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LAND RESOURCE INVENTORY, PRIORITIZATION OF MICRO-WATERSHED FOR SOIL, WATER AND LAND USE IN NORTHERN DRY ZONE OF VIJAYAPURA DISTRICT OF KARNATAKA BY USING GIS TECHNIQUES

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ABSTRACT

A study was conducted to determine land capability and to develop suitability map based on soil characteristics and climate factors of sub watershed area. Detailed soil survey was carried out for Atharga (4D5A6G) sub watershed which comes under Indi taluk of Vijayapura district, Karnataka to acquire the comprehensive data related land resources. From the study area, it was observed that based on soil-site characteristics four soil series were identifiedBabaleshwar (BBL),Dadamatti (DMT), Halagani (HLG), Jumanal (JML), Naihalla (NHL), Tenihalli (THL) series and mapped into 14 mapping units using GIS techniques. Atharga sub watershed area has been grouped into four land capability classes (LCC) viz., I, II, III, IV with four subclasses lies Is, IIes, IIIs, IVes. Subclass 'e' is due to major limitation of soil property group 'e' i.e. erosion and slope, subclasses 's' is due to major limitations group 's' having parameters like texture, depth and gravellines. Subclass 'se' and 'es' are due to limitation of both soil parameters group above mentioned, however 'se' and 'es' are different classes which are based major limitation one of the group and followed by other group. Land capability map was developed using GIS techniques which indicates that out of 1044.36 ha study area, LCC class IIes covering major area i.e., 354 ha (33.88%), followed by class IIes i.e., 136 ha (13.0%), class IIs i.e., 97 ha (9.32%) and minor area of 3 ha (0.28%) area is covered by class IIIs. Soil suitability assessment indicates that majority of land is moderately suitable for agriculture. Class II soils are designated as moderately fertile agricultural land with significant constraints. However, with special conservation practices soils under class II can be used for cultivation of different crops. Class IV soils are categorized as reasonably fertile for intermittent cultivation, characterized by significant restrictions that limit crop options but with careful management practices theses can be used for cultivation of crops. Therefore, the utilization of a land use planning approach (LUP) is instrumental in formulating tailored land resource management strategies to enhance land productivity, mitigate land degradation and attain sustainability goals.

Keywords **:** Crop suitability, Geographic information system (GIS), Land resource inventory (LRI) and Cropping pattern.

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 geographical 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 farmlands and water resources for non-agricultural purposes. Sehgal *et al.,* 1990. 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. Naidu *et al.* 2006. 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. Katyal *et al.* 2003.

The district of Vijayapura lies in Northern zone of Karnataka it is grouped under northern dry zone of Karnataka (Agro-climatic zone-3). The district covers an expanse of 10,541 sq, km of land and lies between 15^0 50' and 17^0 28' North latitude and 74^0 54' and 76^0 28' East longitude. The district is bounded by districts namely Yadgiri on east, Kalburgi on the northeast, Bagalkot on the southwest and Maharashtra state on the north-west. The geology of the district consists of Deccan trap, Bhima group and peninsular gneiss. The major agricultural area is under rainfed farming dominated by crops like cotton, maize, groundnut, chickpea and pulses with very little horticultural crops. Shivaprasad *et al.,* 1998 .

Materials and Methods

Description of study area

The Atharga Sub-watershed is located in between $17^0$0'0" to $16^0$57'30" North latitudes and $75^0$50'30" to $75^0$58'0"East longitudes, covering an area of about 1044.36 ha. Extends over entire Koppal, Vijayapur, and Bellary district and five taluks of Belgaum, six of Bagalkot, two of Raichur, one of Dharwad and Davanagere, four of Gadag. The total geographical area of the zone is about 4.78 M ha. Most of the zone is at an elevation of 450-800 m MSL, but some area is between 800 and 900m. Average annual rainfall of the zone ranges from 464.5 to 785.7 mm. The soils are medium and deep black clay in major areas, sandy loams in remaining areas. The main cropping season is kharif. sorghum, maize, bajra, red gram groundnut, green gram, cotton, sugarcane, wheat, chickpea, horticultural crop like grape, lime, pomegranate and vegetables like chilli, onion, brinjal and cucurbits are the important crops of the zone.

Soil survey and mapping

A comprehensive soil survey of the study area was conducted utilizing data from IRS-LISS IV and Cartosat-1 satellite images (1:8000 scale) and Vijayapura district toposheet as per procedure outlined by Land resource inventory (LRI) for surface study during which the area was intensively traversed, surface characteristics like texture, slope, erosion, gravellines, calcareousness and stoniness were recorded. Surface soil samples were collected at 320m grid intervals and were analysed for macro and micronutrients status, salinity, soil reaction and organic carbon. Based on soil heterogeneity, pedon locations were marked to carry out sub surface study. At each pedon location, a new profile was excavated and a detailed horizon-wise examination was conducted. Soil samples were then collected and analysed for essential physical and physicochemical properties following standard analytical procedures. Following the correlation of these soil properties, classification into four series was carried out according to the guidelines provided in the field guide for LRI Sujala-III project, ICAR-NBBSS & LUP. Subsequently, these soils were mapped into 14 distinct mapping units based on variations in texture, depth, slope and erosion characteristics.

Land capability and soil suitability assessment

The soil-site characteristics of various soil units were determined by calculating the weighted average of each soil property. Which was then interpreted to assess land capability. The properties were compared with the criteria outlined for land capability

classification (Table 1) the land capability classification is organized into three primary categories of soil, namely:

i) Capability unit, ii) Capability subclass, and iii) Capability class.

i. Land capability unit is a categorization of soils with similar responses to cultivated crops and pasture plants, often determined by their respective yields.
ii. Capability subclass is a classification of capability units that share similar types of limitations and hazards.
iii. Land capability refers to group of soils with the same degree of limitations, which escalate from class I to VIII. Classes I to IV are suitable for cultivation, while classes V to VIII are not suitable for cultivation but may be suitable for grazing, forestry, wildlife maintenance, recreation or watershed protection, ICAR (1980).

In the present study the land capability classification is followed as per third category (III) of above-mentioned classes which is mainly based on the inherent soil characteristics, external land features and environmental factors. The land capability classes and subclasses were determined according to the guidelines provided in the LRI Field Guide, REWARD project, ICAR-NBSS & LUP (2016). With the advancements in remote sensing and Geographic Information System (GIS), thematic layers were generated, integrated, and subjected to spatial analysis to create land capability maps and soil-site suitability maps. This process was conducted using the ArcView Interface within ArcGIS 10.8.2 software. Suryawanshi *et al*. (2005), Mishra *et al* (2006), Mishra and Babu (2009) Mary Silpa and Nowshaja (2016).

Result and Discussion

Soil map and soil mapping units

A soil map is crafted to depict the spatial distribution of various soil types or other mapping units relative to prominent physical and cultural features of the Earth's surface. In the identification of soil mapping units within the study area, input parameters such as soil series, soil texture, soil depth, slope, erosion and gravel content were utilized. Study area is grouped into four series namely, Babaleshwar (BBL), Dadamatti (DMT), Halangeni (HLG), Jumanal (JML), Naihalla (NHL) and Tenihalli (THL) series (Table 2). Babaleshwar series covers 495 ha (87.39%) of the study area and they are very deep, black soils, vary from clay loam to clay texture. Dadamatti series which cover 127 ha (12.03%) area and they are shallow clay soil with gentle sloping. Halangeni series covers 143 ha (13.68%) and are classified as very deep, Jumanal series covers 121 ha (11.58%) and they are deep with gently sloping, Naihalla series covers 56 ha (5.33) and 56 ha (5.35%) of Atharga sub-watershed area belongs to Tenihalli series which is characterized by clay soils which are moderately deep moderately eroded with gravel soils.

These mapping units were delineated into fourteen categories during various phases of soil series using the Arc View Interface of ArcGIS 10.8.2 GIS software (refer to Fig. 1). The legend for mapping units is represented as follows: for example, "DMTiB2g1", where the first three capital letters denote the name of the series (e.g., DMT for Dadamatti), followed by a lowercase letter indicating surface texture (i.e., for sandy clay), the subsequent capital letter denotes slope (e.g., B for 1 to 3% slope), the following numerical value signifies erosion status (e.g., 2 for moderately eroded), and finally, "g1" indicates the class of gravellines (e.g., gravelly). The design of the legend and the types of mapping units for the study area were determined according to the procedures outlined in the LRI Field Guide for the REWARD project. Soil depth varied from shallow to very deep, slope grouped under very gently sloping class (1-3%) with moderately eroded with gravelly (15-35%) class. Fig. 2 (a) and (b) depict the EC and pH of the Atharga sub watershed area.

Land capability classification

Based on the soil-site characteristics of the study area, the soils were classified into two land capability classes (refer to Table 3). These classes are described as follows:

Class III: Our study indicates that majority of Atharga sub-watershed area i.e., 874 ha (83.73% of the study area) were categorized as land capability class III lands (Fig. 3). Soils within this class are considered moderately good cultivable lands with limitations that erosion or runoff. These limitations may include one or more of the following factors: 1) soil depth 2) gravellines 3) light or heavy texture 4) salinity or alkalinity. Hence soil conservation practices like ploughing across the slope for field crops, levelling of land, ridges and furrows, providing proper drainage will help to improve the soil properties and land productivity. Sharma *et al.* (1987).

Class IV: The result showed that 11.62% (121 ha) of Athargasub watershed area has been categorized into IV class with severe limitation of erosion/runoff. These soils are categorized as fairly good cultivable lands, suitable for occasional cultivation only due to

severe limitations. They are characterized by: 1) severe restrictions on the choice of crops, 2) high susceptibility to erosion, 3) steep slopes, 4) shallow soil depth, 5) low water-holding capacity, 6) poor drainage, and 7) severe alkalinity and salinity. These soils exhibit moderate to rapid permeability and are moderately well-drained, with severe limitations regarding slope, moderate to severe limitations in erosion and depth, profile development, and base saturation. They also have moderate limitations in terms of coarse fragments and organic carbon content. Natarajan *et al.* (2015). To achieve sustainable production of field crops and horticulture on these soils, management practices such as terracing, strip cropping, and contour tillage may be necessary. Reported from their study that in IVth class soils occasional cultivation is rotated with hay or pasture, or by orchards and should be protected by permanent cover crops for control of intensive erosion. Amara *et al.* (2021).

Conclusion

Atharga sub watershed land capability maps generated from information collected through LRI depicts that all the study area belongs to arable lands and it is fit for cultivation. In the study area, there were no lands categorized as Class I. The majority of the area falls under Class III lands, Soils within this class are considered moderately good cultivable lands, Hence soil conservation practices like ploughing across the slope for field crops, levelling of land, ridges and furrows, providing proper drainage will help to improve the soil properties and land productivity. Class IV lands can be utilized for crop cultivation by adopting major soil conservation practices. Suitable soil conservation and management practices like graded bunds, terracing, strip cropping and contour-tillage should be followed to improve the soil physico chemical properties along with enhancing the productivity. Hence site specific LCC study and its interpretation helps to conserve the valuable agricultural resources and to achieve the sustainability. The capability maps generated from information collected through field work and topographical maps for Atharga sub-watershed area shows that all the study area belong to arable lands and fit for cultivation. Thus the data on crop-land suitability can help farmers and decision makers to develop new crop management systems along with enhancing land productivity. The above studies and information will be helping farmers to go for horticulture cropping system.

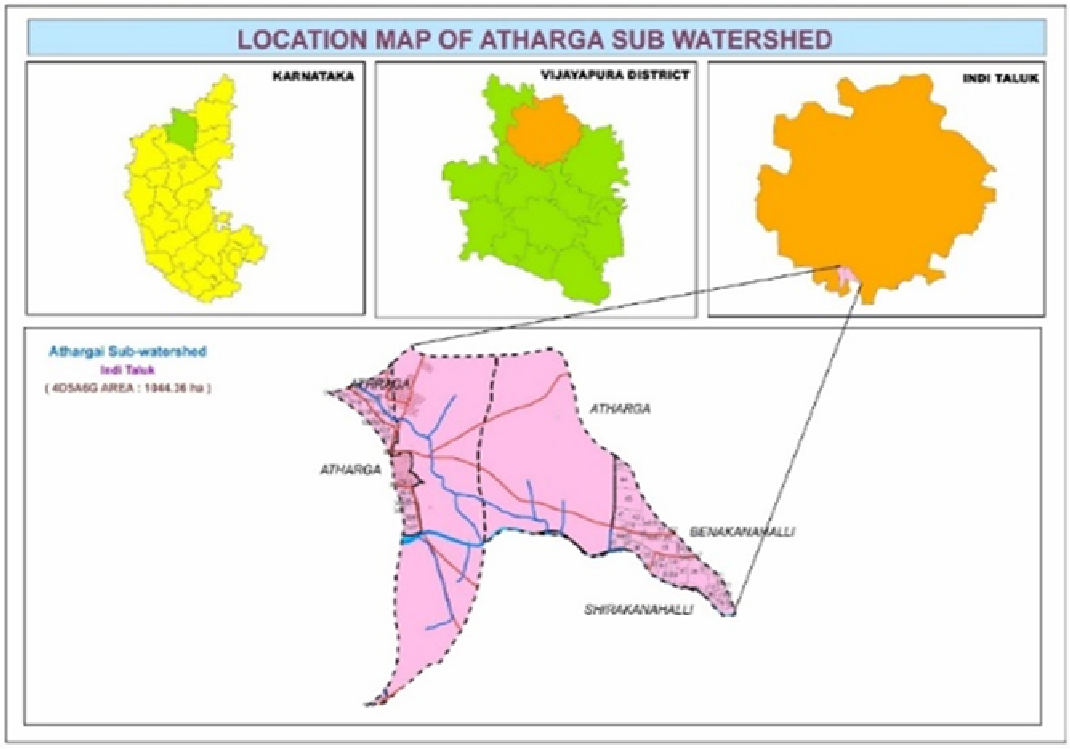

Fig 1: Location map of Atharga sub-watershed

Table 1: Parameters and their rating to be used for grouping parcels into land capability classification (LCC) units/classes

Characteristics	LCC classes							
	I	II	III	IV	V	VI	VII	VIII
Climate	Humid with well distributed rainfall	Humid with occasional dry spells/sub humid yield frequently reduced by droughts	-	Semi-arid/Arid	-	-	-	-
Slope (%)	<1%	1-5% (Red soils), 1-3% (Black soil)	5-10%	10-25%	-	25-50%	>50%	-
Erosion	Slight	Moderate	-	Severe	-	Very severe	-	-
Drainage	Well to moderate drained	Imperfect to poor	Very poor	-	-	-	-	-
Soil depth	>100 cm	50-100 cm	25-50 cm	10-25 cm	-	<10 cm	-	-
Texture	Sl, scl, cl, l	sc, si, c	c	ls	s	-	-	-
Gravels (%)	<15	15-35	35-60	>60	-	-	-	-
Rock out crops (%)	<2	2-10	10-50	50-90	50-90	-	-	>90
Salinity (EC)	<2	2-4	4-8	8-16	-	-	-	-
pH	6.5	-	5.5-6.5 & 7.5-8.5	<4.5, 4.5-5.54 & 8.5-9.5	-	-	-	-
Permeability	Very slow	Moderately slow	Slow	Very slow	-	-	-	-

Source: Ref. 6.: Texture classes denoted in the table indicate: sl: sandy loam, scl: sandy clay loam, cl: clay loam, l: loam, sc: sandy clay, si: silt, c- clay, ls: loamy sand and s: sand

Table 2 : Mapping unit description of Atharga sub-watershed

Soil. No.	Mapping unit	Mapping Unit Description
1	BBLmB2	Very deep (>150 cm), clay soils developed on very gently sloping (1-3%), with moderate erosion.
2	BBLmB3	Very deep (>150 cm), clay soils developed on very gently sloping (1-3%), with severe erosion.
3	BBLmB2g1	Very deep (>150 cm), clay soils developed on very gently sloping (1-3%), moderately eroded with gravelly (15-35%).
4	DMTmB2	Shallow (25-50 cm), clay soils developed on very gently sloping (1-3%) with moderate erosion.
5	DMTmB2g1	Shallow (25-50 cm), clay soils developed on very gently sloping (1-3%), moderately eroded with gravelly (15-35%).
6	DMTmB2g2	Shallow (25-50 cm), clay soils developed on very gently sloping (1-3%), moderately eroded with very gravelly (35-60%).
7	HLGmB2	Deep (100-150 cm), clay soils developed on very gently sloping (1-3%), with moderate erosion.
8	HLGmB3	Deep (100-150 cm), clay soils developed on very gently sloping (1-3%), with severe erosion.
9	JMLmB2	Deep (100-150 cm), clay soils developed on very gently sloping (1-3%), with moderate erosion.
10	JMLmB2g1	Deep (100-150 cm), clay soils developed on very gently sloping (1-3%), moderately eroded with gravelly (15-35%).
11	NHLmB2g2	Moderately shallow (50-75 cm), clay soils developed on very gently sloping (1-3%), moderately eroded with very gravelly (35-60%).
12	NHLmC3	Moderately shallow (50-75 cm) clay soils developed on gently sloping (3-5%) with severe erosion.
13	THLmB2	Moderately deep (75-100 cm), clay soils developed on very gently sloping (1-3%) with moderate erosion.
14	THLmB2g1	Moderately deep (75-100 cm), clay soils developed on very gently sloping (1-3%), moderately eroded with Gravelly (15-35%).

Source: WDPD project, UHS, Bagalkot

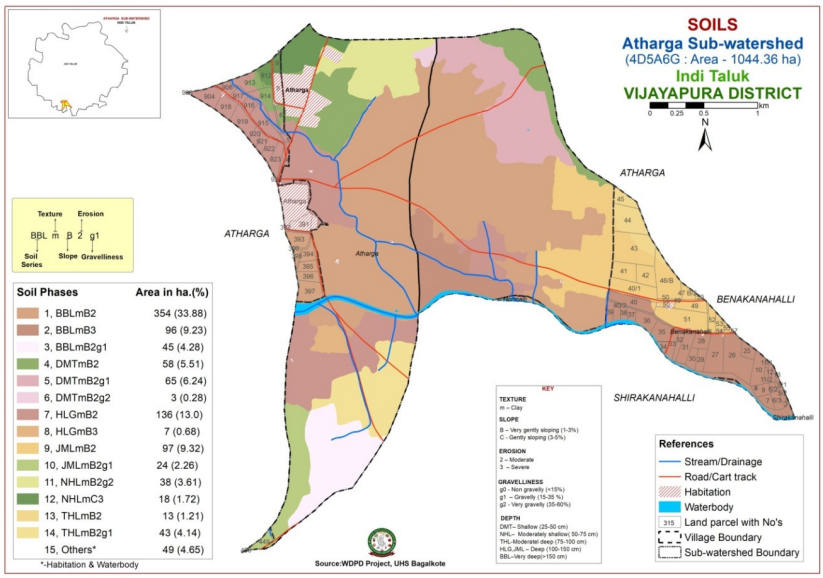

Fig 2 (a): Different mapping units of Atharga sub watershed

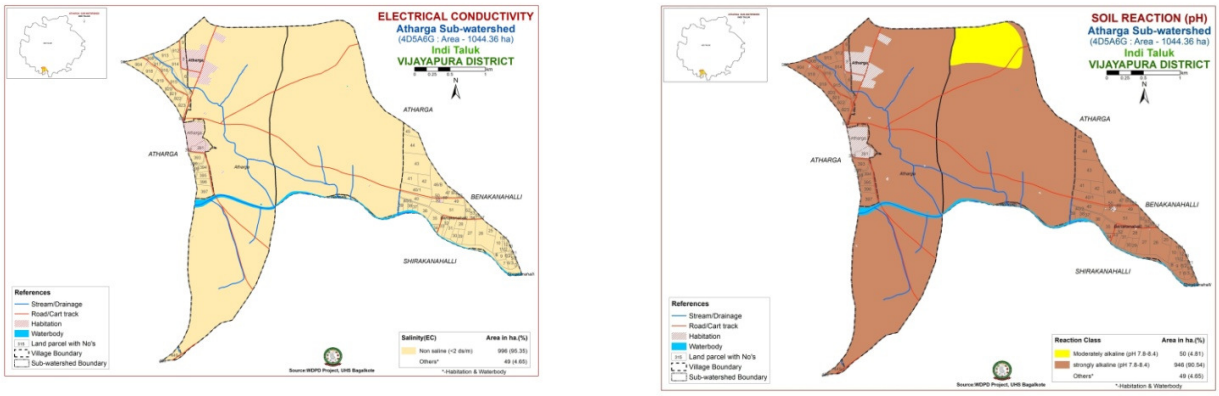

Fig 2 (b): The EC and pH of the Atharga sub watershed

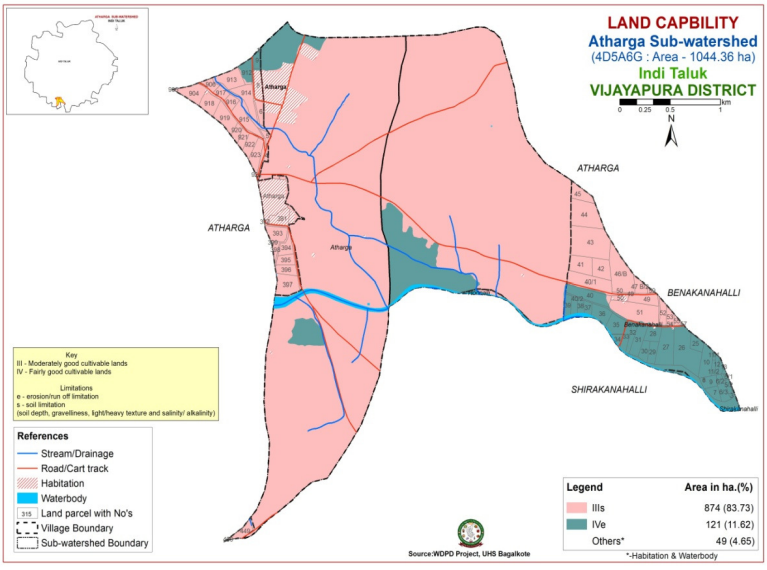

Fig 3: Land capability classes of Atharga sub watershed

Table 3: Grouping of soil-site suitability characteristics of soil mapping units of Atharga sub-watershed according to LCC classification

Sl. No.	Mapping units	Depth (cm)	Texture	Slope (%)	Erosion	Gravels (%)
1.	BBLmB2	>150	c	1-3	Moderate	<15
	LCC class	II	III	II	II	I
2.	BBLmB3	>150	c	1-3	Severe	>60
	LCC class	II	III	II	IV	IV
3.	BBLmB2g1	>150	c	1-3	Moderate	15-35
	LCC class	II	III	II	II	II
4.	DMTmB2	25-50	c	1-3	Moderate	<15
	LCC class	III	III	II	II	I
5.	DMTmB2g1	25-50	c	1-3	Moderate	15-35
	LCC class	III	III	II	II	II
6.	DMTmB2g2	25-50	c	1-3	Moderate	35-60
	LCC class	III	III	II	II	III
7.	HLGmB2	100-150	c	1-3	Moderate	<15
	LCC class	II	III	II	II	I
8.	HLGmB3	100-150	c	1-3	Severe	>60
	LCC class	II	III	II	IV	IV
9.	JMLmB2	100-150	c	1-3	Moderate	<15
	LCC class	II	III	II	II	I
10.	JMLmB2g1	100-150	c	1-3	Moderate	15-35
	LCC class	II	III	II	II	II
11.	NHLmB2g2	50-75	c	1-3	Moderate	35-60
	LCC class	III	III	II	II	III
12.	NHLmC3	50-75	c	3-5	Severe	>60
	LCC class	III	III	II	IV	IV
13.	THLmB2	75-100	c	1-3	Moderate	<15
	LCC class	III	III	II	II	I
14.	THLmB2g1	75-100	c	1-3	Moderate	15-35
	LCC class	III	III	II	II	II

Source: WDPD project, UHS, Bagalkot

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