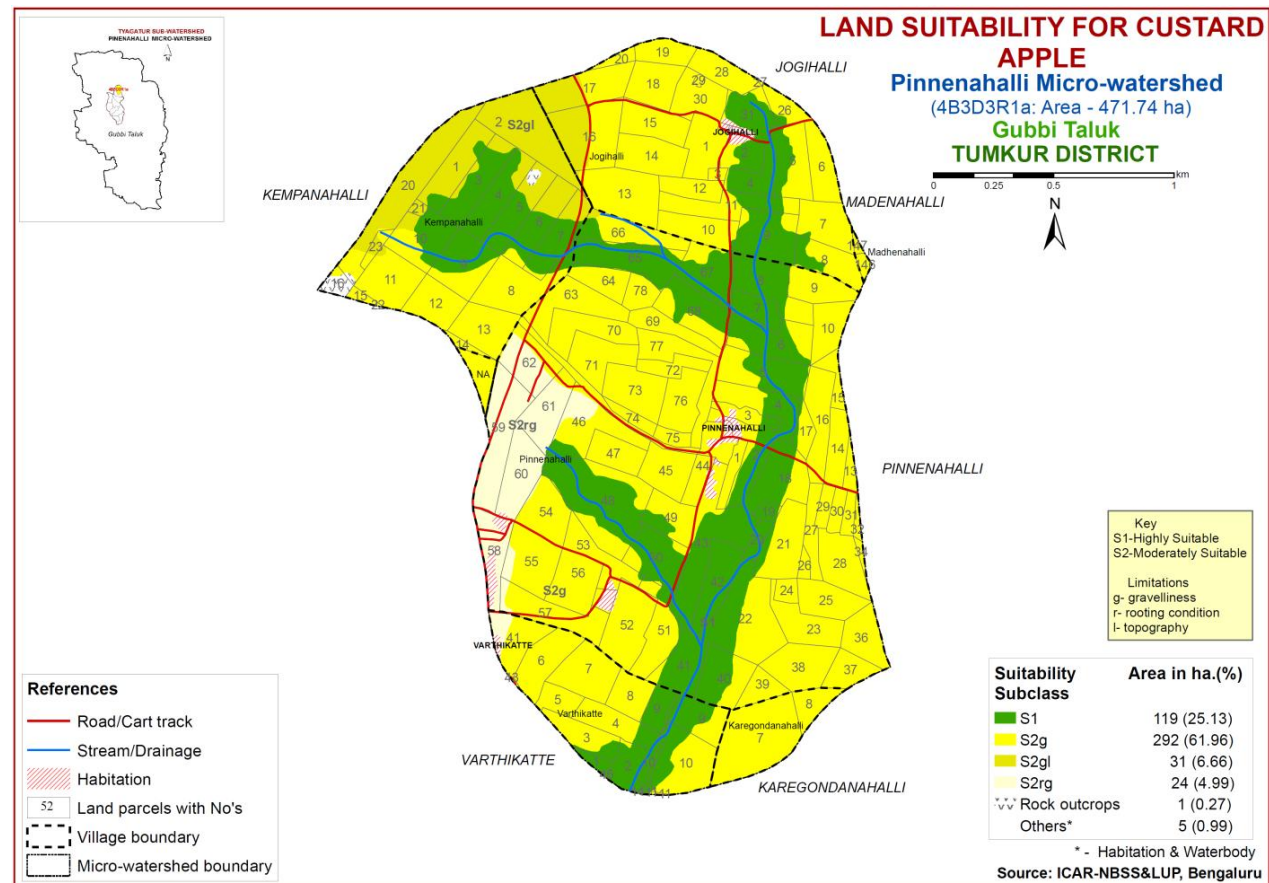
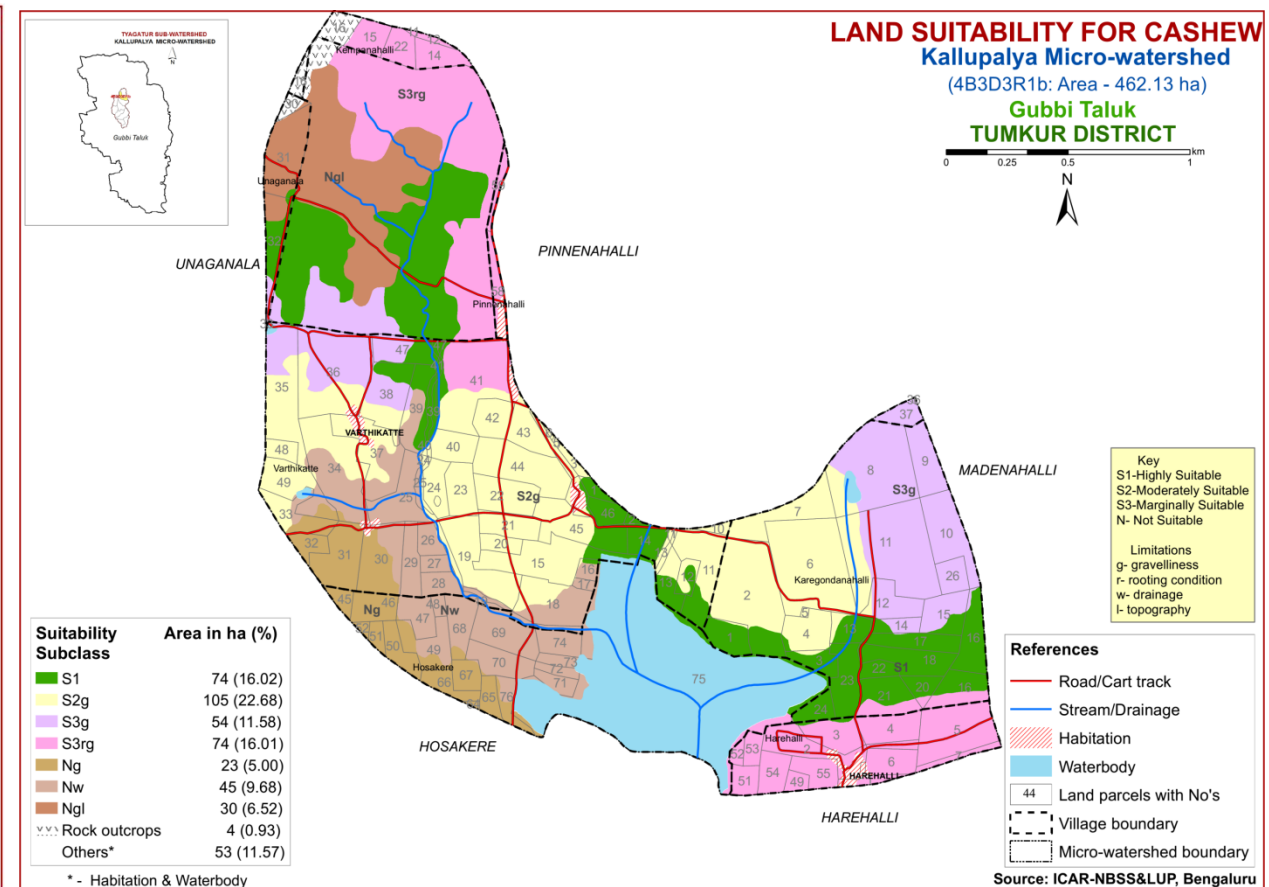
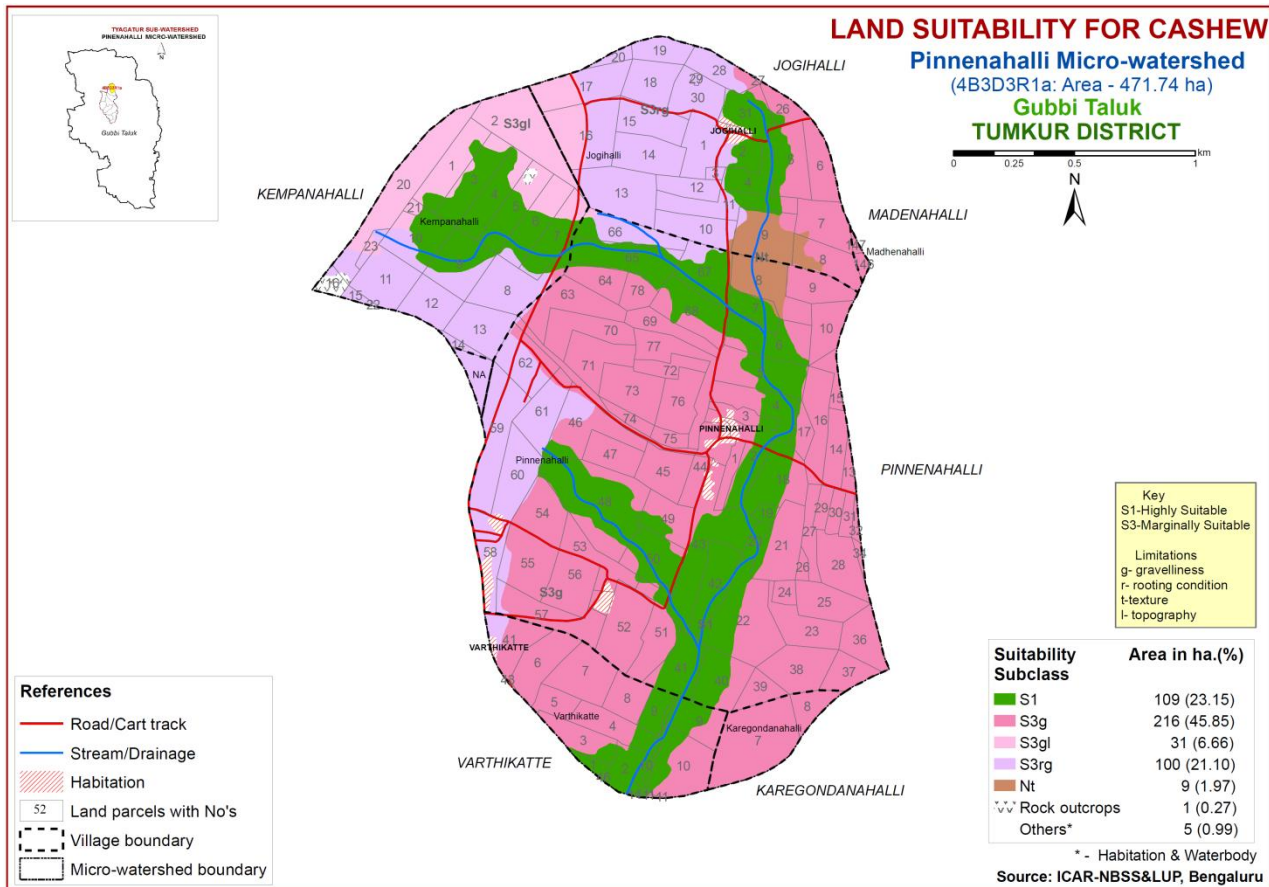


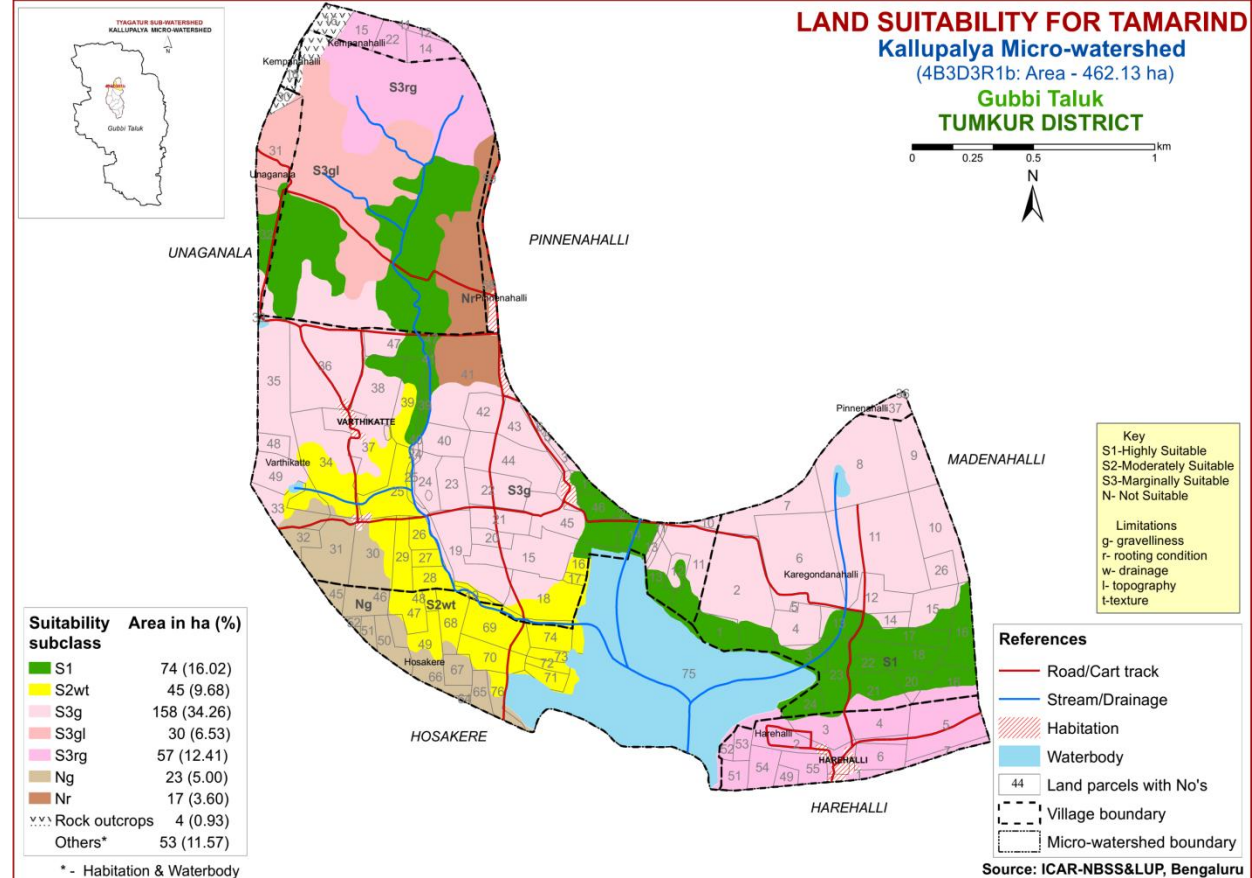
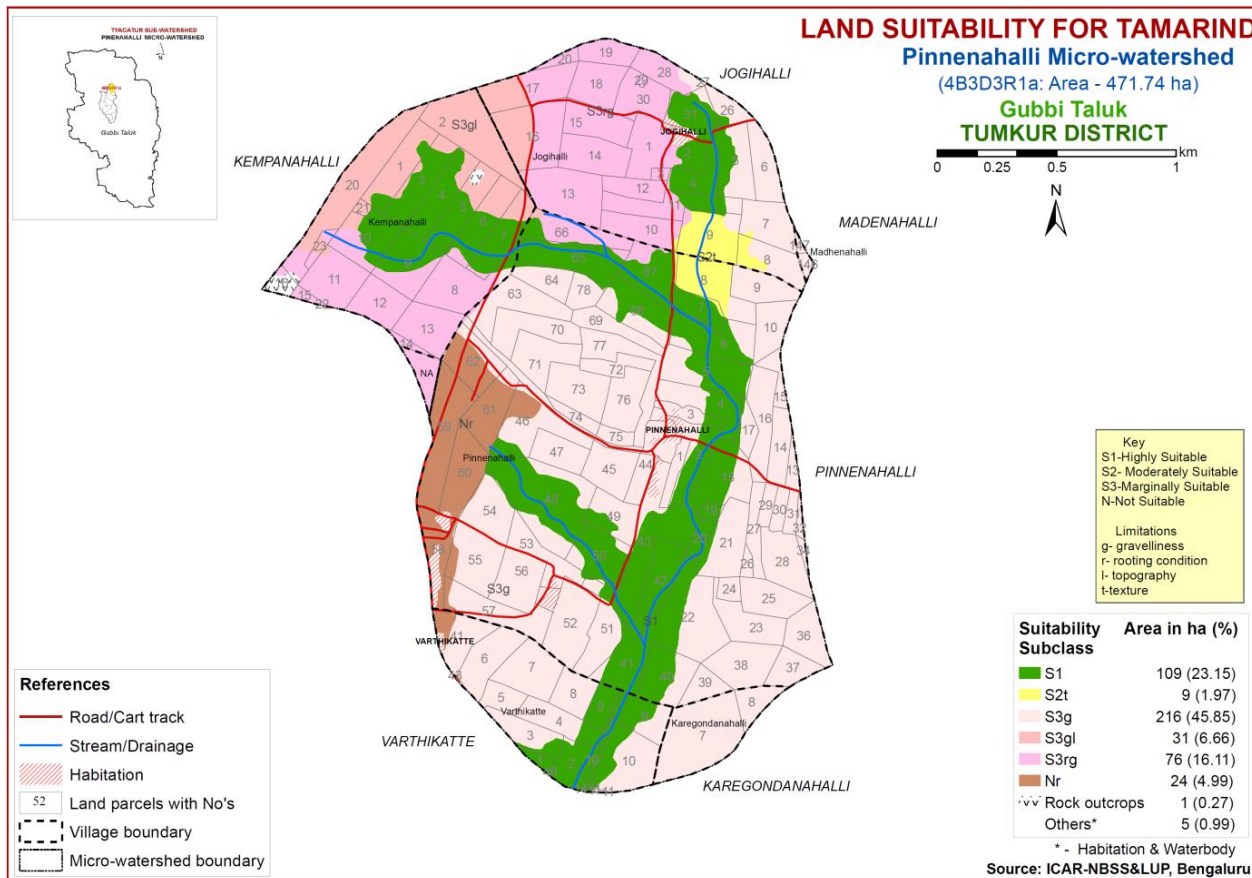
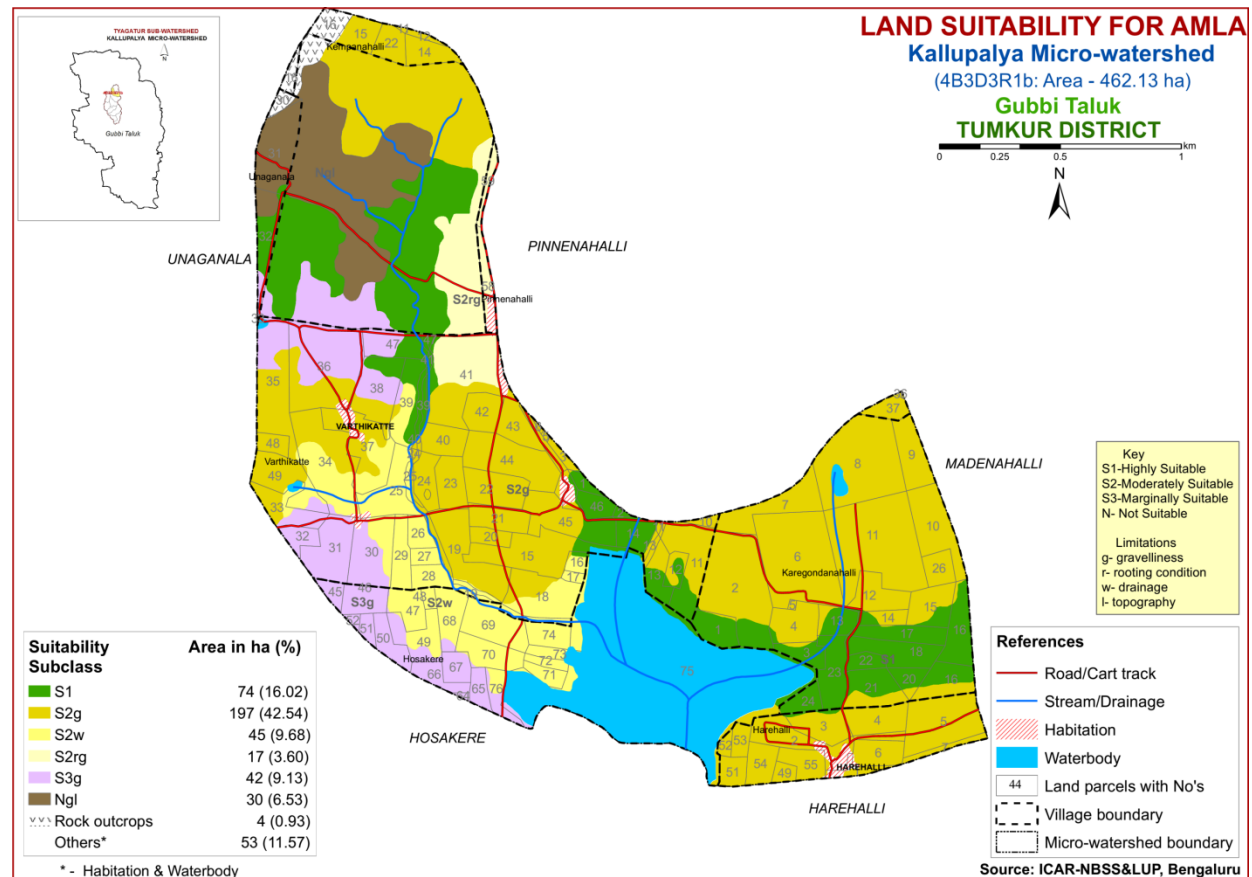
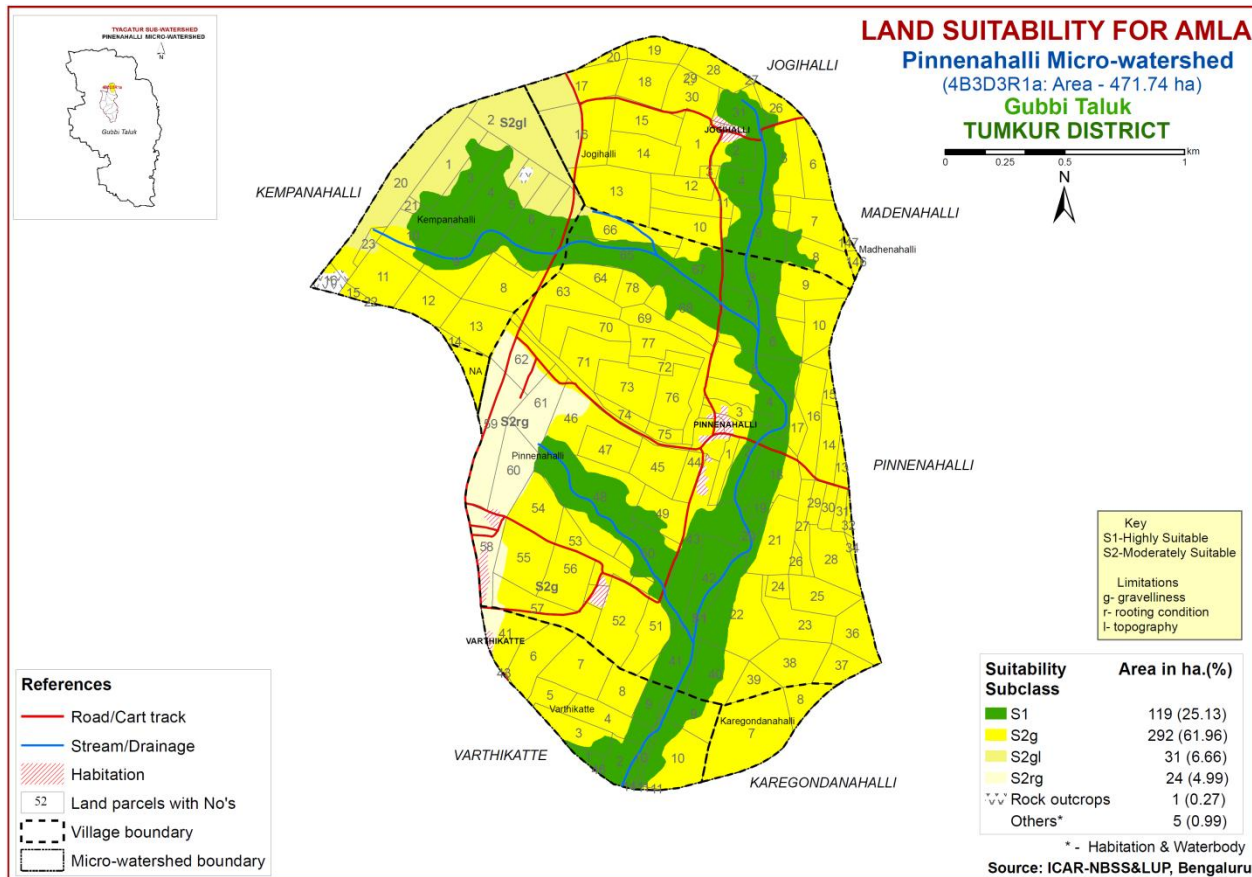


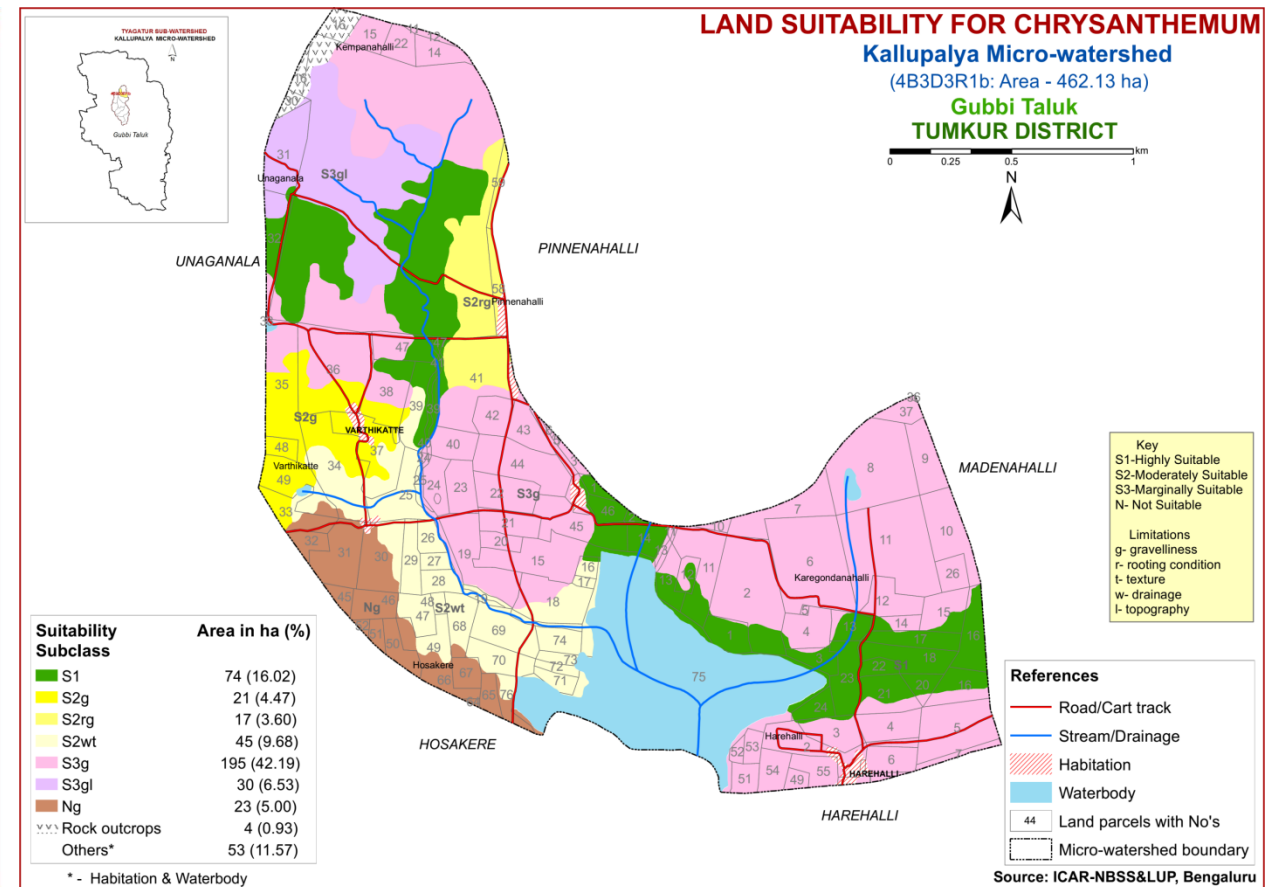
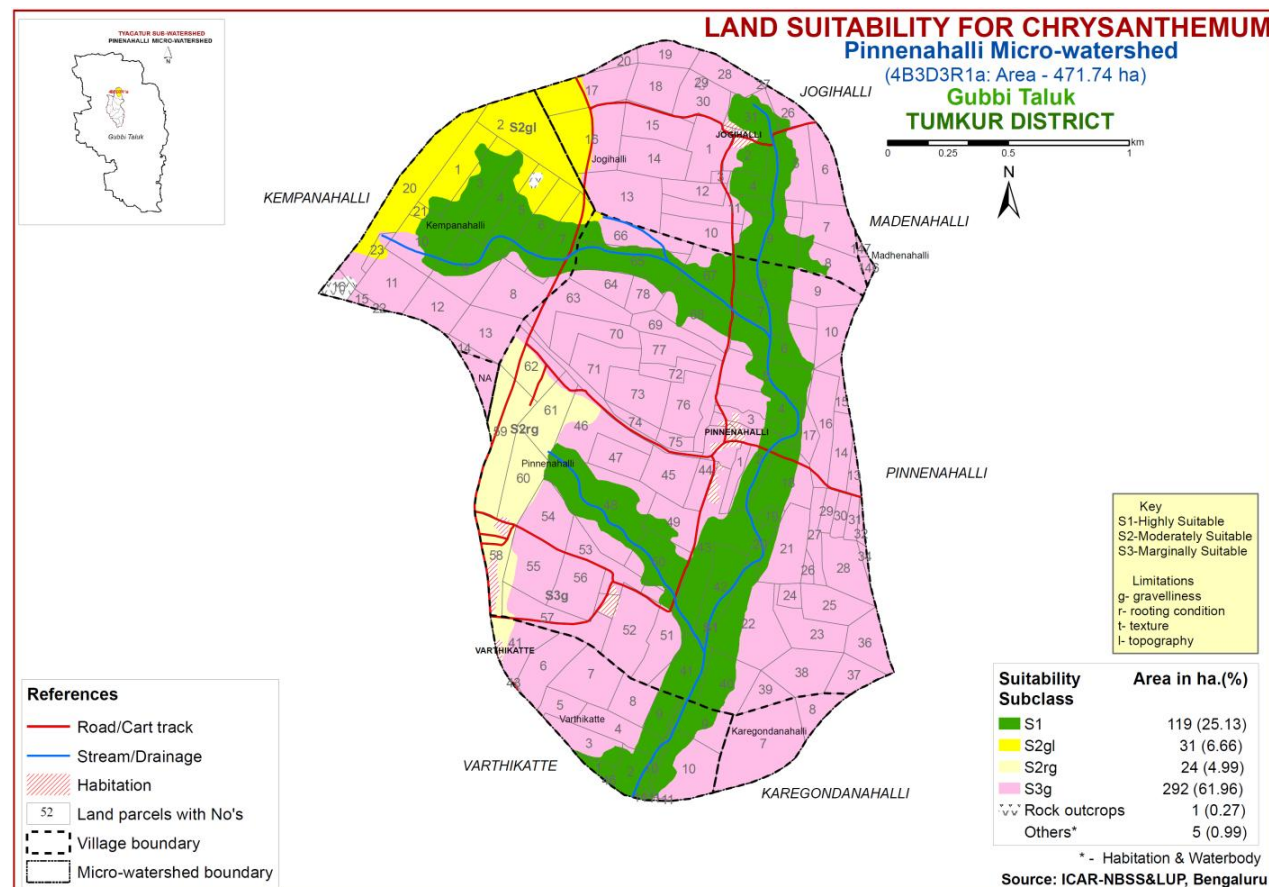
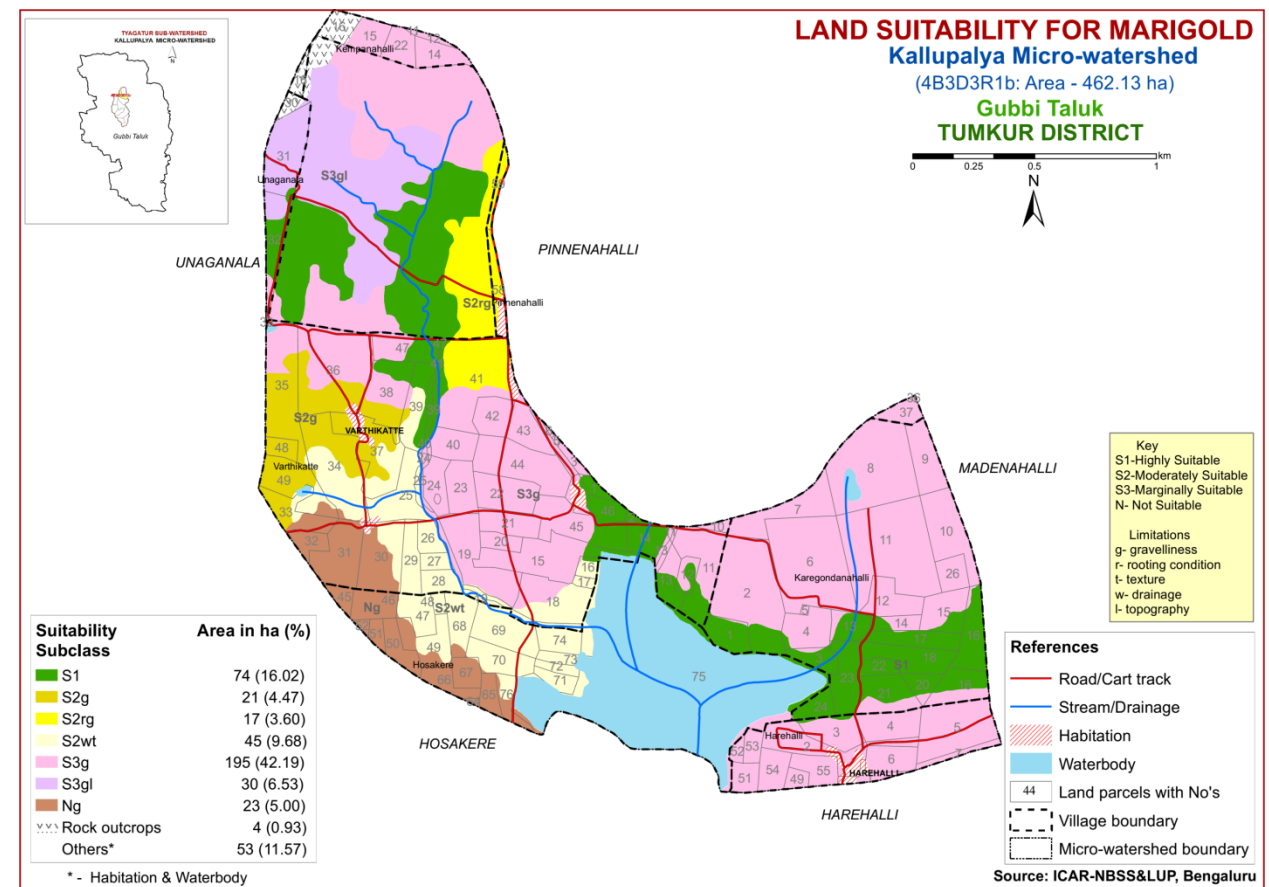
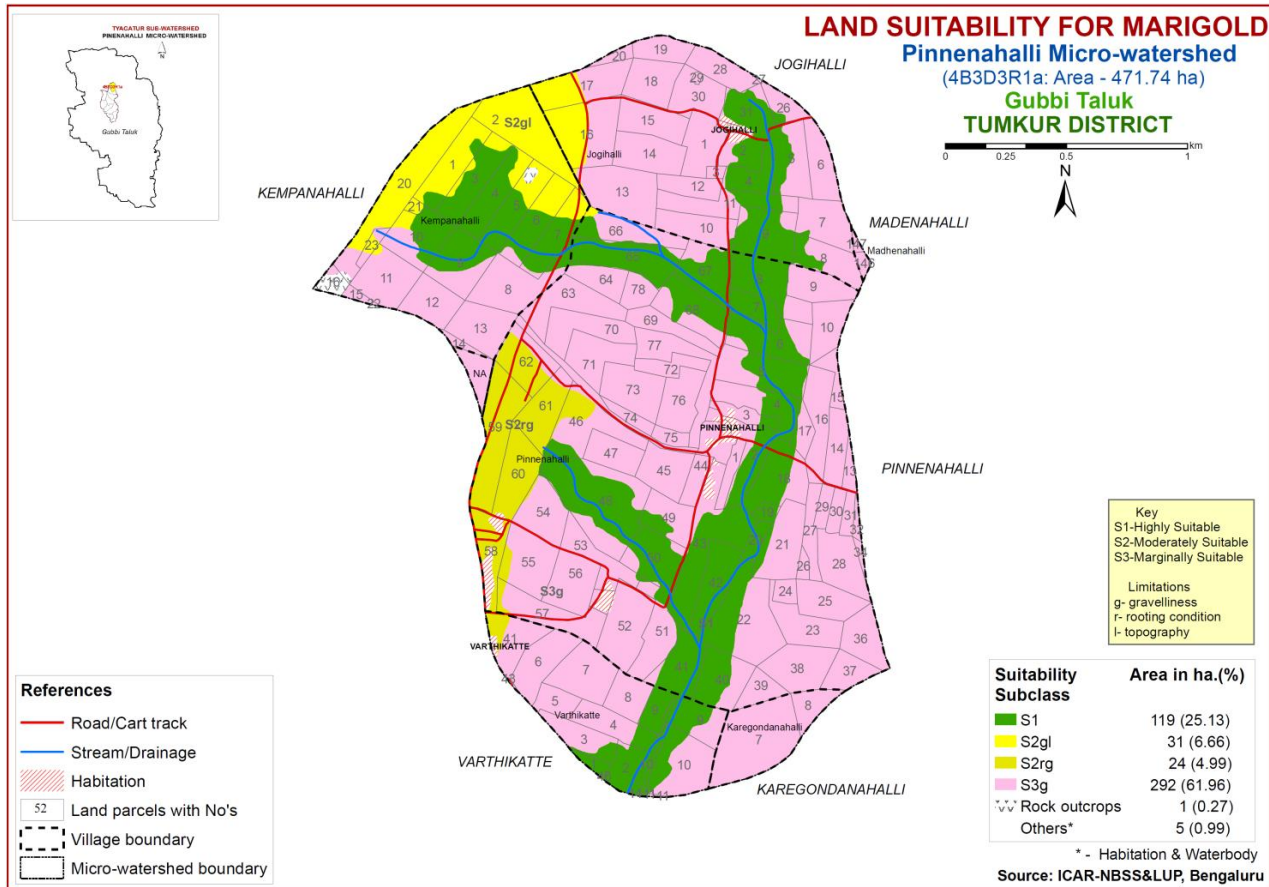


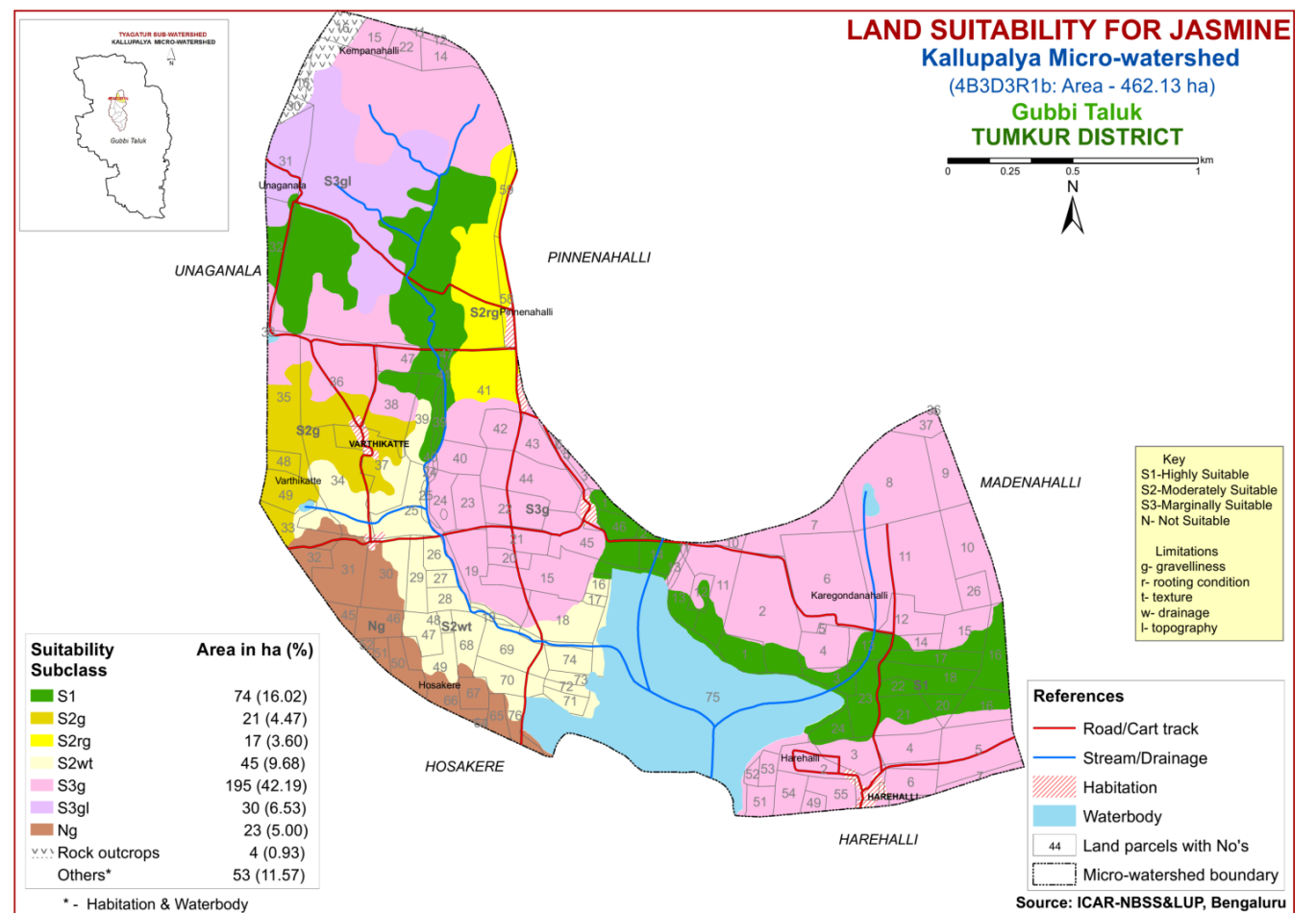
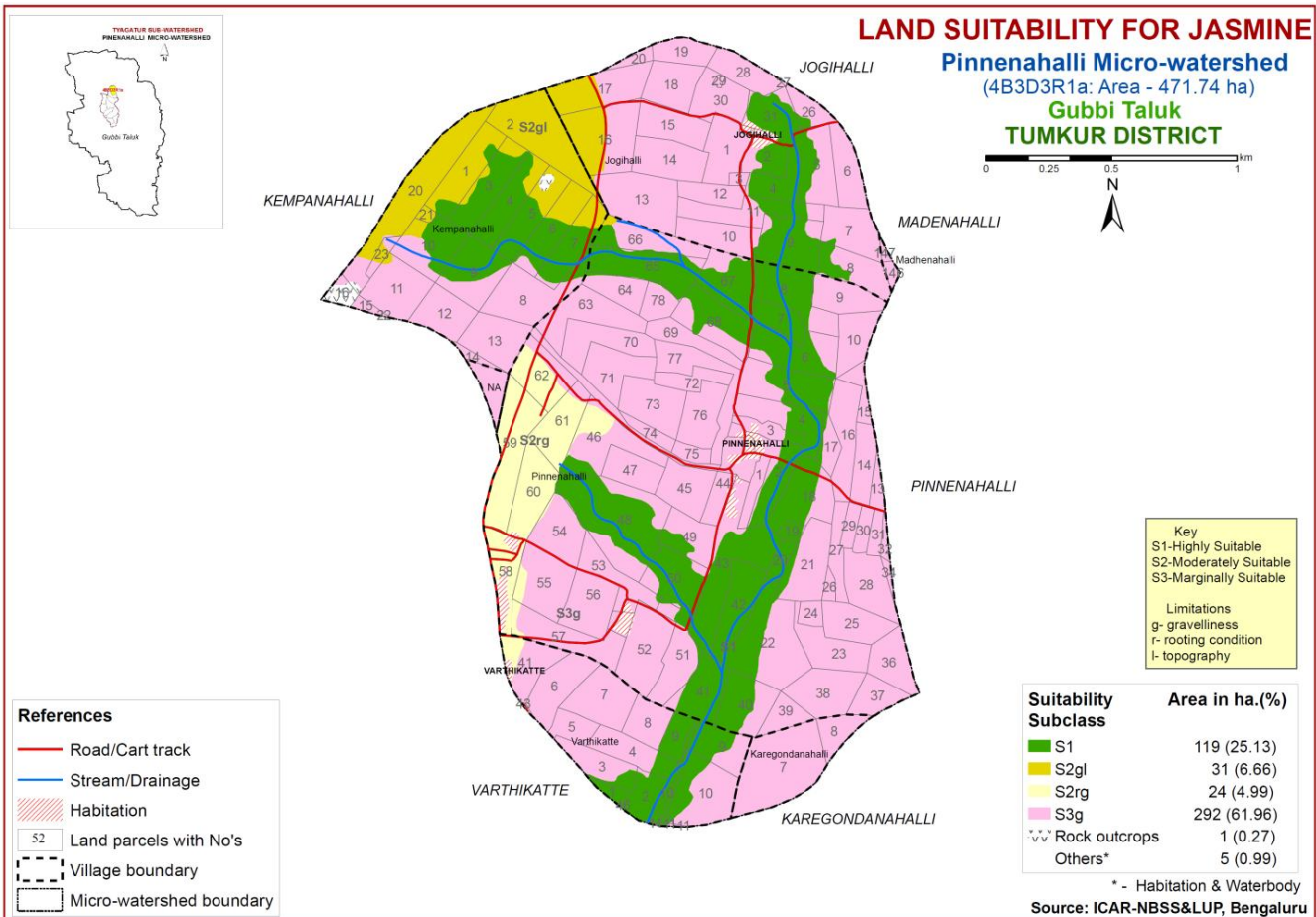








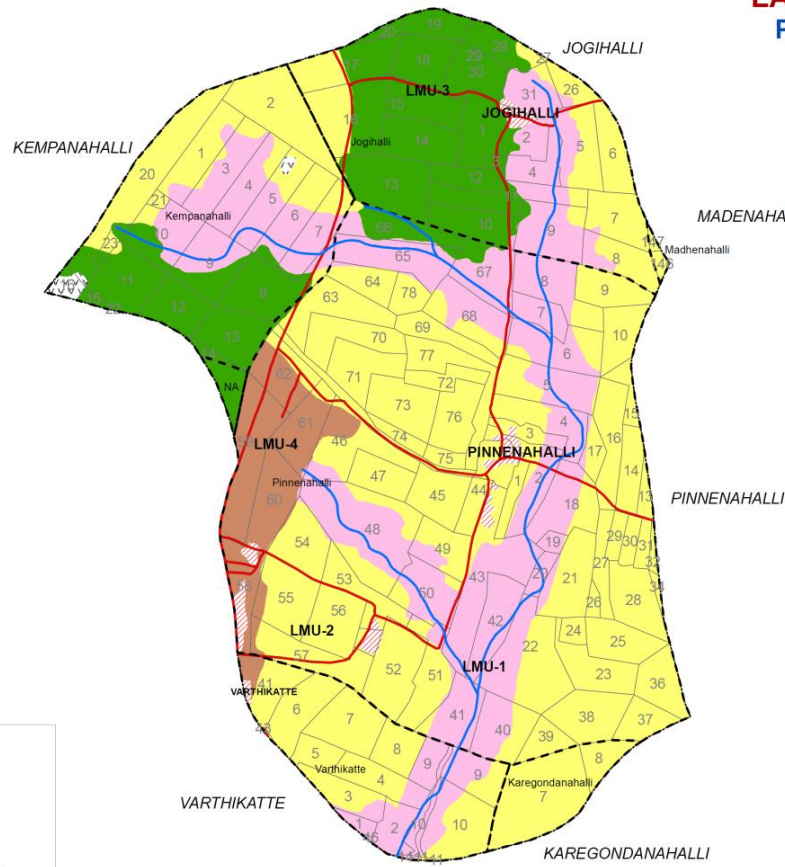
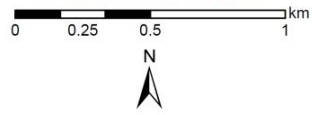




LAND MANAGEMENT UNITS

Pinnenahalli Micro-watershed
(4B3D3R1a: Area - 471.74 ha)

Gubbi Taluk
TUMKUR DISTRICT



References

- Road/Cart track
- Stream/Drainage
- Habitation
- Land parcels with No's
- Village boundary
- Micro-watershed boundary

LMU	Area in ha (%)
LMU-1	119 (25.13)
LMU-2	248 (52.51)
LMU-3	76 (16.11)
LMU-4	24 (4.99)
Rock outcrops	1 (0.27)
Others*	5 (0.99)

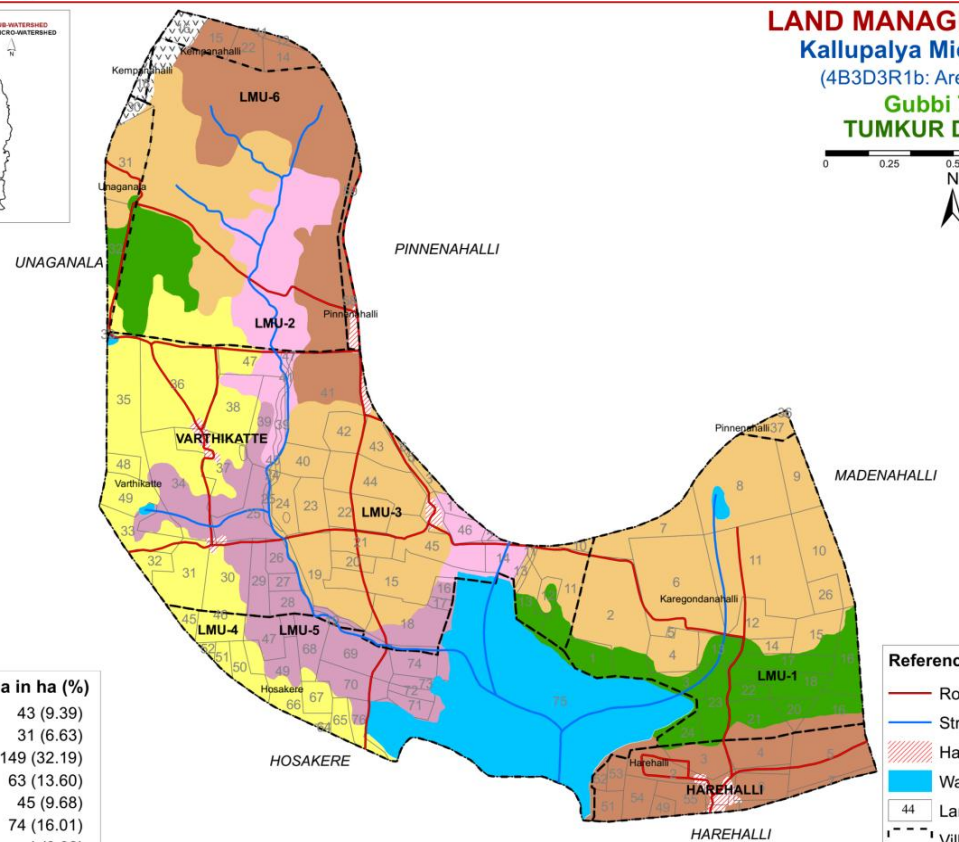
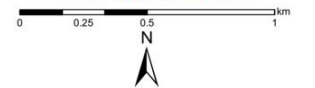
* - Habitation & Waterbody

Source: ICAR-NBSS&LUP, Bengaluru (2017)

LAND MANAGEMENT UNITS

Kallupalya Micro-watershed
(4B3D3R1b: Area - 462.13 ha)

Gubbi Taluk
TUMKUR DISTRICT



LMU	Area in ha (%)
LMU-1	43 (9.39)
LMU-2	31 (6.63)
LMU-3	149 (32.19)
LMU-4	63 (13.60)
LMU-5	45 (9.68)
LMU-6	74 (16.01)
Rock outcrops	4 (0.93)
Others*	53 (11.57)

* - Habitation & Waterbody

References

- Road/Cart track
- Stream/Drainage
- Habitation
- Waterbody
- Land parcels with No's
- Village boundary
- Micro-watershed boundary

Source: ICAR-NBSS&LUP, Bengaluru (2017)

NOTE: Proposed Crop Plan for LMU's are given in Table

**Table. Proposed Crop Plan for Pinnenahalli Micro-watershed, Tyagatur Sub-watershed
Gubbi Taluk, Tumkur District based on soil-site–crop suitability Assessment**

LMU No	Mapping Units	Survey Number	Field Crops	Forestry/Grasses	Horticulture Crops with suitable interventions	Suitable Interventions
LMU1 (119 ha.)	5, 14,15,16 Deep to very deep (100- >150 cm) black clayey soils	Jogihalli: 2,4,9,31 Kempanahalli: 3,4,5,6,7,9 Pinnenahalli: 2,4,5,6,7,8,18,19,20,40, 41,42,43,48,50,65,67,68 Varthikatte: 1,2,9,14,46,STREAM	Sole crops: Sorghum, Sunflower, Fodder sorghum, Redgram, Field bean, Horse gram Intercropping: Redgram+Fodder sorghum	Hebbevu, Silveroak Grasses: <i>Styloxanthes hamata,</i> <i>Styloxanthes scabra,</i> Hybrid napier	Vegetables: Brinjal, Tomato, Chillies, Cucurbits Flower crops: Marigold, Chrysanthemum Fruit crops/ Plantation crops: Pomegranate, Tamarind, Custard Apple, Amla, Lime, Musambi Arecanut, Coconut	Application of FYM and micronutrients, drip irrigation, mulching, use of medium duration varieties, suitable conservation practises
LMU 2 (248 ha.)	6, 7, 8, 9, 10, 11, 12, 13 Deep to very deep (100- >150 cm), gravelly red clayey soils	Jogihalli: 5,6,7,8,16,26,27 Karegondanahalli: 7,8 Kempanahalli: 1,2,20,21 Madhenahalli: 146,147 Pinnenahalli: 1,3,9,10,13,14,15,16,17,21, 22,23,24,25,26,27,28,29,30, 31,32,34,36,37,38,39,44,45, 46,47,49,51,52,53,54,55,56, 57,63,64,69,70,71,72,73,74, 75,76,77, 78,SETTLEMENT Varthikatte:3,4,5,6,7,8,10, 11, 41,43	Sole Crops: Ragi, Upland paddy, Maize, Sorghum, Fodder sorghum, Groundnut, Redgram, Fieldbean, Cowpea Intercropping: Redgram+Fodder sorghum Ragi+Cowpea Ragi+Redgram Ragi+Fieldbean	Neem, Silver Oak Grasses <i>Styloxanthes hamata,</i> <i>Styloxanthes Scabra,</i> Hybrid Napier, Sesbania,	Vegetables: Onion, Tomato, Brinjal Chillies, Coriander, Drumstick Flower crops: Chrysanthemum, Jasmine, China aster, Marigold Fruit crops/ Plantation crops: Mango, Sapota, Guava, Cashew, Custard apple, Amla, Pomegranate Jackfruit, Musambi, Arecanut, Coconut	Drip irrigation, Mulching, suitable conservation practices (Crescent Bunding with Catch Pit etc)

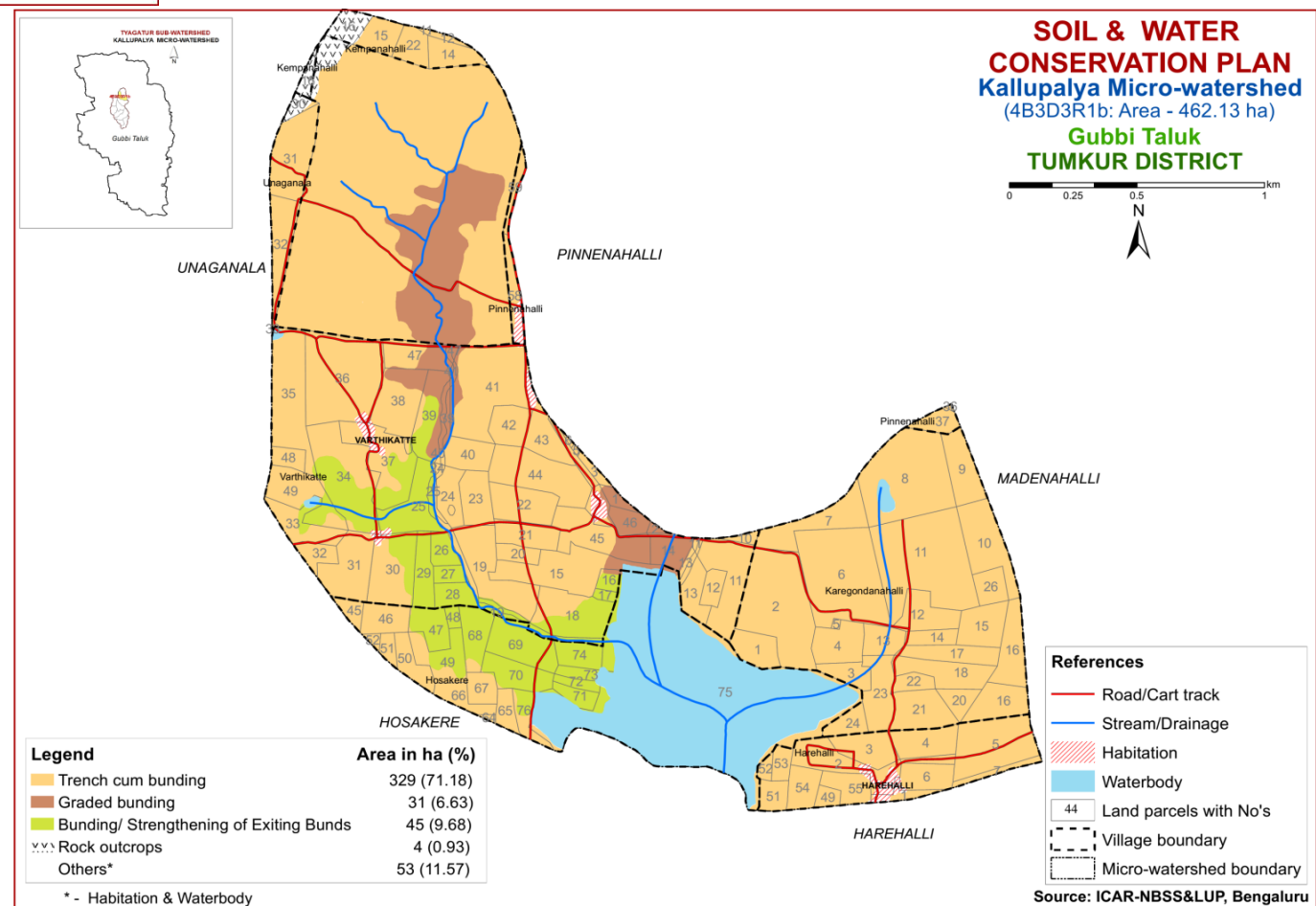
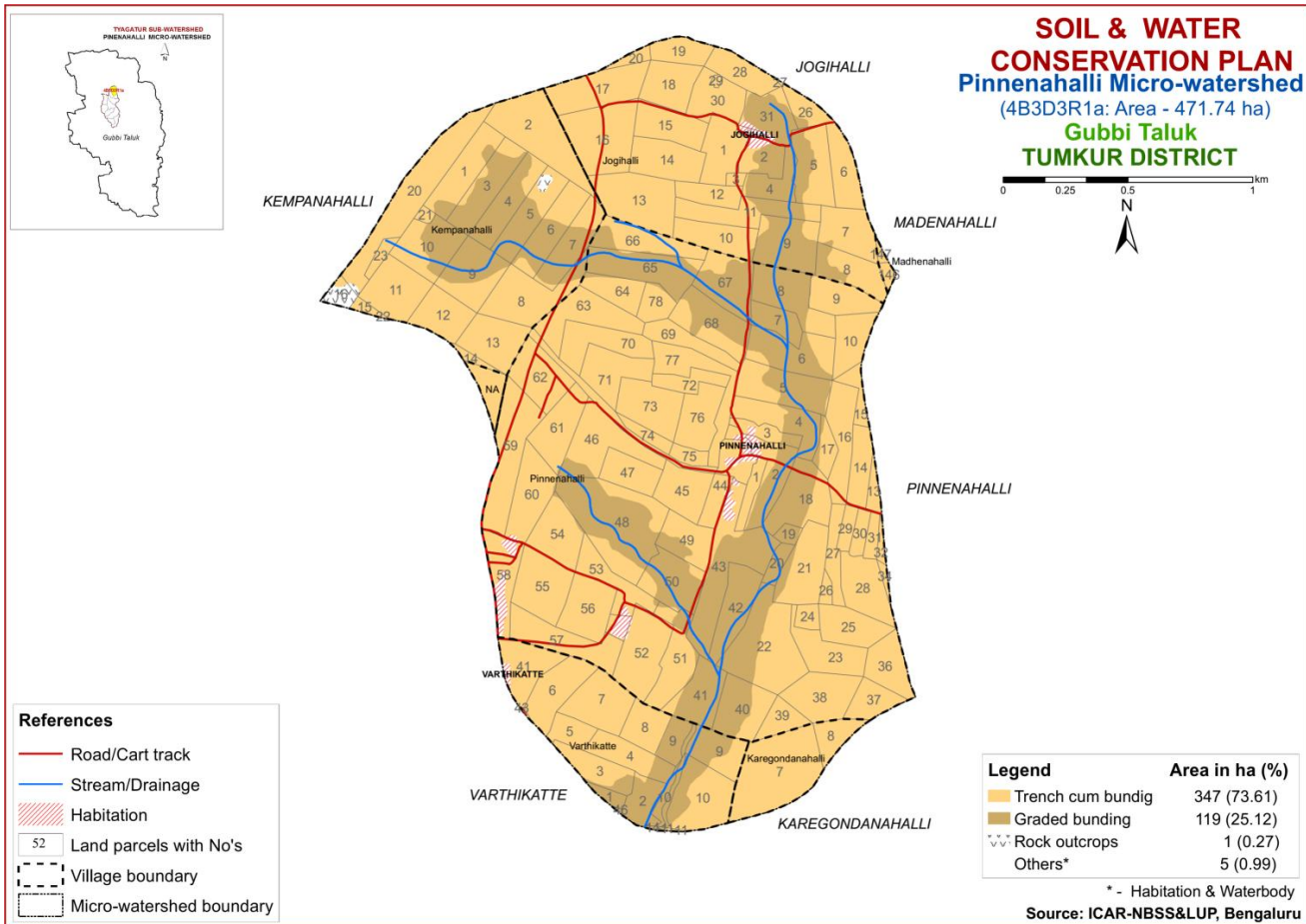
LMU No	Mapping Units	Survey Number	Field Crops	Forestry/Grasses	Horticulture Crops with suitable interventions	Suitable Interventions
LMU 3 (76 ha.)	2, 3, 4 Moderately deep to deep (75-150 cm), gravelly red clayey soils	Jogihalli: 1,3,10,11,12,13,14,15,17,18, 19,20,28,29,30 Kempanahalli: 8,10,11,12,13,14,15,22, 23 Pinnenahalli: 66	Sole crops: Upland paddy, Ragi, Maize, Sorghum, Groundnut, Fieldbean, Cowpea, Fodder sorghum, Horsegram	Glyricidia, Grasses: <i>Styloxanthes hamata</i> , <i>Styloxanthes scabra</i> , Hybrid Napier	Vegetables: Tomato, Brinjal, Drumstick, Chillies, Curry leaf Flower crops: Chrysanthemum, Marigold, Crossandra, Fruit crops: Tamarind, Custard Apple, Amla, Lime, Musambi	Drip irrigation, Mulching, suitable conservation practices (Crescent Bunding with Catch Pit etc)
LMU 4 (24 ha.)	1 Moderately shallow (50-75 cm), red loamy soils	Pinnenahalli: 58,59,60,61,62	Sole crops: Maize, Ragi, Groundnut, Fodder sorghum, Cowpea, Horsegram	Glyricidia, Grasses <i>Styloxanthes hamata</i> , <i>Styloxanthes scabra</i>	Vegetables: Tomato, Onion, Chillies, Curryleaf, Fruit crops: Custard apple, Amla, Bael	Drip irrigation, Mulching, suitable conservation practices (Crescent Bunding with Catch Pit etc)

**Table. Proposed Crop Plan for Kallupalya Micro-watershed, Tyagatur Sub-watershed
Gubbi Taluk, Tumkur District based on soil-site–crop suitability Assessment**

LMU No	Mapping Units	Survey Number	Field Crops	Forestry/Grasses	Horticulture Crops with suitable interventions	Suitable Interventions
LMU1 (43 ha.)	11,12 Very deep (>150 cm), red clay to clay loam soils	Karegondanahalli: 1,3,13,16,17,18,20, 21,22,23,24 Unaganala: 32 Varthikatte: 13	Sole crops: Ragi, Upland paddy, Maize, Sorghum, Fodder sorghum, Sunflower, Groundnut, Redgram, Fieldbean, Cowpea Intercropping: Redgram+Fodder sorghum Ragi+Cowpea Ragi+Redgram Ragi+Fieldbean	Neem, Silver Oak Grasses <i>Styloxanthes hamata</i> , <i>Styloxanthes Scabra</i> , Hybrid Napier, Sesbania,	Vegetables: Onion, Tomato, Brinjal Chillies, Coriander, Drumstick Flower crops: Chrysanthemum, Jasmine, China aster, Marigold, Crossandra Fruit crops/ Plantation crops: Mango, Sapota, Guava, Cashew, Pomegranate Jackfruit, Musambi, Arecanut, Coconut	Summer ploughing, cultivation on raised beds with mulches, Drip irrigation and suitable conservation practices (Crescent Bunding with Catch Pit etc)
LMU 2 (31 ha.)	15,16 Very deep (>150 cm), clay black soils	Varthikatte: 1,2,14,39,46	Sole crops: Sorghum, Sunflower, Fodder sorghum, Redgram, Field bean, Horse gram Intercropping: Redgram+Fodder sorghum	Hebbevu, Silveroak Grasses: <i>Styloxanthes hamata</i> , <i>Styloxanthes scabra</i> , Hybrid napier	Vegetables: Brinjal, Tomato, chillies, Cucurbits Flower crops: Marigold, Chrysanthemum Fruit crops: Pomegranate, Tamarind, Custard Apple, Amla, Lime, Musambi Arecanut, Coconut	Application of FYM and micronutrients, drip irrigation, Mulching, suitable conservation practises
LMU 3 (149 ha.)	6,7,8, 9, 10 Moderately deep to deep (75-150 cm), red gravelly clay soils	Karegondanahalli: 2,4,5,6,7,8,9,10,11,12 ,14,15,26 Pinnenahalli: 36,37 Unaganala: 31 Varthikatte: 3,5,6,10,11,12,15,19, 20,21,22,23,24,40,42 ,43,44,45	Sole crops: Upland paddy, Ragi, Maize, Sorghum, Groundnut, Fieldbean, Cowpea, Fodder sorghum, Horsegram	Glyricidia, Grasses: <i>Styloxanthes hamata</i> , <i>Styloxanthes scabra</i> , Hybrid Napier	Vegetables: Tomato, Brinjal, Drumstick, Chillies, Curry leaf Flower crops: Chrysanthemum, Marigold, Crossandra Fruit crops/ Plantation crops: Tamarind, Custard Apple, Amla, Lime, Musambi, Arecanut, Coconut	Drip irrigation, Mulching, suitable conservation practices (Crescent Bunding with Catch Pit etc)

To be continued..

LMU No	Mapping Units	Survey Number	Field Crops	Forestry/Grasses	Horticulture Crops with suitable interventions	Suitable Interventions
LMU 4 (63 ha.)	13,14,5 Deep to very deep (100-150 cm), red loamy soils	Hosakere: 45,46,50,51,52,64,65,66,67,76 Unaganala: 33 Varthikatte: 30,31,32,33,35,36,37,38,47,48,49,TANK	Sole crops: Upland paddy, Ragi, Maize, Sorghum, Groundnut, Sunflower, Fieldbean, Cowpea, Fodder sorghum Intercropping: Redgram+Fodder sorghum Ragi+Cowpea Ragi+Redgram	Glyricidia, Subabul, Hebbevu Grasses: <i>Styloxanthes hamata</i> , <i>Styloxanthes scabra</i> , Hybrid napier	Vegetables: Onion, Tomato, chillies Brinjal, Cucurbits Flower crops: Chrysanthemum, Jasmine, Crossandra, China aster Fruit crops/ Plantation crops: Musambi, Sapota, Pomegranate, Banana, Amla, Lime Arecanut, Coconut	Drip irrigation, Mulching, suitable conservation practices (Crescent Bunding with Catch Pit etc)
LMU 5 (45 ha.)	17 Very deep (>150 cm), clay black and lowland soils	Hosakere: 47,48,49,68,69,70,71,72,73,74 Varthikatte: 16,17,18,25,26,27,28,29,34,STREAM	Sole crop: Paddy	Hebbevu, Silveroak Grasses: <i>Styloxanthes hamata</i> , <i>Styloxanthes scabra</i> , Hybrid napier	Fruit crops/ plantation crops: Tamarind, Custard Apple, Amla, Arecanut, Coconut	Providing proper drainage, addition of organic manures, green leaf manuring, suitable conservation practises
LMU 6 (74 ha.)	1,2,3,4 Moderately shallow to moderately deep (50-100 cm), red gravelly loamy soils	Harehalli: 1,2,3,4,5,6,7,49,51,52,53,54,55 Kempanahalli: 11,12,14,15,22 Pinnenahalli: 58, 59 Varthikatte: 41	Sole crops: Upland paddy, Ragi, Maize, Sorghum, Groundnut, Fieldbean, Cowpea, Fodder sorghum, Horsegram	Glyricidia, Grasses: <i>Styloxanthes hamata</i> , <i>Styloxanthes scabra</i> , Hybrid Napier	Vegetables: Tomato, Brinjal, Chillies, Curry leaf Flower crops: Chrysanthemum, Marigold, Crossandra Fruit crops: Custard Apple, Amla, Bael	Drip irrigation, Mulching, suitable conservation practices (Crescent Bunding with Catch Pit etc)



PART - B

Hydrological Inventory of Tyagatur Sub-watershed, Gubbi Taluk, Tumkur District, Karnataka for Watershed Planning and Development



Sujala - III

**Karnataka Watershed Development Project-II
Watershed Development Department
Government of Karnataka**



Hydrological Inventory of Tyagatur Sub-watershed, Gubbi Taluk, Tumkur District, Karnataka for Watershed Planning and Development



ICAR - NBSS & LUP

Prepared by

**ICAR-National Bureau of Soil Survey and Land Use Planning
Regional Centre, Hebbal, Bangalore - 560 024**

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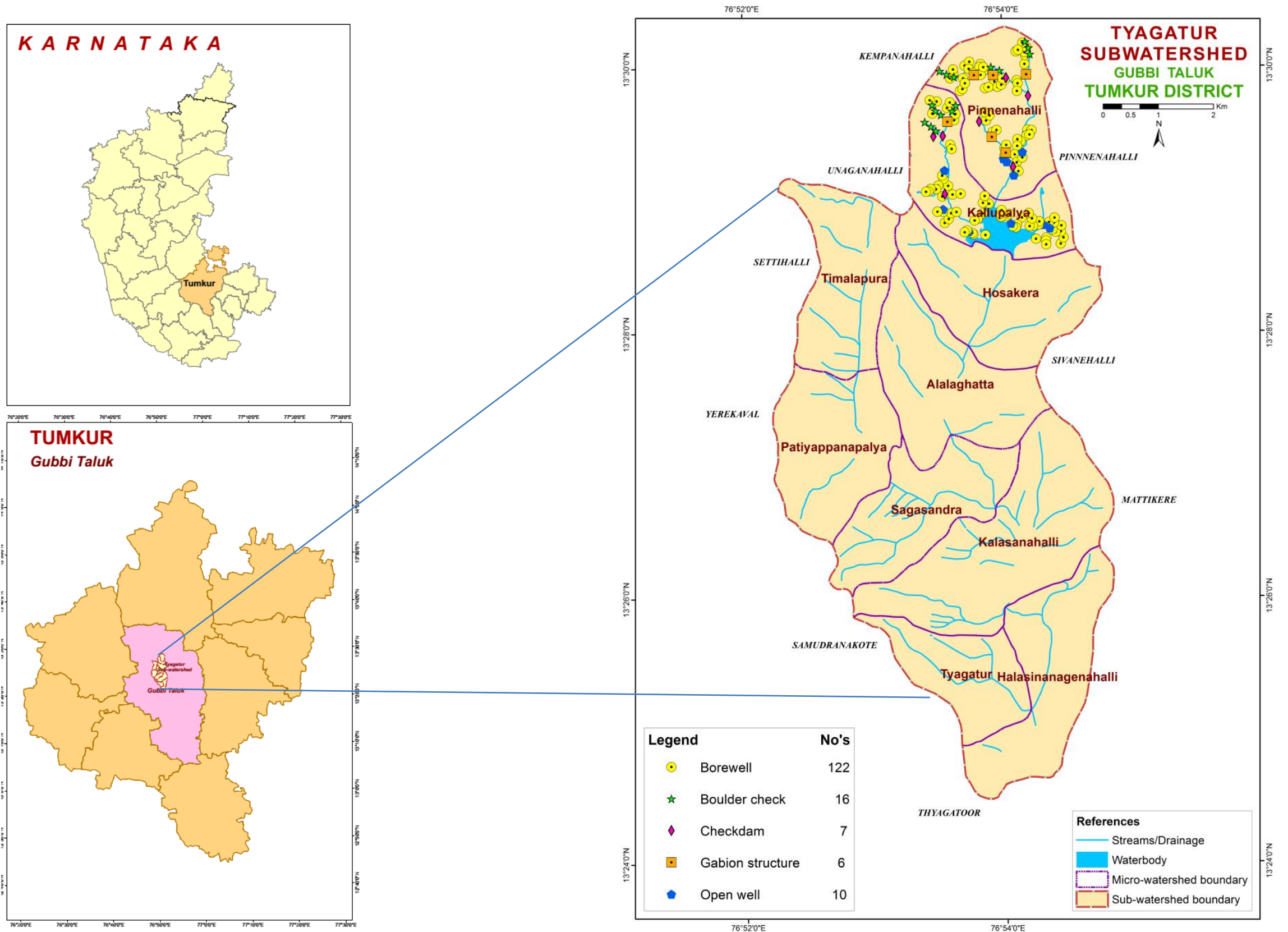
Details of Hydrology Team of LRI Partner Responsible for Preparation of Atlas

Name	Designation
Dr. Rajendra Hegde	Principal Scientist & Head Coordinator
Dr. S. Srinivas	Principal Scientist
Dr. K .V. Niranjana	Chief Technical Officer
Sh. R.S.Reddy	Consultant
Sh. A.G.Devendra Prasad	Consultant
Smt. K.Karunya Lakshmi	Research Associate
Ms. Seema, K.V.	Senior Research Fellow
Dr. Sekhar Muddu (Reviewed and approved)	Professor & Lead Scientist, Dept. of Civil Engineering & ICWaR, IISc, Bangalore
<p style="text-align: right;">Email: hd_rcb.nbsslup@icar.gov.in nbssrcb@gmail.com Phone: Office: 080-23412242,23410993 Fax: 080-23510350</p>	

INTRODUCTION

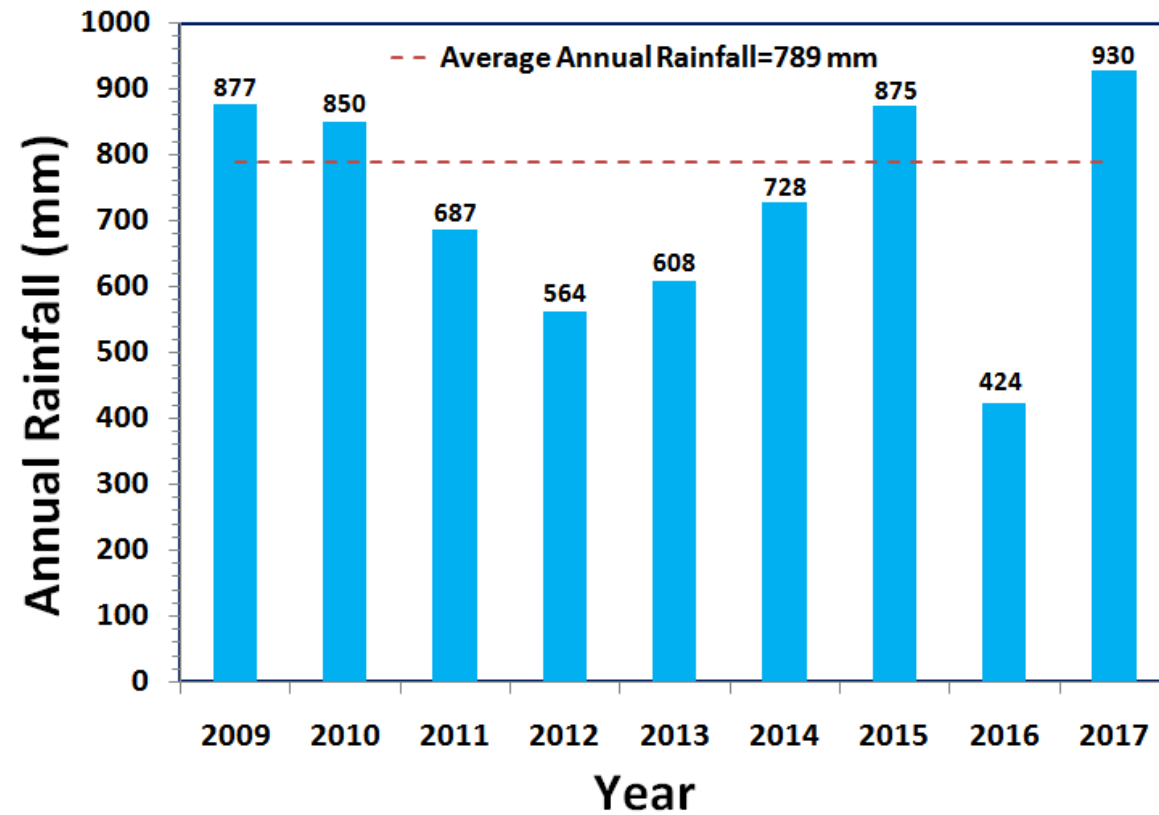
- The inventory and documentation of spatial and temporal changes in hydrological components of Tyagatur sub-watershed (4B3D3R) in Gubbi Taluk, Tumkur District, has been undertaken for integrated planning, development and management.
- Tyagatur sub-watershed (Gubbi Taluk, Tumkur District) is located between $13^{\circ}21' 15''$ – $13^{\circ}28' 47''$ North latitudes and $76^{\circ} 47' 17''$ - $76^{\circ} 53' 42''$ East longitudes, covering an area of about 5380 ha.
- This sub-watershed encompasses of 10 MWs namely Alalaghatta (4B3D3R1d), Halasinanagenahalli (4B3D3R2f), Hosakere (4B3D3R1c), Kalasanahalli (4B3D3R2d), Kallupalya (4B3D3R1b), Patiyappanapalya (4B3D3R2b), Pinnenahalli (4B3D3R1a), Sagasandra (4B3D3R2c), Timalapura (4B3D3R2a) and Tyagatur (4B3D3R2e). Land Resource Inventory (LRI) was generated for two among ten micro-watersheds .
- Average annual rainfall (1960-2014) of the Hobli (Block) pertaining to the sub-watershed is 789 mm.
- In this sub-watershed major *kharif* crops are Maize, Finger millet, Redgram , Groundnut , Sunflower, Paddy and major *rabi* crops are Sorghum.
- Hydrological components namely rainfall (annual, *kharif*, *rabi* and summer), PET, AET, runoff, surface soil moisture, ground water status and water balance are presented.

LOCATION MAP OF TYAGATUR SUB-WATERSHED



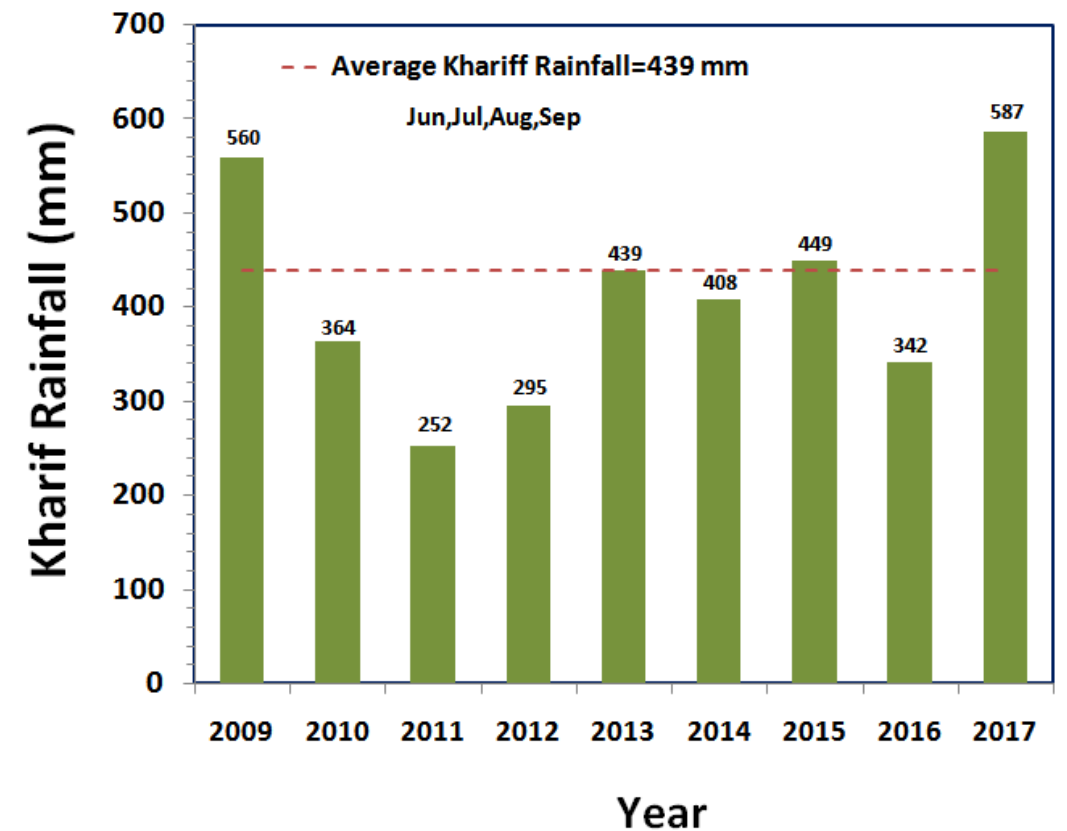
Soil & Water Conservation Structures in Tyagatur Sub-watershed, Gubbi Taluk, Tumkur District

RAINFALL INDEX

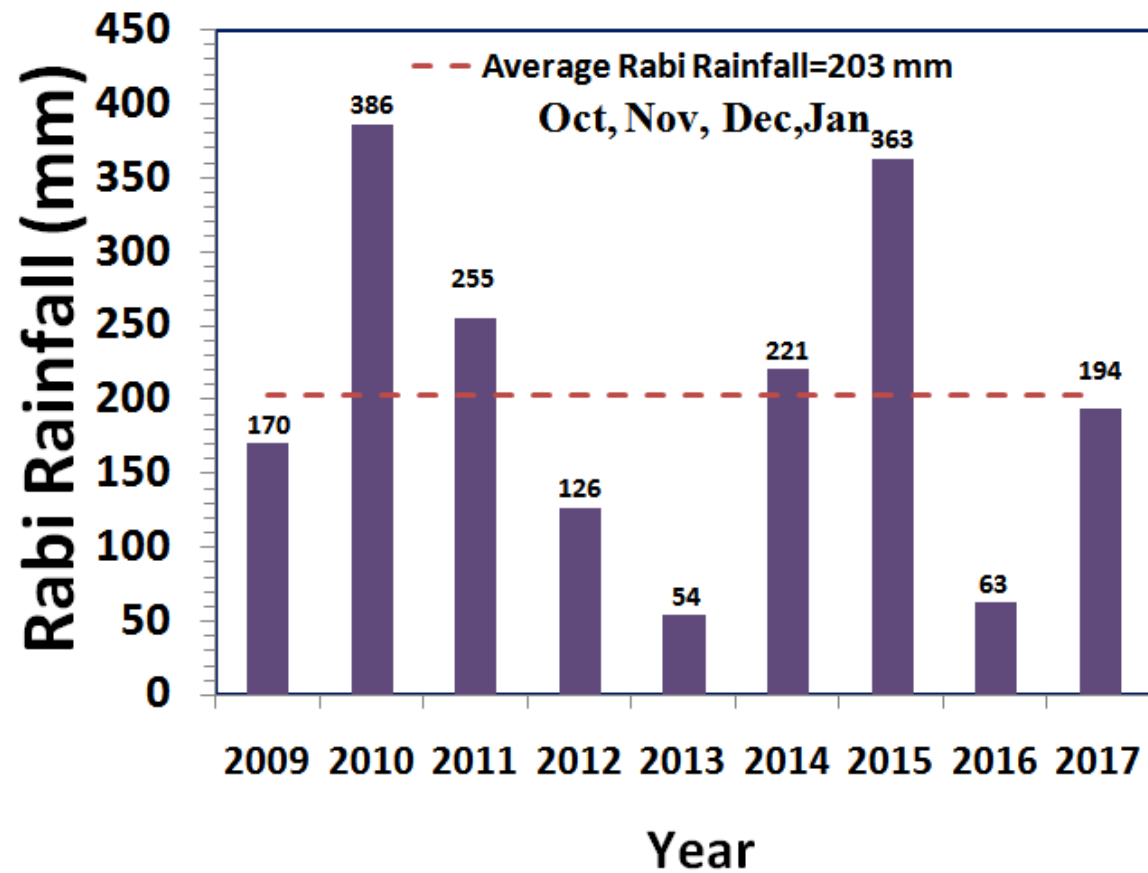


The average annual rainfall (1960-2014) recorded at the Gubbi station in Gubbi taluk of Tumkur district is 789 mm. The annual rainfall at Hagalvadi station (Hobli H.Q.) is presented. During the years 2011, 2012, 2013, 2014 and 2016 the annual rainfall was deficient by 13%, 29%, 23%, 8% and 46% respectively.

The *kharif* rainfall (Jun–Sep) is an average about 58% of the annual rainfall and it typically follows the annual rainfall patterns.

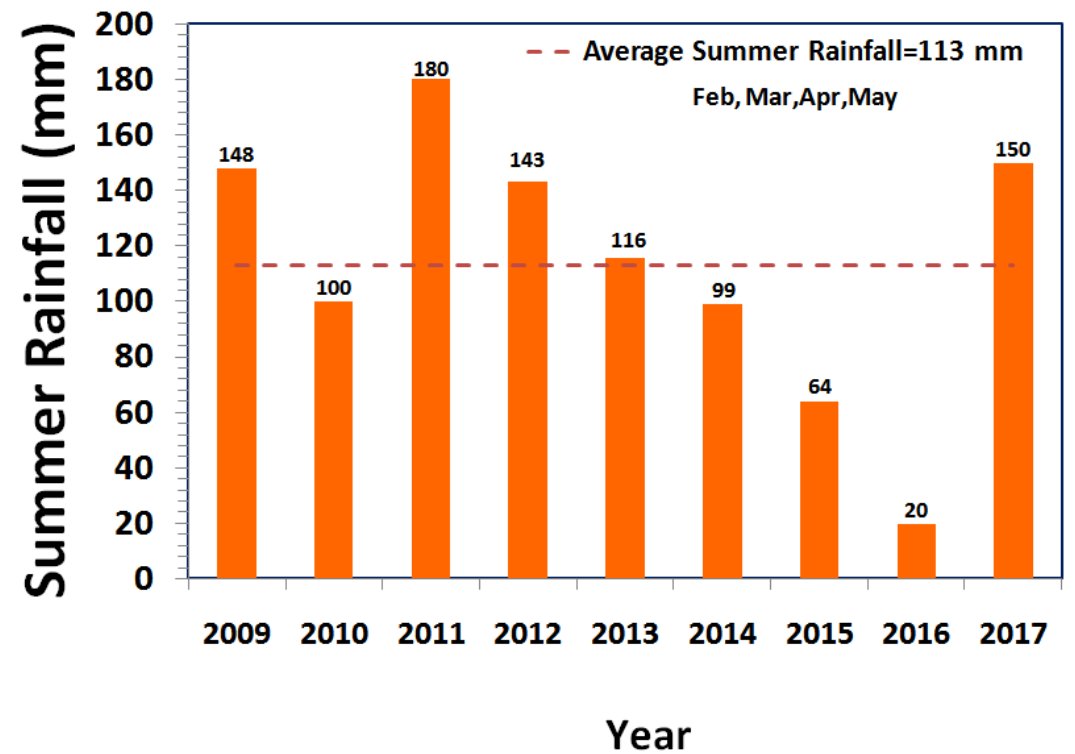


RAINFALL INDEX

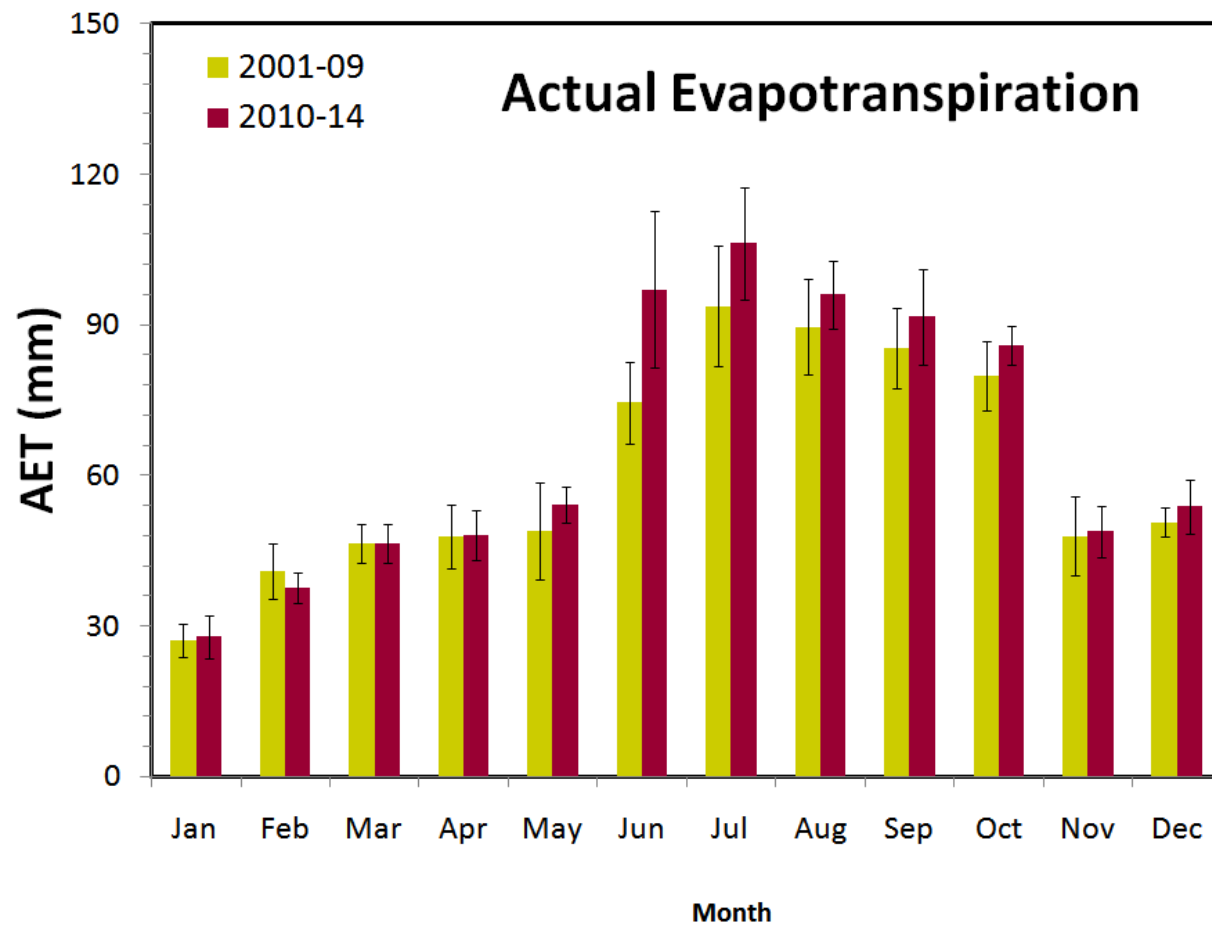
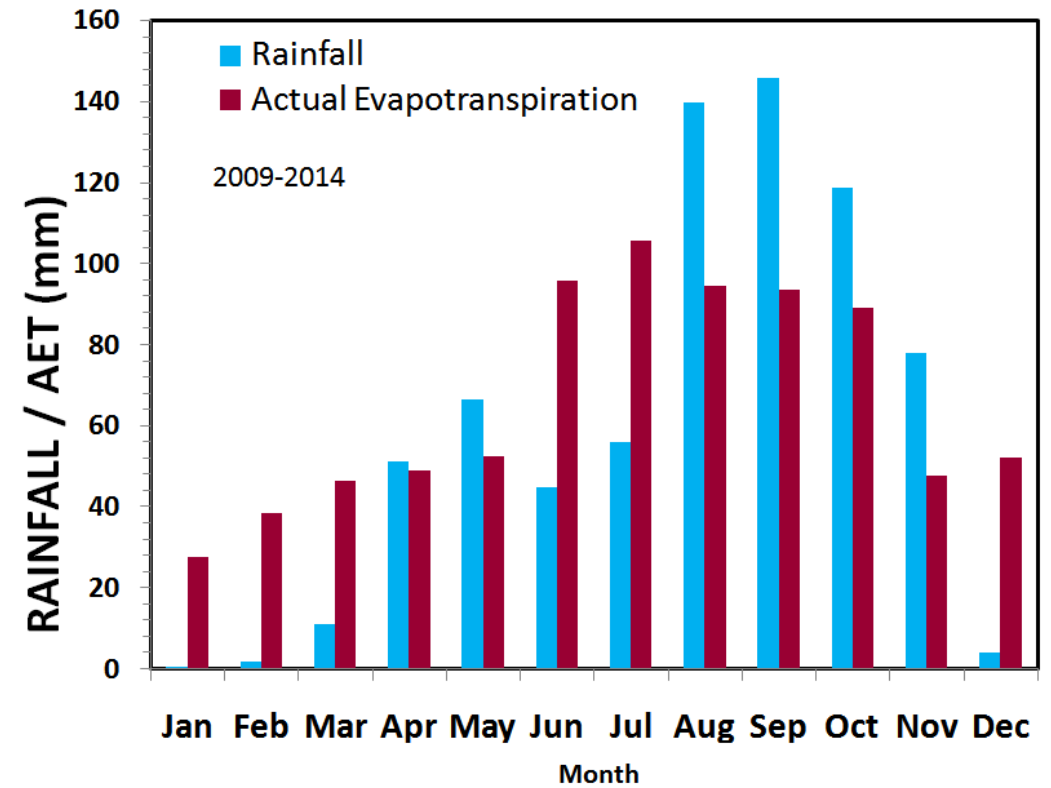
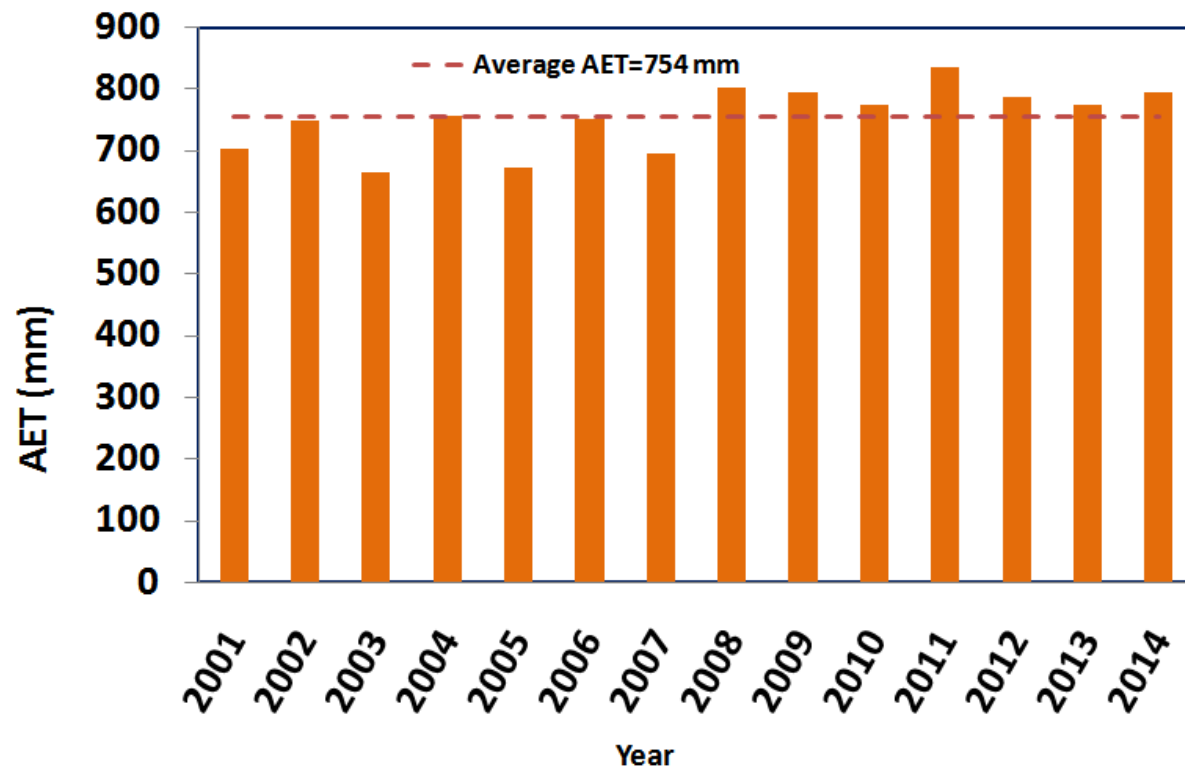


The average *rabi* rainfall (Oct-Jan) is about 27% of the Average annual rainfall. During the years 2009, 2012, 2013, 2016 and 2017 the *rabi* rainfall was deficient by 16%, 38%, 73%, 69% and 5% respectively.

The average summer rainfall (Feb-May) is about 16% of the average annual rainfall.

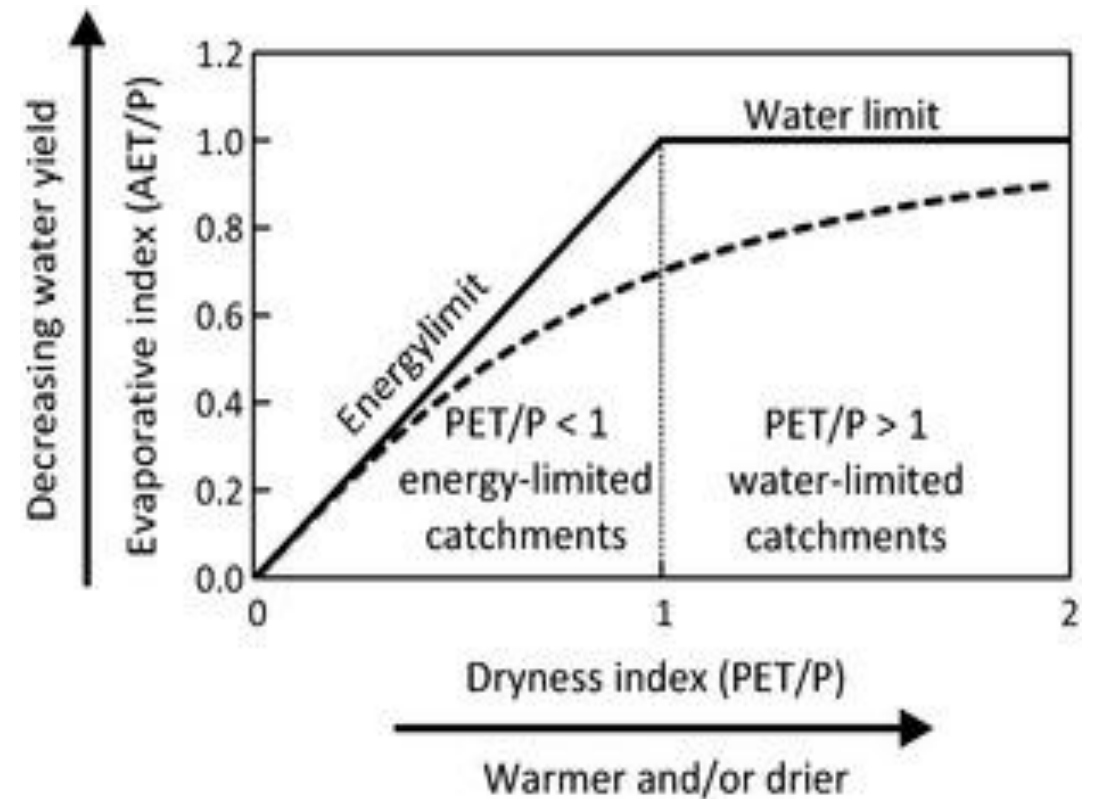
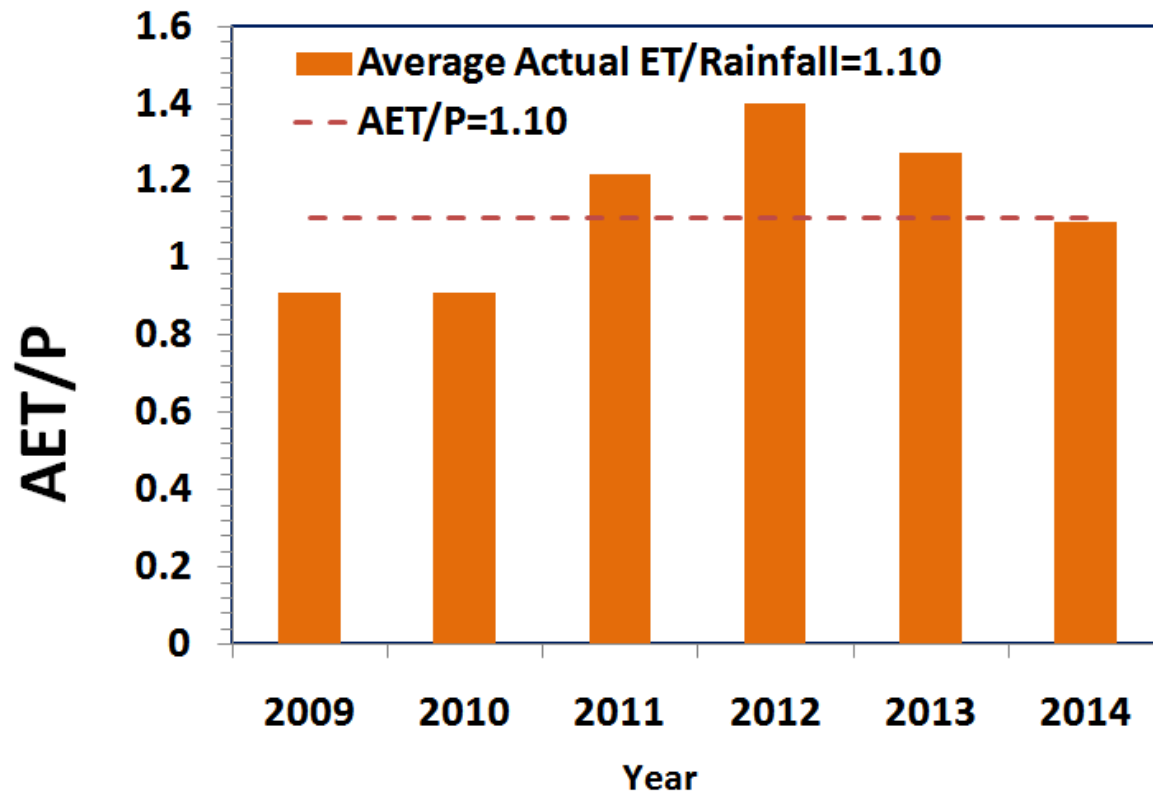


EVAPOTRANSPIRATION

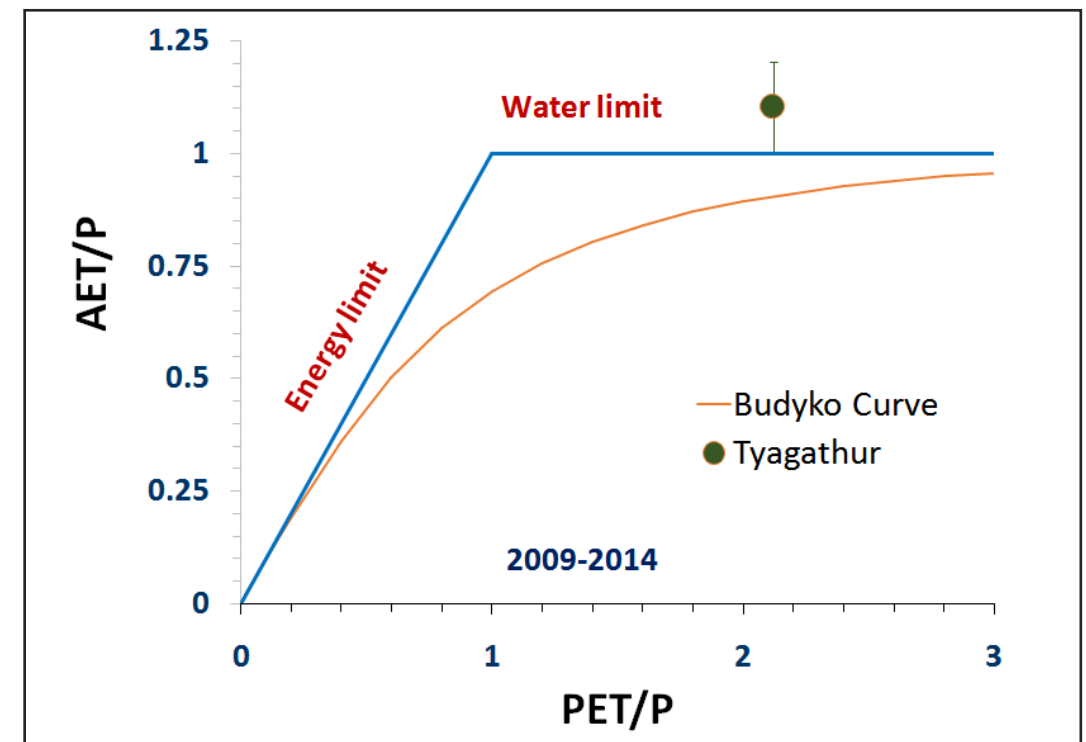


The average annual actual ET is lower than the average rainfall. During *kharif*, average rainfall and AET was found to be 439 mm and 390 mm respectively, whereas in *rabi* it was about 203 mm and 217 mm. The annual ET increased by 8% during 2010-2014 compared to 2001-2009 .

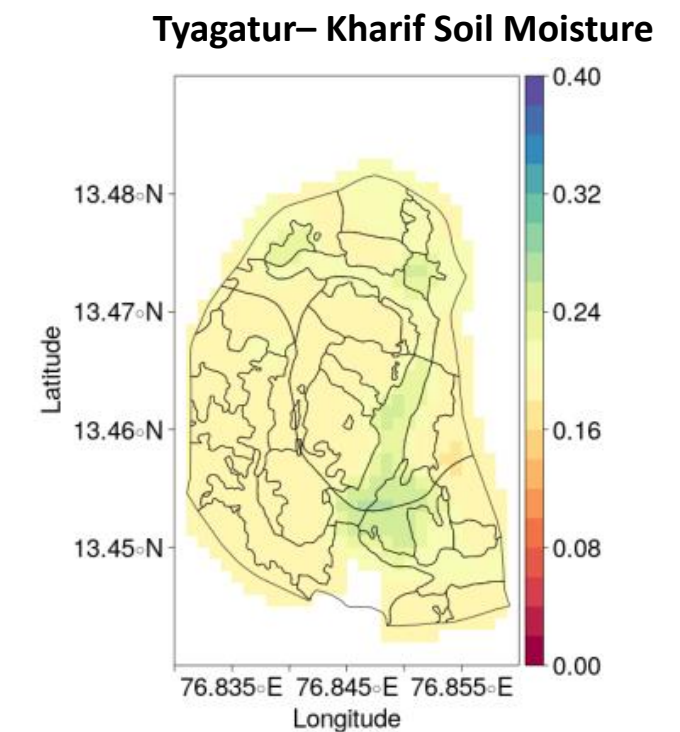
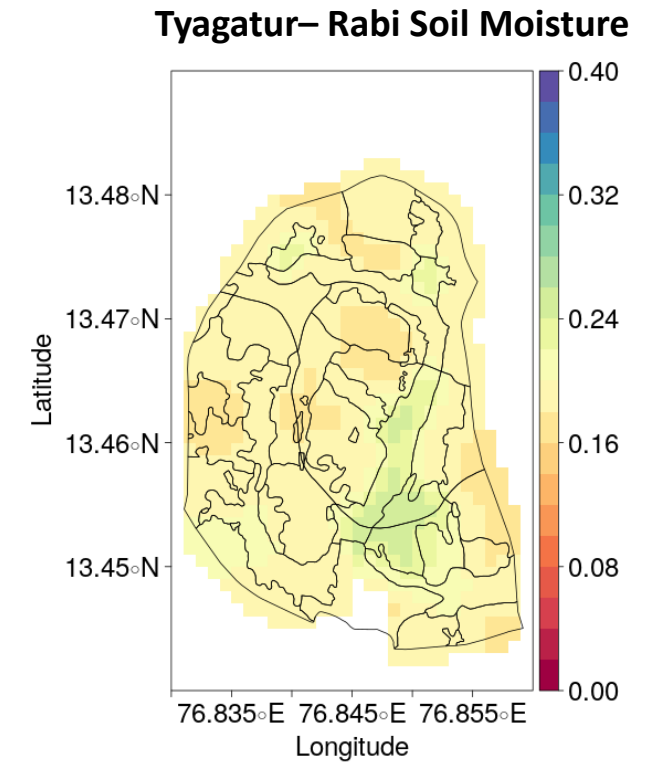
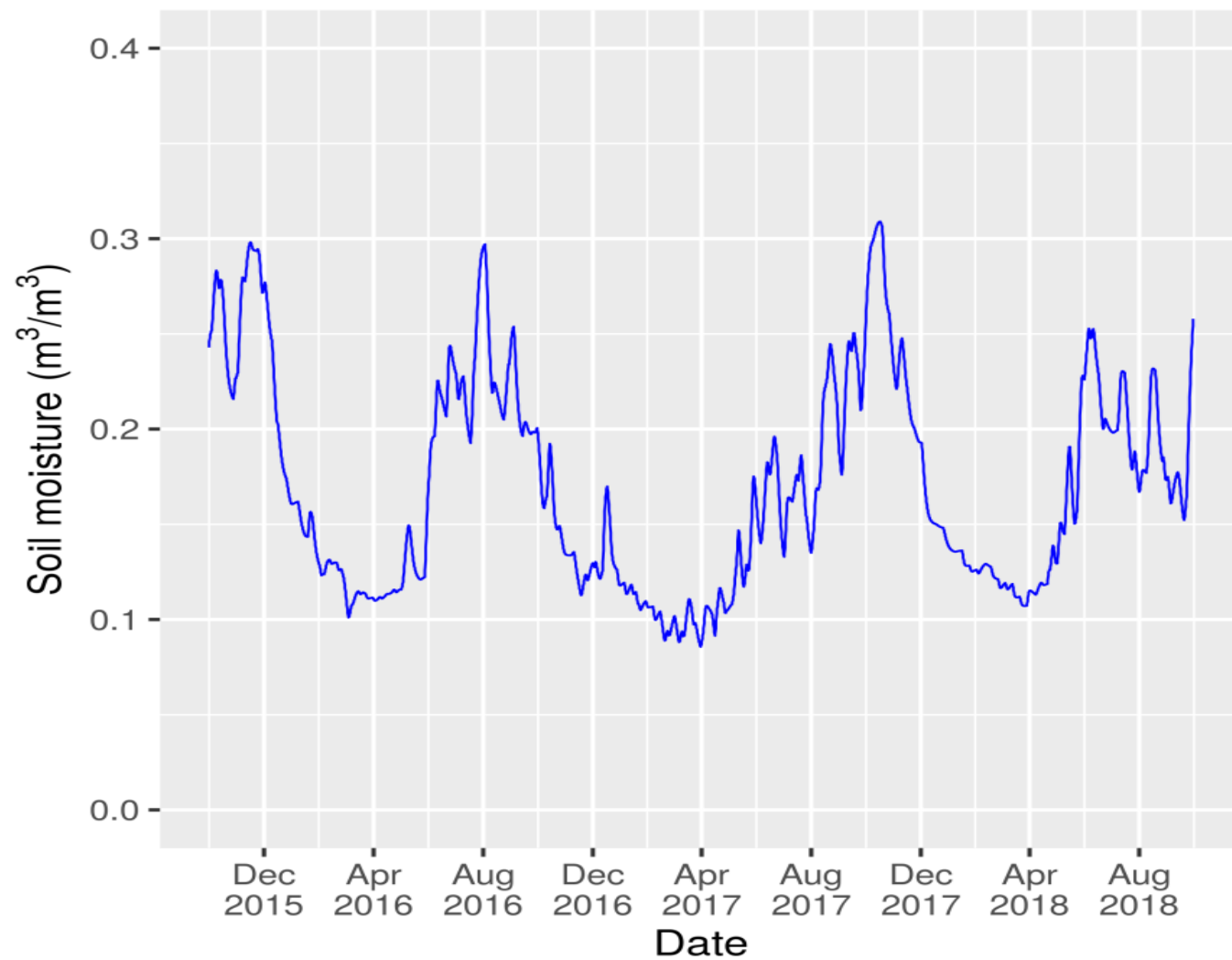
EVAPOTRANSPIRATION INDEX



The average AET/P ratio was about 110%, which is higher than the sustainable limit of about 80%. Even during extremely lower rainfall year of 2012, AET was 760 mm. This suggests the presence of water storage and utilization from other sources such as groundwater, which buffered the lower rainfall.



SATELLITE RETRIEVED SOIL MOISTURE

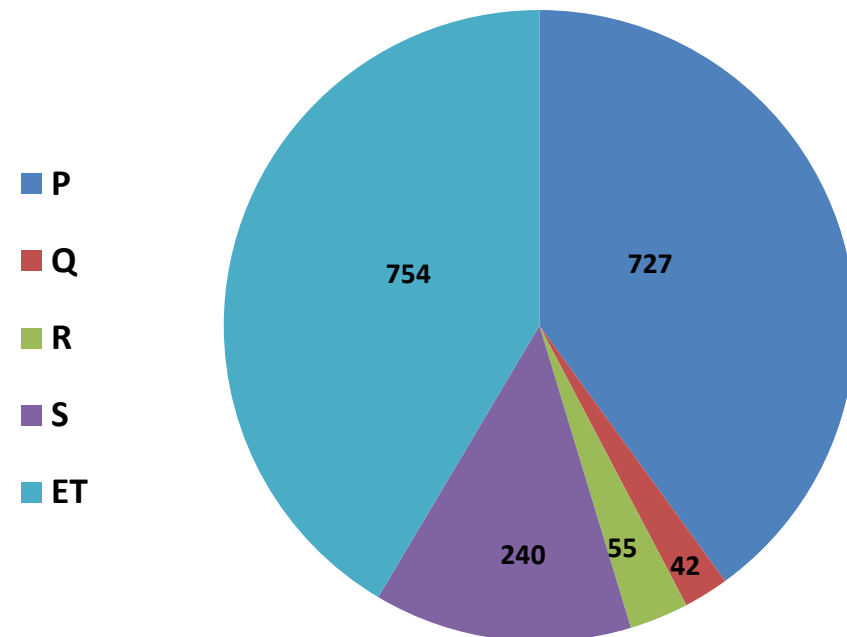


The method developed for retrieving soil moisture from multi-satellite observations allowed to map surface soil moisture behavior in the micro-watershed. The available surface moisture was varied in the range of 19-26 % in *kharif* and 12-20% in *rabi* seasons of 2016 and 18-24 % in *Kharif* and 15-29% in *rabi* seasons of 2017.

WATER BALANCE

$$Q = P - E - R - S$$

- Q = Runoff
- P = Precipitation
- E = Evapotranspiration
- R = Groundwater recharge
- S = Soil moisture storage change

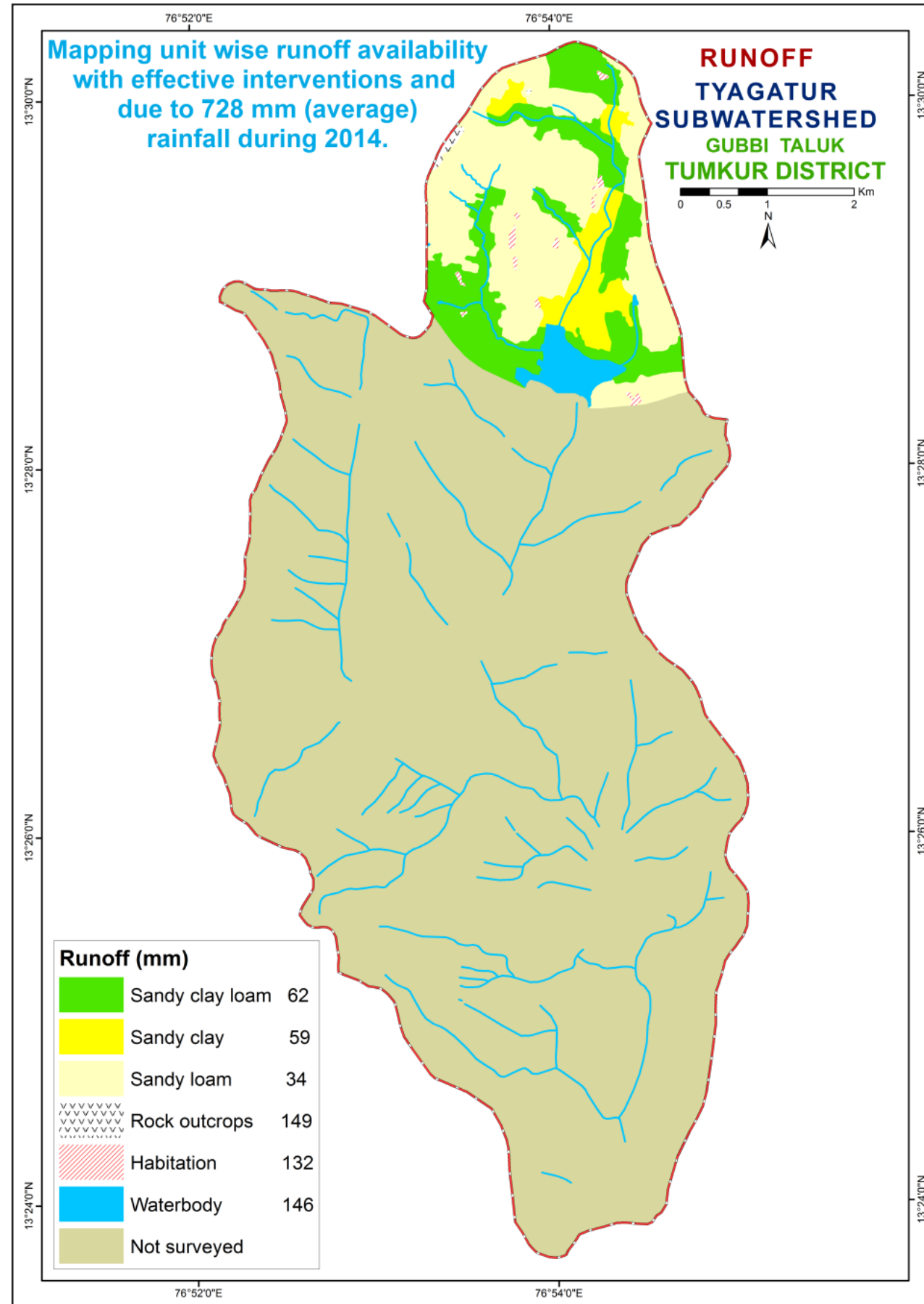


During August-November months, Precipitation is higher than Evapotranspiration, hence Runoff can occur in the watershed.

P = 727 mm (average of 2009-2017) ET = 754 mm R = 55 mm S = 240 mm Q = 42 mm

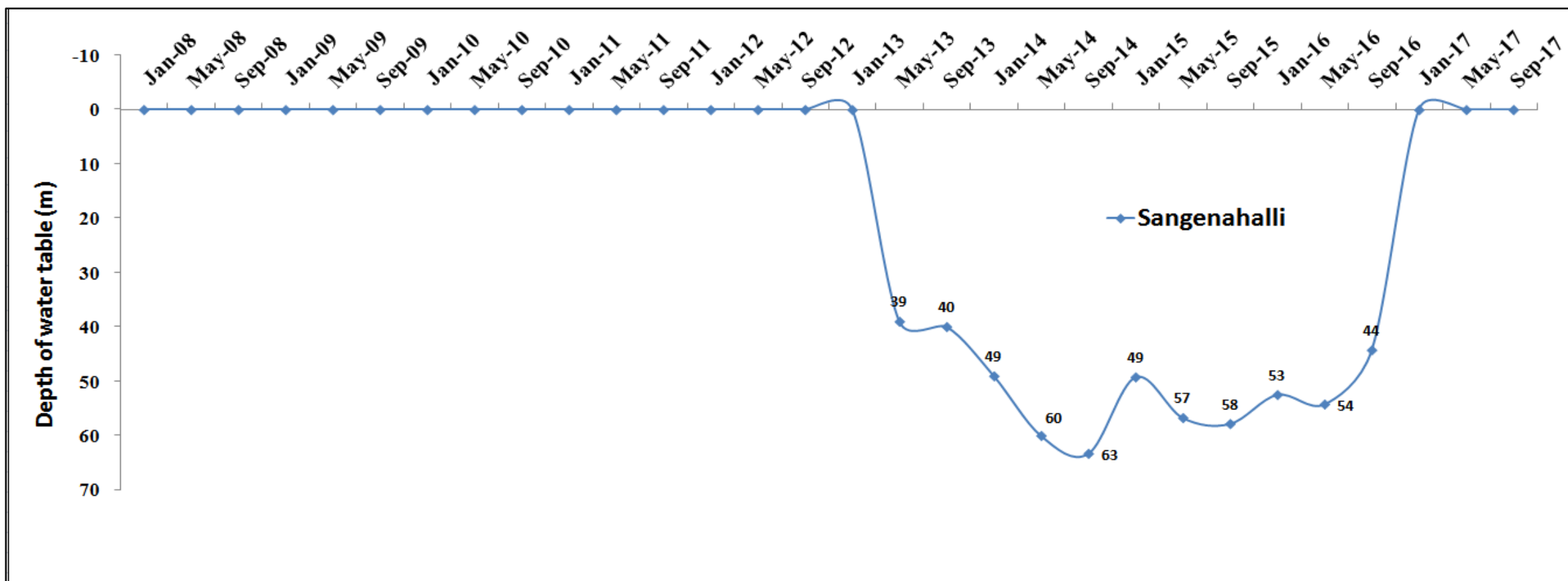
Sl. No.	Parameters	Average_ 2014 (mm)
1.	Rainfall	728
2.	Runoff availability with existing conditions	86
3.	Runoff availability with effective interventions	53
4.	Runoff allowed as environmental flow at the outlet	11
5.	Runoff excess for harvesting by construction of structures	42

RUNOFF



GROUND WATER STATUS

SANGENAHALLI STATION



The total number of wells present in Tyagatur Sub-watershed as per LRI data is 132 (122-Borewells and 10-Open wells). The groundwater level shown above is from the data obtained from Dept. of Mines & Geology for the nearest station Sangenahalli. The graph depicts the groundwater levels during the years 2008-2012 and 2017 were constant, whereas during the years 2013-2016 were slightly varying.

SUMMARY

- The average annual rainfall of 789 mm in the Tyagatur sub-watershed as recorded from the Hagalvadi station data.
- 58%, 27% and 16% of the annual rainfall occurs during *kharif*, *rabi* and summer seasons respectively and exhibited a higher temporal variability.
- The evapotranspiration estimation tool developed indicates that the watershed water balance is in deficit. The cropping & irrigation choices are not appropriate and need to be altered to shift the deficit water balance.
- The estimated runoff available to use is 42 mm for an average annual rainfall of 727 mm (2009-2017). The utilizable groundwater is 38 mm (70% of 55 mm recharge estimated). This means the total available water resource combining the soil moisture store for kharif & rabi (240 mm) and utilizable runoff plus recharge is 320 (=240+42+38)
- The average actual evapotranspiration estimated in the watershed based on the current land use and irrigation practices for the kharif and rabi seasons is 607 mm. Hence the amount of water use for kharif and rabi seasons may be estimated as 759 mm (i.e. 125% of AET). This demand for the two seasons is higher by 439 mm, i.e. (759-320). The AET in June-Sept months is more than the rainfall. Hence, there is slightly less opportunity to harvest the excess water through watershed management practices for utilizing during rabi season.
- The total number of wells present in Tyagatur Sub-watershed as per LRI data is 132 (122-Borewells and 10-Open wells). The groundwater level shown above is from the data obtained from Dept. of Mines & Geology for the nearest station Sangenahalli.