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Land suitability for grape cultivation and its economic evaluation in Rajanukunte watershed, Karnataka

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Abstract: A study was carried out to evaluate the suitability of soils for grape and evaluate the economic viability of grape cultivation in Rajanukunte watershed of Bangalore, Karnataka. The land use requirements of grape were matched with land qualities of seven soil series mapped for delineating the potential areas. The temperature, relative humidity, soil texture, depth, pH, drainage and gravel content were used in suitability evaluation. The rainfall and humidity during flowering and fruiting period are suitable. The major limiting factors are pH, gravels in the soil and drainage. The investment in grape vineyards is financially viable.

Additional keywords: *Soil suitability, economic evaluation, gravel, drainage*

Introduction

Grape is grown over an area of 34000 ha in India with an annual production of 1 M tonnes at an average productivity of 29.4 t ha^{-1}. In Karnataka, it is grown over 9000 ha with a total production of 1,71,000 tonnes at an average productivity of 19 t ha^{-1} (Shikhamany 2001).

Grape requires long warm to hot dry summer and moist winter. The optimum climatic conditions required for grape have been reported by many workers (IIHR 1975; Sham Singh *et al* 1963). Grape is grown over a wide range of soil conditions i.e. shallow to deep, coarse loamy to clayey and pH 6.5 to 7.5 (IIHR 1975), and Karnataka is not an exception, that lead to variation in yield and income. Therefore, the suitability of soils and economic viability are the two important aspects, which can guide the farmers in proper site selection and management of grape gardens to bring down the cost of production.

Keeping in view the importance of land resource information in grape cultivation, an attempt was made to study the land resources, evaluate the suitability and economic viability of grape cultivation in Rajanukunte watershed, Bangalore rural district, Karnataka.

Materials and Methods

Location and Extent

Rajanukunte watershed falls in three villages namely Shanuboganahalli, Chokkanahalli and Adde Viswanathapura, in the Bangalore north taluk, Bangalore rural district of Karnataka. It is 25 km from Bangalore city on Bangalore-Rajanukunte-Madhure main road ($13^0$10' to $13^0$11' N; $77^0$32' to $77^0$33' E) and covers an area of about 570 ha at 860 to 915 m above MSL. In Rajanukunte watershed, the total area under grape cultivation was 73.22 ha and the average productivity was 25.75 t ha^{-1}.

Climate

The climate of the area is semi-arid tropical with mean annual rainfall of about 870 mm in about 42 rainy days, 476 mm from southwest monsoon (June to September), 225 mm from northeast monsoon (October to December), 169 mm in the winter and hot period (January to May). The mean annual temperature is 23.6^0C and mean maximum and mean minimum temperatures are 33.4^0C and 15.0^0C, respectively.

Detailed Soil Survey

The detailed survey of soils (AIS & LUS 1970) and socio-economic status in Rajanukunte watershed were taken up in the year 2001. Physiographic units such as mounds, undulating pediment uplands and valleys by means of visible breaks in slope and other topographic features were recorded. Soil profiles were dug in the selected locations along the transect to a depth of 1.5 m or upto the parent material and were examined for morphological characteristics. The major differentiating characteristics used for identifying the soil series were soil depth, soil colour, soil texture, coarse fragments and parent material on a specific landform. The soils were classified according to the Soil Taxonomy (Soil Survey Staff 1999). The soil map was prepared by delineating the phases of soil series on the cadastral map of 1:8,000 scale. Soil samples were collected from the typifying pedon of every soil series and analyzed following standard procedures.

Land suitability evaluation

The suitability of soils for growing grape was evaluated by matching the land-use requirements of grape (Naidu *et al.* 2006) with the land characteristics of the watershed. The soil units were grouped as S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable) and N (not suitable) as per FAO guidelines (FAO 1983) considering the limiting characteristics of the land for growing grape and a suitability map was prepared.

Economic analysis

The socio-economic survey of the farmers in the watershed was carried out by personal interview with the help of a questionnaire. The economic evaluation for grape was made by reclassifying the grape growing farmers based on soil series. Due to differences in age of grape gardens and also non-availability of comparable cost and returns, the results of economic evaluation could not be compared among the soil series/suitability class. Since maximum area under grape represents soil series C, economic evaluation was carried out for garden on soil series C in the watershed.

The cost of establishment of a vine orchard was estimated by calculating the initial cost of physical requirements and maintenance up to bearing at the prevailing market price. The total value of the fruit at the market rates was the gross return. Net return was worked out by deducting establishment and maintenance cost from the gross return. Project evaluation techniques were used for assessing the feasibility of investment in grape cultivation (Ramesh Kumar *et al.* 2005).

Results and Discussion

Soil resources

The Rajanukunte watershed has undulating surface with mounds, pediment and narrow valleys on a granitic terrain. One soil series on the mound, one in the valley and five on the pediment surface were identified. Some of the physical and chemical characteristics of these soil series are given in Table 1.

The mound is associated with soil series A and occur on a slope of 3-5 per cent and it is moderately eroded and excessively drained, moderately deep, fragmental with more than 75 per cent of coarse fragments, sandy clay and strongly acidic. The organic carbon content is high (0.96%) in the surface soils due to grass cover. Soil series B, C, D, E and F occur on pediment surface and are well drained and moderately eroded. The soils of the series B are deep, clayey, gravelly, slightly acidic and low in organic carbon. Soils of the series C are deep, clayey with low gravel and higher sand per cent and low in organic carbon. The soils of series D are deep, clayey with strongly acidic surface and neutral subsoil and low in organic carbon content. The soils of the series E are moderately deep, clayey with gravel content of 50 per cent or more below 50 cm depth, moderately acidic in the surface and slightly acidic in the subsoil and low in organic carbon. The soils of the series F are deep, clayey with more than 50 per cent sand, gravelly, moderately acidic surface and neutral subsoil and low in organic carbon. The narrow valley occurring on 1-3 per cent slope available with and are moderately well drained to imperfectly drained and moderately eroded soils (soil series, G). The soils of series G are deep to very deep, clayey with lesser than 20 per cent gravel. They are neutral in reaction and have 0.5 per cent of organic carbon.

Table 1. Physical and chemical characteristics of soils

Soil Series	Depth (cm)	Particle-size distribution				Texture	pH 2.5	CEC	Exchangeable cation				OC (%)
		Gravel	Sand (2-0.5 mm)	Silt (0.05-.002 mm)	Clay (<.002 mm)				Ca	Mg	Na	K	
		%						cmol (p+) kg^{-1}					
A	0-15	58.0	70.9	14.7	14.4	gsl	5.1	4.0	1.8	0.6	0.0	0.2	0.96
	15-38	79.0	49.2	12.1	38.7	gsc	5.3	7.8	2.5	1.6	0.1	0.1	0.60
	38-74	76.0	47.6	13.1	39.3	gsc	5.4	6.9	3.2	2.2	0.0	0.1	0.54
B	0-17	41.0	78.8	4.6	16.6	gsl	6.0	5.1	1.7	1.3	0.0	0.2	0.40
	17-50	65.0	39.7	7.3	53.0	gc	5.7	12.5	3.6	1.2	0.0	0.1	0.45
	50-97	50.0	39.7	7.2	53.1	gc	6.1	10.2	3.0	1.9	0.0	0.1	0.24
	97-130	33.0	39.6	21.2	39.2	gcl	6.4	7.3	2.2	1.1	0.1	0.1	0.17
C	0-20	9.0	58.1	5.8	36.1	sc	6.8	16.1	10.5	3.2	0.0	0.2	0.41
	20-56	9.0	51.8	13.0	35.2	sc	6.4	16.9	11.5	4.6	0.0	0.1	0.33
	56-92	11.0	47.9	9.1	43.0	sc	6.5	20.7	12.6	6.4	0.1	0.1	0.26
	92-102	9.0	38.7	14.9	46.4	c	7.1	26.1	17.3	7.8	0.3	0.2	0.25
D	0-14	5.0	70.4	12.4	17.2	sl	5.3	5.2	2.7	1.0	0.0	0.1	0.76
	14-46	2.0	43.2	11.2	45.6	c	5.9	8.6	4.8	1.8	0.1	0.1	0.22
	46-85	1.0	35.9	13.3	50.8	c	6.6	9.2	6.2	2.2	0.1	0.1	0.26
	85-120	1.0	38.3	6.8	54.9	c	6.7	9.6	5.7	3.1	0.1	0.1	0.20
	120-155	2.0	32.4	13.3	54.3	c	6.9	8.9	5.3	2.9	0.1	0.1	0.18
E	0-22	24.0	60.9	14.1	25.0	scl	5.5	10.5	4.4	4.5	0.0	0.2	0.56
	22-53	10.0	39.7	11.8	48.5	c	6.5	21.8	13.6	6.8	0.1	0.1	0.54
	53-90	68.0	33.4	10.7	55.9	gc	6.3	19.5	12.3	6.0	0.2	0.1	0.59
F	0-16	38.0	72.4	12.9	14.7	gsl	5.7	7.8	4.4	1.5	0.0	0.1	0.14
	16-38	32.0	62.7	11.3	26.0	gscl	6.4	10.4	7.7	1.8	0.0	0.1	0.21
	38-66	22.0	50.2	11.7	38.1	sc	6.7	16.2	7.9	2.1	0.2	0.1	0.19
	66-110	15.0	49.5	11.5	39.0	sc	6.8	17.8	8.5	1.7	0.4	0.1	0.10
G	0-17	7.0	51.3	17.5	31.2	scl	7.2	14.8	8.0	5.8	0.5	0.1	0.52
	17-38	18.0	66.6	5.2	28.2	scl	7.4	9.8	4.8	4.6	0.4	0.1	0.31
	38-66	8.0	41.0	20.1	38.9	cl	7.2	15.5	7.9	6.5	0.3	0.10	0.29
	66-104	9.0	50.5	9.0	40.5	sc	7.7	13.1	5.9	3.7	0.6	0.1	0.30
	104-155	11.0	56.9	2.2	40.9	sc	7.9	12.5	5.5	3.8	0.8	0.1	0.19

Climatic suitability for grape

The prevailing temperature, rainfall distribution and relative humidity in the watershed are favourable for cultivation of grape throughout the year (Table 2). Monthly rainfall distribution (<10 mm) and relative humidity (58.5 to 43.5%) during fruit development and ripening period (January to March) are highly favourable for harvest of quality grape. Similarly pruning and young shoot growth period (November to Jan) coincides dry and cool winter favouring good vegetative growth.

Table 2. Climatic conditions of watershed

Month	Mean Temperature (°C)		Mean Rainfall (mm)	Mean Relative humidity (per cent)	
	Max.	Min.		Morning	Evening
January	26.9	15.0	6.1	77	40
February	29.7	16.5	6.6	67	29
March	32.3	19.0	10.2	63	24
April	33.4	21.2	40.9	70	34
May	32.7	21.1	105.7	75	46
June	28.9	19.7	72.6	62	62
July	27.2	19.2	111.0	86	68
August	27.3	19.2	136.3	86	66
September	27.6	18.9	156.1	85	62
October	27.5	18.9	155.4	83	64
November	26.3	17.2	59.1	78	59
December	25.7	15.3	11.2	78	51
Mean	28.8	18.4	-	77	50
Total	-	-	871.2	-	-

Soil suitability assessment

Farmers are allocating larger area (Table 3) under grape on soil series C (37%) followed by A (18 %), D (16 %) F (15%) and B (9%). Gravelliness, pH and depth of the soil are the important parameters influencing the suitability of soil to grape cultivation. Soil series A, E and G are assessed as marginally suitable (S3) for grape cultivation due to strong limitation of high subsoil gravelliness and strong acidity in soil series A and series E and poor drainage in series G. Soil series B, D, and F are moderately suitable (S2) due to limitations of gravelliness and low pH in series B and series D and low pH in series F. Soil series C is highly suitable (S1) for cultivation of grape in Rajanukunte watershed (Table 4). The spatial distribution of the various suitability classes is given (Fig.1). In the watershed, about 149.73 ha (26.5 per cent) was highly suitable, 242.42 ha of land (42.91 per cent) are moderately suitable and 48.5 ha of land (8.58 per cent) is marginally suited for grape.

Table 3. Extent of soil series and area under grape in the watershed

Soil Series		Grape	
Type	Area (ha)	Area (ha)	% to total
A	28.4	13.10	17.87
B	26.8	6.73	9.18
C	148.9	27.32	37.26
D	111.0	11.97	16.32
E	19.0	0.16	0.22
F	91.0	11.28	15.38
G	19.3	0.00	0.00
Total	444.4	73.32	100.00

Economic analysis of grape cultivation

Grape is a perennial fruit crop and therefore its cultivation involves cost of establishment of garden and its maintenance throughout its economic life of 25 years. In

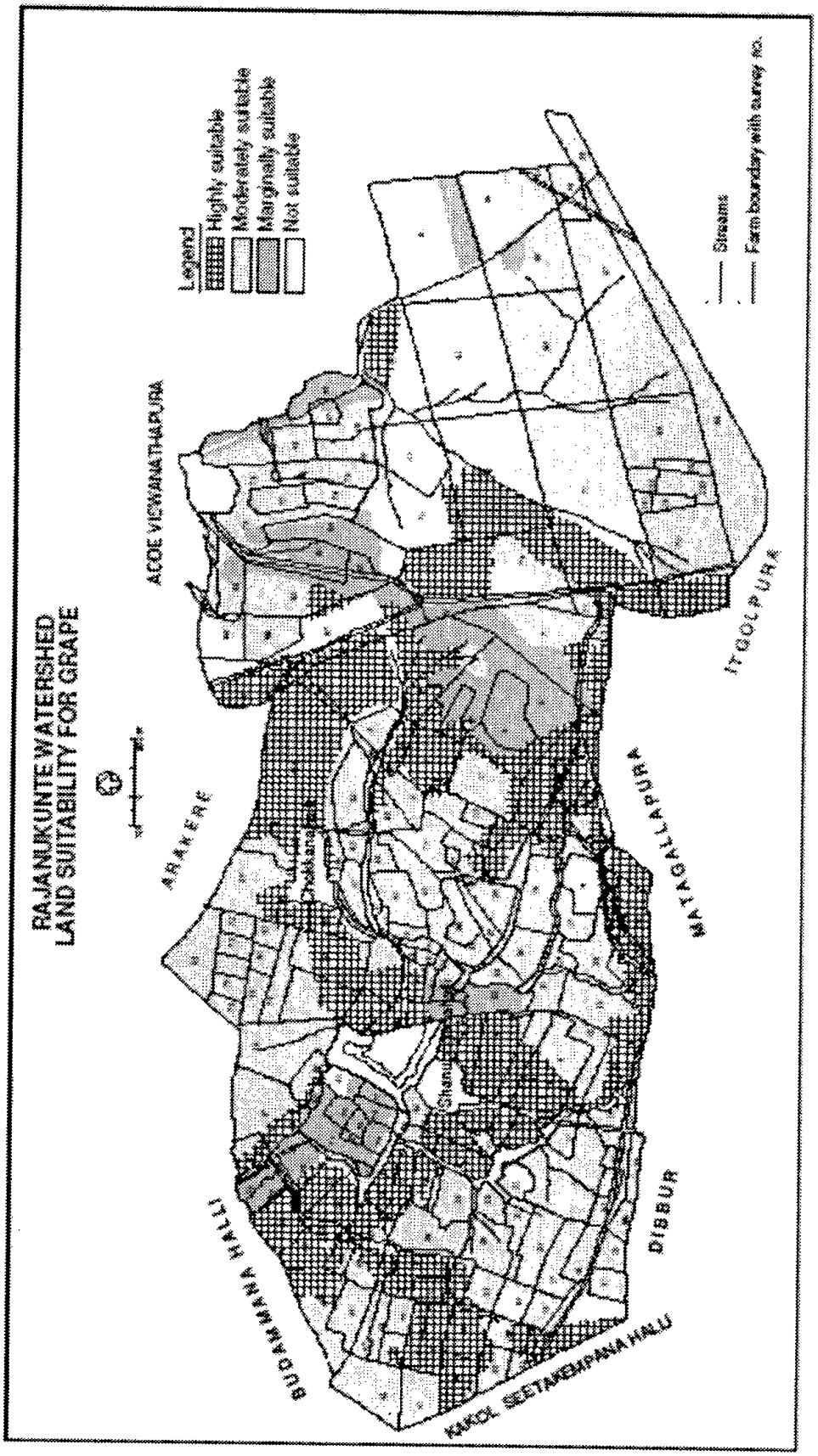

Fig 1. Spatial distribution of suitability classes for grape

Table 4. Soil suitability assessment for grape

Soils	Depth (cm)	Slope (%)	Texture	Drainage	gravelliness (%)	pH	Overall suitability
A	74+	3-5	sc	Excess	75	5.1	(S3)
	(S2)	(S2)	(S1)	(S1)	(S3)	(S3)	
B	130+	1-5	c	Well	60	5.7	(S2)
	(S1)	(S1)	(S1)	(S1)	(S2)	(S2)	
C	102+	1-3	sc	Well	0	6.4	(S1)
	(S1)	(S1)	(S1)	(S1)	(S1)	(S1)	
D	120+	1-3	c	Well	0	5.9	(S2)
	(S1)	(S1)	(S1)	(S1)	(S1)	(S2)	
E	90+	1-5	c	Well	68	5.5	(S2)
	(S2)	(S1)	(S1)	(S1)	(S2)	(S2)	
F	110+	1-3	sc	Well	38	5.7	(S2)
	(S1)	(S1)	(S1)	(S1)	(S1)	(S2)	
G	155	1-3	sc	Mod. Well	18	7.7	(S3)
	(S1)	(S1)	(S1)	(S3)	(S1)	(S1)	

Note:+ indicates weathered parent material below the rooting depth, sc=Sandy clay, c= Clay. Suitability class is given in parenthesis.

Rajanukunte watershed the total cost for establishing the vineyard was Rs 1,91,988 ha^{-1} of which material cost accounts for Rs 1,11,389 ha^{-1} and labour cost at Rs 80,599 ha^{-1} (Table 5).

Table 5. Establishment costs of vineyard on soil series C

Material inputs	**(Rs. ha^{-1})**	
	Value	**Per cent**
Cuttings	8967	4.67
Bamboo sticks	17917	9.33
Stone pillars	26824	13.97
Trellis wires	54649	28.46
Tar	445	0.23
Jute	611	0.32
Bukles	1976	1.03
Sub total	111389	58.02
Labour Costs		
Land Preparation	58881	30.66
Tractor hiring charges	2625	1.37
Planting of cuttings	3335	1.74
Erection of training system	15136	7.88
Miscellaneous	624	0.33
Sub-total	80599	41.98
Total	191988	100.00

The major material cost was for Trellis wire (28%) followed by stone pillars (14%), Bamboo sticks (9%) and cuttings (5%). Among the labour costs, human labour was the major

Table 6. Cost and return and net profit in grape cultivation on soil series C

Particulars	**In Rs.**
Cost (Rs. ha^{-1})	
Variable costs	113247.39
Fixed costs	20769.48
Total costs	134016.87
Yield (Kgs ha^{-1})	25735.00
Gross Returns (Rs. ha^{-1})	205880.00
Net Income (Rs. ha^{-1})	
Over variable costs	92632.61
Over total costs	71863.13
Cost Kg^{-1} (Rs.)	
Variable costs	4.40
Total costs	5.21
Net profit Kg^{-1} (Rs.)	
Over variable costs	3.60
Over total costs	2.79
Returns per rupee of investment (Rs.)	1.54

cost (31%). The per hectare costs, returns and net profit for soil series C were computed (Table 6). The cost of cultivation was Rs. 1,34,016 and the net return was Rs. 71,863. The net return per kg of grape was Rs. 2.79.

For evaluation of investment in grape vineyards, the criteria such as net present value, benefit cost ratio, internal rate of return and pay back period were used. The annual net cash flow was discounted at 12 per cent to obtain the present value of the net benefits in grape vineyards. The net present value per ha was Rs. 357512.The pay back period was 3 years and with an internal rate of return 40 per cent (Table 7). The result shows that investment in grape vineyards was financially viable.

Table 7. Financial viability of investment made in grape cultivation on soil series C

Measures of viability	
Net present value (at 12% discount rate)	357512.96
Benefit cost ratio (at 12% discount rate)	2.86
Pay back period (Years)	2.67
Internal rate of return (Per cent)	39.91

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