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Computer model for Vedavati ground water basin. Part 3. Irrigation potential

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Abstract. An estimate of the irrigation potential over and above the existing utilisation was made based on the ground water potential in the Vedavati river basin. The estimate is based on assumed crops and cropping patterns as per existing practice in the various taluks of the basin. Irrigation potential was estimated talukwise based on the available ground water potential identified from the simulation study. It is estimated that 84,100 hectares of additional land can be brought under irrigation from ground water in the entire basin.

Keywords. Ground water; crop water requirements; irrigation potential; regional estimates.

1. Introduction

A major portion of the cropped area in the Vedavati river basin is rainfed cultivated at present. The net sown area is about 53 % of the total geographical area of the basin. Out of the total sown area, approximately 6 % is irrigated by canals, 10 % by tanks and 7 % by wells. At present, 10 % of the ground water draft is being used for drinking purposes in the basin.

One of the objectives of the Vedavati river basin ground water modelling study is to determine the additional irrigation potential from the ground water resources of the basin over and above the present utilisation. Regional ground water simulation modelling (Part 2, Sridharan *et al* 1986) revealed that the average annual safe yield from the basin is 910 m cu m†. The Central Ground Water Board estimates that, in addition, a quantity of 230 m cu m due to recharge from canals and tanks is available for local use annually. The present study is limited to estimating the irrigation potential corresponding to the ground water potential of 910 m cu m over the basin. The present paper

† 1 m cu m = 10^6 m^3

estimates the talukwise irrigation potential consistent with the talukwise ground water potential and the cropping patterns (assumed based on the existing practice in each taluk), such that the irrigated areas will receive irrigation supply to the full requirement of the crops for their optimum growth.

Areas, presently under the command of canals or tanks, which may be receiving inadequate water supply as per the existing cropping patterns may however be considered, for augmentation of their present supplies, out of the 230 m cu m of annual recharge from the canals and tanks in the basin estimated by the Central Ground Water Board.

2. Objective and scope

The basin is predominantly a semiarid basin with scanty rainfall unevenly distributed and with limited irrigation facilities. The ground water potential is considered primarily for irrigation development. One of the primary goals of irrigation planning as recommended by the Second Irrigation Commission (Ministry of Irrigation and Power 1972) is to spread irrigation over as large an area as possible. The present study keeps in view these guidelines and estimates the maximum to which irrigation facilities may be extended in each taluk. Irrigation may be considered for presently rainfed cultivated areas or other cultivable land which is presently not being cultivated.

The objective of the study is to identify talukwise irrigation potential (over and above the existing level of irrigation from ground water) in the Vedavati river basin from the talukwise estimates of the safe yield based on assumption of crops and cropping patterns in the various taluks as per the existing practice. Thus the extent of additional area that can be brought under irrigation is determined for each taluk consistent with the availability of water and crop water requirements. The cropping pattern for future development of the ground water potential is assumed to be the same as at present because (i) predominantly semidry crops are grown in the basin and a radical change in the cropping pattern is unlikely to come about with increased ground water utilisation for irrigation, especially as irrigation does improve the crop yield to some extent even with the existing cropping pattern, and (ii) changing to new (water intensive) crops and new cropping patterns need additional investment which many farmers may find difficult to afford at the relatively low levels of land holdings in the basin.

3. Ground water available for irrigation

The ground water potential for additional development in the basin is given talukwise in table 1. The number in the table against the name of a taluk was obtained by deducting the existing draft from the safe yield for the taluk obtained from the regional simulation model (Part 2). Out of this, the estimated use of ground water for drinking is to be deducted in order to arrive at the ground water availability for irrigation development. It was observed from the available data that nearly ten % of the existing ground water draft in the basin is being used for drinking and the rest for irrigation. It is assumed that the same proportion (i.e. 10%) of use for drinking purposes holds good in the future also and the remaining ground water will be available for irrigation development. Thus, for the purpose of the present study, 90% of the ground water potential over and above

Table 1. Ground water development potential of parts of the taluk area within Vedavati basin (excluding recharge from canals and tanks)

Taluk	Development potential (ha m/year)	Taluk	Development potential (ha m/year)
Chickanayakanahalli	2455	Kadur	5835
Gubbi	734	Tarikere	1790
Koratagere†	26	Channagiri	67
Pavagada	763	Arsikere	3612
Sira†	458	Belur	975
Tiptur	897	Hassan	411
Tumkur†	90	Gooty	536
Madhugiri†	108	Uravakonda	385
Challakere	372	Kalyandurg	1202
Chitradurga	1867	Rayadurg	934
Hiriyur	1922	Madakasira	Nil
Holalkere	452	Alur	1503
Hosadurga	4315	Bellary	2057
Jagalur	870	Kudligi	1858
Molakalmuru	968	Sandur	361
Chickamagalur	1713	Siruguppa	1406

† Part of the taluk is already overexploited. The estimate given is for the remaining area.

Note: In addition to the estimates in this table, 23,000 ha m of water are available annually from recharge from canals and tanks in the vicinity of these recharge sources (as estimated by the Central Ground Water Board).

the existing draft was considered available for irrigation development and is termed ground water development potential.

4. Methodology used to determine irrigation potential

Once the cropping pattern for each taluk was assumed as known, the monthly crop water requirements of each of the crops during its growing season were computed based on the guidelines given by the Ministry of Agriculture (1971). Estimates of crop consumptive use require data on measured or computed pan evaporation in the cropped region and the nature and duration of the crop under consideration. Monthly crop consumptive use was estimated for each of the crops in each of the taluks based on the available data in the various regions. The effective rainfall in each month was estimated based on the crop consumptive use and the average rainfall for the crop duration in that particular month. The net irrigation requirement is then given by the difference between the crop consumptive use and the effective rainfall. The field irrigation requirement was computed allowing for the on-farm losses for each of the crops. As the cropping pattern was known, the average annual field irrigation requirement for a taluk is given by the sum total of the field requirement of all the crops in that taluk for all the months in the year.

The irrigation potential (hectares) from ground water is computed by dividing the annual ground water potential (hectare metres) by the annual field irrigation requirement (hectare metres per hectare). The sum of these values for each taluk in the basin gives the total irrigation potential for the basin over and above the existing utilisation.

4.1 *Crops and cropping patterns*

Keeping in view the type and extent of present cropping in the various taluks of the basin, specific crops and cropping patterns were indicated by the project team of the Central Ground Water Board for each of the taluks. Table 7 (referred to later) for example, gives the cropping pattern for the Chickanayakanahalli taluk. The table gives the name of the crop, the percent area of its cropping over the total cropped area and the growing season of the crop indicated by the months in which entries (of water requirement in metres) are made against the crop. The numbers in the table give monthly water requirements of each crop, the detailed computations of which are discussed in the subsequent section.

For purposes of estimating crop consumptive use, a total of 9 crops in the basin were considered in a year grown over three seasons, kharif, rabi and summer. The kharif crops were assumed to be sown on June 15, those in rabi on October 15 and those in summer on February 15. Table 2 gives the various crops considered and their growing periods.

5. Estimation of crop water requirements

Crop consumptive use and irrigation water requirements of the various proposed crops in the taluks were determined based on the guidelines by the Water Management Division of the Ministry of Agriculture (1971). Monthly crop consumptive use was obtained by multiplying the pan evaporation in the region by a suitable crop factor. The method requires either measured or computed pan evaporation for the specific regions under study.

5.1. *Evaporation*

Measurements of pan evaporation are available for limited lengths of time at 6 different stations, five of which are located in the basin and the sixth just outside it. Table 3 gives the locations of the stations and the length of the data available at the time of the present study.

Attempts were made to compute the evaporation at places where measured data were not available based on Christiansen's and other methods, but the lack of necessary

Table 2. Crops and their duration

Crop	Duration (days)	Sowing date	Crop factor* for
Paddy	145	15 June	Rice
Ragi/jowar/maize/bajra/ groundnut	120	15 June	Maize (Ludhiana)
Cotton	240	15 June	Cotton
Sugarcane	365	15 June	Sugarcane
Wheat	110	15 October	Wheat (Ludhiana)
Millet (ragi)/Bajra (short)	105	15 October	Maize (Ludhiana)
Gram/pulses	110	15 October	Small vegetables
Paddy	145	15 February	Rice
Pulses/vegetables	110	15 February	Small vegetables

*Ref: Water Technology Centre (1977, p. 101).

Table 3. Pan evaporation stations in the basin

Station	Length of data	Source
Chickanayakanahalli	1 yr	CGWB Project
Hiriyur	1 yr 5 mth	WRDO, Karnataka
Siddergadda	5 yr	CSIR, New Delhi
Siruguppa	5 yr	ICAR, New Delhi
Madhudi	2 yr	GWD, Andhra Pradesh
Gorur	$1\frac{1}{2}$ yr	WRDO, Karnataka

Abbreviations: CGWB—Central Ground Water Board; WRDO—Water Resources Development Organization; CSIR—Council of Scientific & Industrial Research; ICAR—Indian Council of Agricultural Research; GWD—Ground Water Division.

climatological data at the desired locations precluded such an approach. It was finally decided to base the estimates of crop consumptive use on the measured values of pan evaporation alone by assuming the evaporation from each of the taluks in the basin to correspond to the measurements at one of the stations, identified as index station (in table 3), which bears close resemblance to the meteorological conditions in the taluk under consideration. Table 4 gives a list of the index stations and the taluks associated with it. The average monthly values of the index station were used for all the taluks listed against it. The monthly evaporation values at the index stations used in the study are listed in table 5.

5.2 *Crop factors*

Evapotranspiration is taken to be equal to the evaporation multiplied by the crop factor. For any given crop, the crop factor depends on its foliage characteristics, stage of growth, climate and geographical location. Because of the lack of such specific information for the present study the crop factors given in the Indian Agricultural Research Institute Monograph No. 4 on Water Requirement and Irrigation Management of Crops in India (Water Technology Centre 1977) were used (table 2).

Monthly values of consumptive use were computed based on the measured pan evaporation values and the appropriate crop factors for all the crops in all the taluks of the basin.

Table 4. Index stations for pan evaporation for taluks

Index station	Taluks
Chickanayakanahalli	Chickanayakanahalli, Gubbi, Tiptur, Arasikere, Hosadurga, Tumkur, Chickamagalur, Kadur, Tarikere (including Channagiri), Sandur, Kudligi
Hiriyur	Hiriyur, Sira, Challakere, Chitradurga, Jagalur, Molkalmuru, Holalkere
Siddergadda	Bellary, Gooty (including Uravakonda), Rayadurg
Siruguppa	Siruguppa, Alur, Adoni
Madhudi	Madakasira, Koratagere, Madhugiri, Pavagada, Kalyandurg
Gorur	Belur, Hassan

Table 5. Pan evaporation, measured (mm)

Month \ Station	Chickanayakanahalli	Hiriyur	Siddergadda	Madhudi	Gorur	Siruguppa
January	135·0	168·4	205·4	149·3	266·0	129·8
February	151·0	190·9	236·3	187·9	239·0	156·8
March	211·8	256·9	321·6	275·6	312·0	223·2
April	220·4	238·3	372·8	275·1	343·0	235·5
May	203·4	251·3	327·7	248·2	230·5	240·4
June	117·0	182·2	296·8	185·7	288·0	278·6
July	74·6	149·8	267·2	167·9	212·0	244·9
August	110·0	151·4	245·4	166·5	208·0	201·5
September	118·0	154·8	206·2	175·4	221·0	165·0
October	115·0	169·2	198·6	134·2	225·0	141·0
November	96·6	136·2	154·0	117·7	210·0	117·0
December	89·1	148·7	158·0	131·4	245·0	134·8

5.3 *Effective rainfall*

From the point of view of the water requirement of crops, the effective rainfall is defined as that part of the seasonal or annual rainfall which is useful for crop production at the site where it falls. In the present study, the average monthly effective rainfall was estimated from the consumptive use and mean monthly rainfall (as given by the Soil Conservation Service of the US Department of Agriculture) from table 4.21 of the IARI monograph (Water Technology Centre 1977). The estimates of the effective rainfall were based on a net depth of application of 75 mm. The effective rainfall depends on the consumptive use and the rainfall itself. It may be noted here that the effective rainfall for a given consumptive use increases with increase in the rainfall, but is limited, at a certain value of the rainfall, to the value of the consumptive use. At and beyond this limit of rainfall, all the crop water need is met by the contribution from the rainfall itself and there is no need for irrigation. In all other cases, the crop needs irrigation to the extent of the difference between the consumptive use and the effective rainfall.

5.4 *Irrigation requirements*

The net irrigation requirement is the amount of irrigation water just required to bring the soil moisture content in the root zone depth of the crops to field capacity. Monthly values of the net irrigation requirement for any given crop (during its growing season) in any given region were obtained by deducting the effective rainfall values from the crop consumptive use. Rough estimates of the field losses at isolated locations in the basin, as indicated by the Central Ground Water Board, amount to about 30%. The field irrigation requirement was computed based on the assumption of an average irrigation efficiency of 70% in all the taluks of the basin. Thus the field irrigation requirement was obtained by dividing the net irrigation requirement by 0·7.

Table 6 shows the detailed computations of the field irrigation requirements of the kharif crop paddy in the taluk Chickanayakanahalli. The irrigation requirements of all the crops in all the taluks were computed based on the procedure adopted in table 6. The values in the last column giving the field irrigation requirement were transferred to the first row in table 7, which gives the monthly water requirements of all the crops in

Table 6. Computation of water requirement of crops – a typical example

Taluk: Chickanayakanahalli; crop: paddy; duration: 145 days; sowing date: 15 June

Month	Days	No. of days	Mid point days	% growing season	Crop factor K[a]	Evaporation E_t (mm)[b]	CU[c] (mm)	R[d] (mm)	R_E[e] (mm)	NIR[f] (mm)	FIR[g] (mm)
June	15–30	16	8	5·5	1·022	62·4	63·77	22·24	17·56	46·21	66·01
July	1–31	47	32	22·1	1·078	74·55	80·36	50·60	35·60	44·76	63·94
August	1–31	78	63	43·4	1·174	110·0	129·14	47·50	35·76	93·38	133·40
September	1–30	108	93	64·1	1·220	118·0	143·96	114·30	83·67	60·29	86·13
October	1–31	139	124	85·5	1·100	115·0	126·50	141·40	98·68	27·82	39·74
November	1–6	145	142	97·9	0·900	19·32	17·38	7·02	7·02	10·36	14·80
Total										282·82	404·02

Note:
[a] Crop factor, K, from p. 101 of IARI Monograph no. 4 (Water Technology Centre 1977);
[b] monthly average pan evaporation (for the days), measured at the station, E_t;
[c] consumptive use $= K.E_t$;
[d] monthly average rainfall for the taluk (for the days), measured;
[e] R_E, effective rainfall estimated from p. 146 of IARI Monograph no. 4 (Water Technology Centre 1977);
[f] NIR, net irrigation requirement $= \mathrm{CU} - R_E$;
[g] FIR, field irrigation requirement = NIR/0·7 (assuming 30% on-farm losses).

Table 7. Cropping pattern and water requirement of crops.

Taluk: Chickanayakanahalli

Crop (duration in days)	Percent area grown	Water requirement (FIR) of crops (m)												
		June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Paddy (145)	3·0	0·066	0·064	0·133	0·086	0·040	0·015	–	–	–	–	–	–	0·404
Ragi/jowar/ maize/bajra/ groundnut (120)	38·0	0·018	0·035	0·122	0·056	0·015	–	–	–	–	–	–	–	0·247
Wheat (110)	0·5	–	–	–	–	0	0·061	0·085	0·143	0·004	–	–	–	0·293
Millet (ragi) (105)	11·0	–	–	–	–	0	0·083	0·131	0·156	–	–	–	–	0·368
Grams/pulses (110)	14·0	–	–	–	–	0	0·040	0·072	0·094	0·002	–	–	–	0·208
Paddy (145)	2·0	0·142	0·007	–	–	–	–	–	–	0·109	0·318	0·322	0·235	1·133
Pulses/vegetables (110)	31·5	0	–	–	–	–	–	–	–	0·030	0·167	0·170	0·064	0·430
Total for 100 ha (in ha m)		1·173	1·555	5·040	2·390	0·701	1·551	2·491	3·101	1·191	5·887	5·993	2·484	33·559

Values are rounded off to 3 decimal places.

Chickanayakanahalli taluk along with the percent area of each crop proposed to be grown. Tables similar to table 7 were prepared for each of the 31 taluks in the basin.

6. Irrigation potential

Table 8 gives the additional irrigation potential (area) in each of the taluks under each of the districts covered by the basin. The table gives the taluk name, its geographical area in the basin, its development potential (for irrigation) in hectare meters (as determined from the regional simulation study), the annual water requirements for

Table 8. Ground water irrigation potential in the basin

Taluk	Geographic area in basin (ha)	Ground water irrigation potential (GIP) (ha m)	Annual water requirement for irrigation (AWRI) (ha m/100 ha)	Irrigation potential (IP) IP = GIP/AWRI (ha)
Tumkur district				
Chickanayakanahalli	114738	2210	33·6	6585
Gubbi	42920	661	31·6	2091
Koratagere	13156	23	60·3	39
Madhugiri	33935	97	44·6	218
Pavagada	25603	687	51·3	1339
Sira	155377	412	53·7	767
Tiptur	26163	808	28·5	2838
Tumkur	12562	81	30·2	268
				14145
Chitradurga district				
Challakere	206219	335	73·6	455
Chitradurga	126180	1681	59·0	2848
Hiriyur	170093	1730	89·0	1943
Holalkere	34010	407	74·8	544
Hosadurga	142870	3883	54·4	7145
Jagalur	42432	783	66·5	1177
Molkalmuru	73859	871	75·1	1159
				15271
Chickamagalur district				
Chickamagalur	39282	1541	32·7	4717
Kadur	132008	5251	30·9	17005
Tarikere	32084	1611	35·9	4483
				26205
Hassan district				
Arasikere	110794	3251	28·8	11279
Belur	24998	877	81·0	1083
Hassan	10403	370	75·1	493
				12855

(table continued)

Table 8. continued

Taluk	Geographic area in basin (ha)	Ground water irrigation potential (GIP) (ha m)	Annual water requirement for irrigation (AWRI) (ha m/100 ha)	Irrigation potential (IP) IP = GIP/AWRI (ha)
Bellary district				
Bellary	149054	1851	90·7	2041
Kudligi	82950	1672	37·3	4483
Sandur	34025	325	38·2	849
Siruguppa	70323	1266	57·2	2213
				9586
Anantapur district				
Gooty	42914	483	81·7	591
Kalyandurg	11,1292	1082	63·2	1712
Madakasira	67186	*	65·6	*
Rayadurg	166862	841	103·8	810
Uravakonda	30835	347	65·4	530†
				3643
Kurnool district				
Adoni	400	6	60·9	10††
Alur	92863	1347	60·9	2213
				2223
Shimoga district				
Channagiri	1200	60	67·0	168
				168
			Total for the basin	84096

†Included in Gooty in figure 1; ††included in Alur in figure 1; *overexploited presently.

irrigation in ha m/100 ha determined from the estimates of crop water requirements, and the irrigation potential in hectares obtained by dividing the development potential by the water requirement. The district totals of the irrigation potential are also given in table 8. These estimates are intended for use in the irrigation development planning of the basin.

The total irrigation potential for the entire basin adds up to 84,096 hectares from the ground water aquifers in the basin over and above the existing level of ground water utilisation. Figure 1 shows the estimated irrigation potential for each of the taluks in the basin due to ground water.

7. Conclusion

A talukwise estimate of the irrigation potential from ground water in the Vedavati river basin was given. The estimate of the total irrigation potential of the basin from ground water is 84,100 hectares over and above the existing utilisation. This is in addition to the local potential for irrigation due to recharge from canals and tanks.

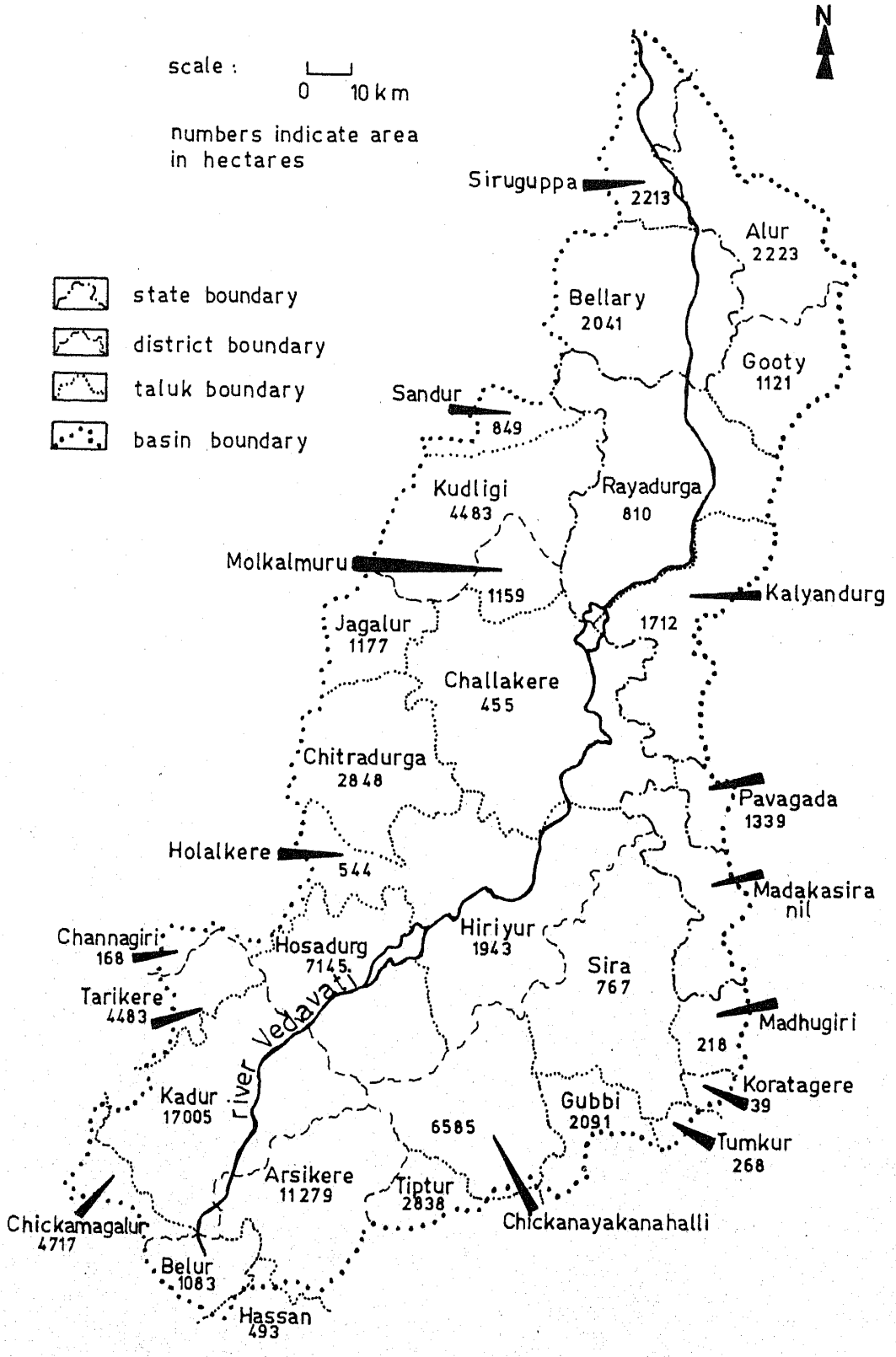

Figure 1. Talukwise irrigation potential (additional) in hectares.

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