PROGRESS REPORT 9
ECONOMICS PROGRAM

TANK IRRIGATION IN SEMI-ARID TROPICAL INDIA

M. von Oppen and K.V. Subba Rao

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS
ICRISAT PATANCHERU POST OFFICE
ANDHRA PRADESH 502 324

May 1980

TANK IRRIGATION IN SEMI-ARID TROPICAL INDIA

M. von Oppen and K.V. Subba Rao†

INTRODUCTION

Small water reservoirs behind earthen dams are called tanks in India. Tanks supply many villages with drinking water, but their primary purpose is for irrigation. Tank irrigation is an old established practice in most of the semi-arid tropical parts of India and of some other countries. In India, the monsoon rains fall erratically during a few months in the year, and irrigation tanks serve to store and regulate the flow of water for agricultural use. In southern India this is primarily for the production of rice.

DEVELOPMENT OF TANK IRRIGATION OVER TIME

A number of tanks with inscriptions dating back a millenium or longer provide evidence that this technology of utilizing runoff water is deeply rooted in Indian culture. Historians and anthropologists have pointed out that there is a dialectic relationship between population and tank irrigation, one enforcing the other.[1]

However, the relationship between density of population and the intensity of tank irrigation is not linear. Initially, where physically feasible and economically attractive, tank irrigation systems are expanded when the population density crosses a certain minimum level; tanks and population increase in mutual support to another level of population density,

---

†The authors are Principal Economist and Research Technician, respectively, in the Economics Program of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru Post Office, Andhra Pradesh 502 324, India. Presented at the National Seminar on *Economic Criteria for Fixation of Irrigation Charges for Various Sources of Irrigation,* Indian Agricultural Research Institute, New Delhi 110 012, March 1980.

[1]For example, Ludden

beyond which further population pressure may tend to adversely affect the existing tank irrigation systems, and special measures may be required to preserve the capital of irrigation tanks.

The data available for tank development in different states over the years, indicate that the threshhold density for intensive tank construction to begin lies between 50 and 60 persons/km^2. The upper limit is not as clearly discernible -- it seems to vary from one region to another -- but there is clearly a decline in tank irrigation. For instance, in India as a whole the absolute area irrigated by tanks increased from about 3.5 million ha in the period 1945 to 1950 to over 4.5 million ha in 1960-70; subsequently it fell to less than 4 million ha from 1973 onwards (Table 1), when rural population density in India increased to more than 135 persons/km^2. Population growth continues while tank irrigation decreases; at the same time canal irrigation and irrigation from wells especially has expanded rapidly.

The development of tank irrigation in India after independence was subject also to forces that may not be directly attributed to population density although they are related. Abolition of ownership rights for private tanks stopped private investment into tank irrigation soon after independence. This also decreased the efficiency in water control and tank management. On the other hand public campaigns were launched to increase food production, and tank building was one of the activities vigorously pursued in such campaigns until the late 1950s. Subsequently, the availability of diesel and electric powered pumps made well water more attractive as an alternative, privately controlled source for irrigation.

Table 1. All India growth of tank irrigation

Year	Total crop-ped area	Net irri-gated area	Well-irri-gated area	Tank irri-gated area	Tank irri-gated area to total cropped area (%)	Tank irri-gated area to net irri-gated area (%)	Well irrigated area to net irrigated area (%)
	(---In million hectares--)						
1950-51	131.9	20.9	5.9	3.6	2.7	17.2	28.2
1951-52	133.4	21.0	6.5	3.4	2.5	16.2	30.9
1952-53	137.5	21.2	6.6	3.2	2.3	15.1	31.1
1953-54	142.3	21.7	6.7	4.1	2.9	18.9	30.9
1954-55	144.0	21.9	6.7	4.0	2.8	18.3	30.6
1955-56	146.7	22.8	6.7	4.4	3.0	19.3	29.4
1956-57	149.1	22.5	6.2	4.5	3.0	20.0	27.6
1957-58	145.4	23.2	6.8	4.5	3.1	19.4	29.3
1958-59	150.8	23.4	6.7	4.8	3.2	20.5	28.6
1959-60	152.1	23.8	6.9	4.7	3.1	19.7	29.0
1960-61	152.3	24.6	7.3	4.6	3.0	18.7	29.7
1961-62	156.2	24.9	7.3	4.6	2.9	18.5	29.3
1962-63	156.8	25.7	7.6	4.8	3.1	18.7	29.6
1963-64	157.0	25.9	7.8	4.6	2.9	17.8	30.1
1964-65	159.3	26.6	8.1	4.8	3.0	18.0	30.4
1965-66	155.3	26.7	8.7	4.4	2.8	16.5	32.6
1966-67	156.8	27.1	9.2	4.6	2.9	17.0	33.9
1967-68	163.0	27.5	9.3	4.6	2.8	16.7	33.8
1968-69	159.7	29.0	10.8	4.0	2.5	13.8	37.2
1969-70	163.9	30.3	11.1	4.4	2.7	14.5	36.6
1970-71	167.4	31.4	11.9	4.5	2.7	14.3	37.9
1971-72	164.2	31.9	12.2	4.1	2.5	12.3	38.2
1972-73	161.5	32.0	13.0	3.6	2.2	11.2	40.6
1973-74	169.5	32.5	13.2	3.9	2.3	12.0	40.8
1974-75	163.9	33.7	14.2	3.5	2.2	10.5	42.1
1975-76	171.0	34.5	14.3	4.0	2.3	11.6	41.5

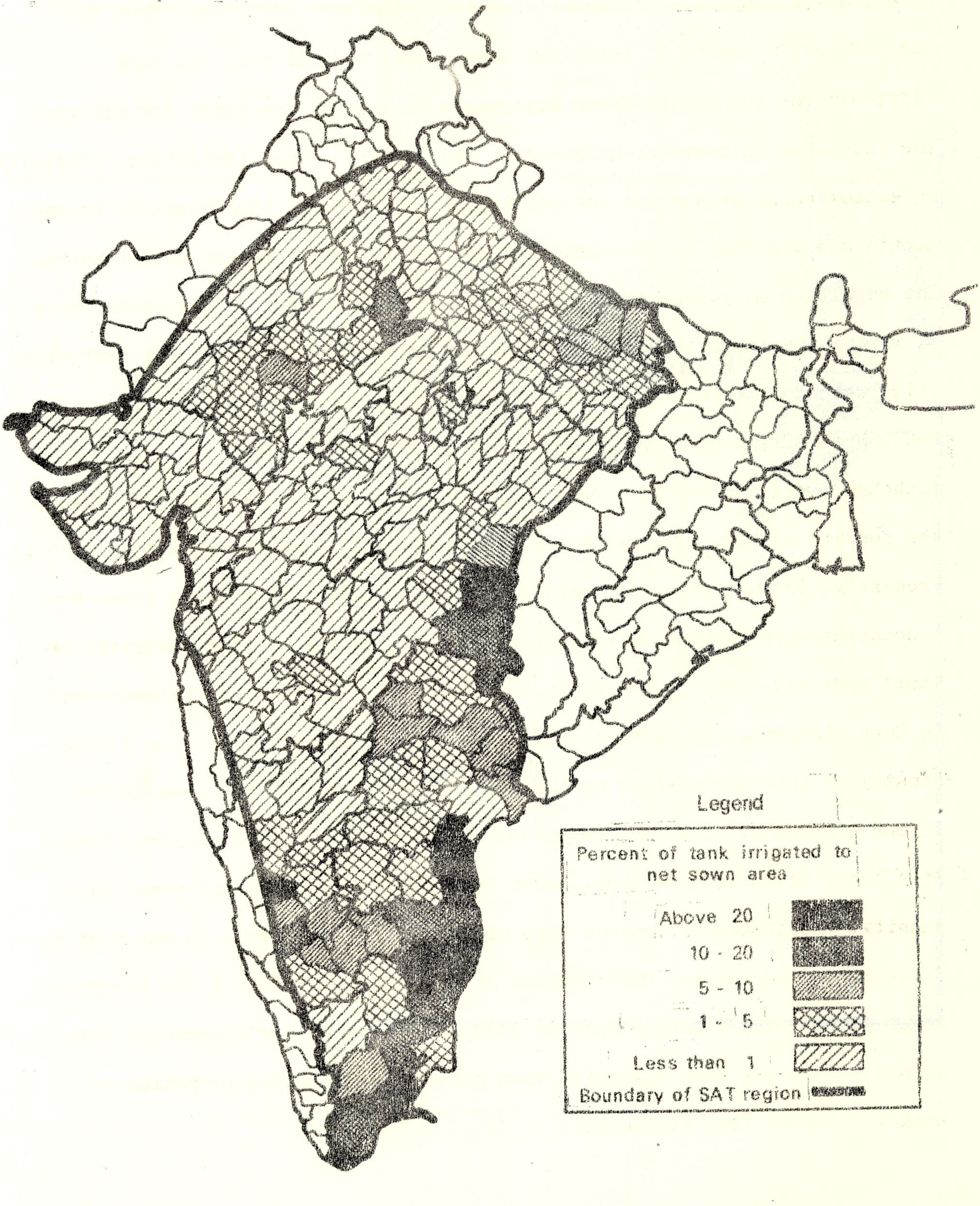
Sources: Government of India, Ministry of Agriculture, *Indian Agriculture in Brief*, various issues.

Resources were shifted from the development of tanks towards wells, leading to a massive expansion of well irrigation. Further, reluctance from the side of policy makers to raise the water rates made it more and more difficult for the Public Works Department to receive the funds for covering the increases in costs of maintenance and repairs. Tank irrigation, basically an economically productive and profitable undertaking, thus began to be neglected and was only half-heartedly supported by policy makers and planners. The resulting decreases in efficiency and in reliability of the performance of irrigation tanks tended to support the erroneous notion of tank irrigation being notoriously inferior to other types of irrigation.

FACTORS AFFECTING REGIONAL DISTRIBUTION OF IRRIGATION TANKS

Although runoff collection tanks exist in nearly every district of India, the density of tank irrigation varies considerably from district to district. Presently, in the semi-arid tropical region of India (Figure 1), tanks are concentrated in South and Central India, i.e., in the coastal districts of Tamil Nadu and Andhra Pradesh, in South-Central Karnataka, in Telegana and in East Vidarbha. In North India, there are two pockets that show a high density of tank irrigation: north-east Uttar Pradesh, in the area of the former kingdom of Oudh, and Rajasthan, east of the Aravalli mountain range. This leads us to believe that, apart from physical factors and population density, institutional factors also might have played a role in the past in determining the present distribution of tanks. A map showing the territory under British and princely rule in 1890 gives rise to the hypothesis that princely rule was more conducive than colonial rule to the promotion of tank irrigation (see Figure 2).

Figure 1. Density of tank irrigation in SAT India



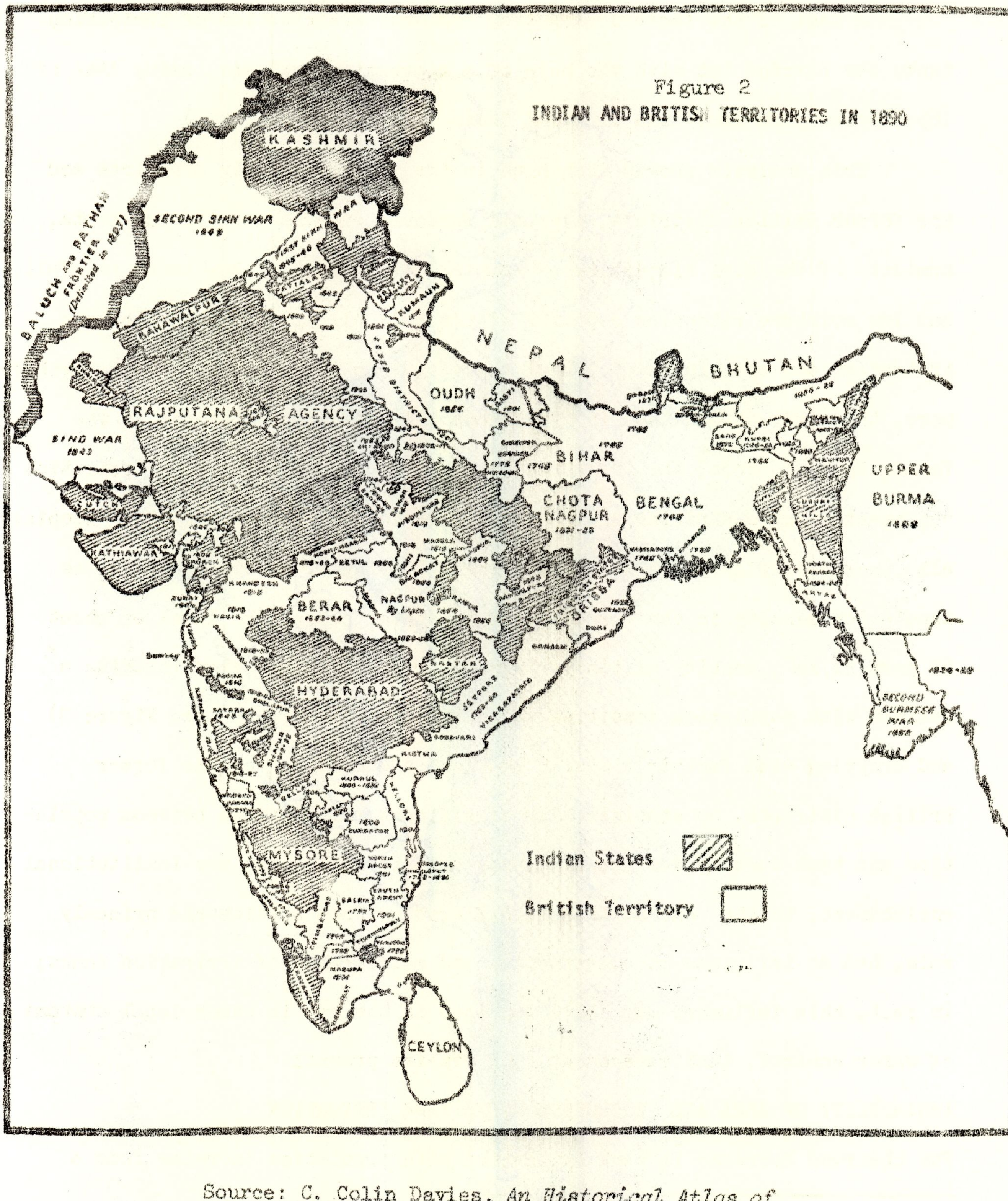


Figure 2
INDIAN AND BRITISH TERRITORIES IN 1890

Source: C. Colin Davies, *An Historical Atlas of the Indian Peninsula*. Second Edition, Oxford University Press, Madras, 1976, p. 73.

A test of the factors affecting regional distribution of irrigation tanks was carried out with the help of a regression analysis, using data of 165 districts in semi-arid tropical India.[2]

This analysis showed that both in the former princely districts and the former British districts, physical factors, such as granite substrata, humidity of the air, bimodality of rainfall distribution, low total rainfall and low moisture retention capacity of the soil all are conducive to tank irrigation and explain about 50% of the variation in tank densities. Furthermore, the study showed that in the former princely areas (but not in the former British areas) the influence of population density on tank irrigation was measurable, explaining another 20% of variation in tank density. Keeping all other variables constant we find the following from this analysis: as population density in the former princely states passes the level of about 60 persons/km^2, density of tank-irrigated areas begins to grow reaching a maximum with population densities of around 220 persons/km^2 (see Figure 3) and dropping with further rises in population density. For the former British districts, no statistically significant relationship between population and tank density was found. These results imply that the institutional environment, to the extent that it differed between British and princely rule, had an influence on construction and maintenance of irrigation tanks; in fact, this influence may still continue in the way in which local customs of water control, tank management, and repairs prevail.[3]

INSTABILITY OF AREA AND PRODUCTION UNDER TANK IRRIGATION

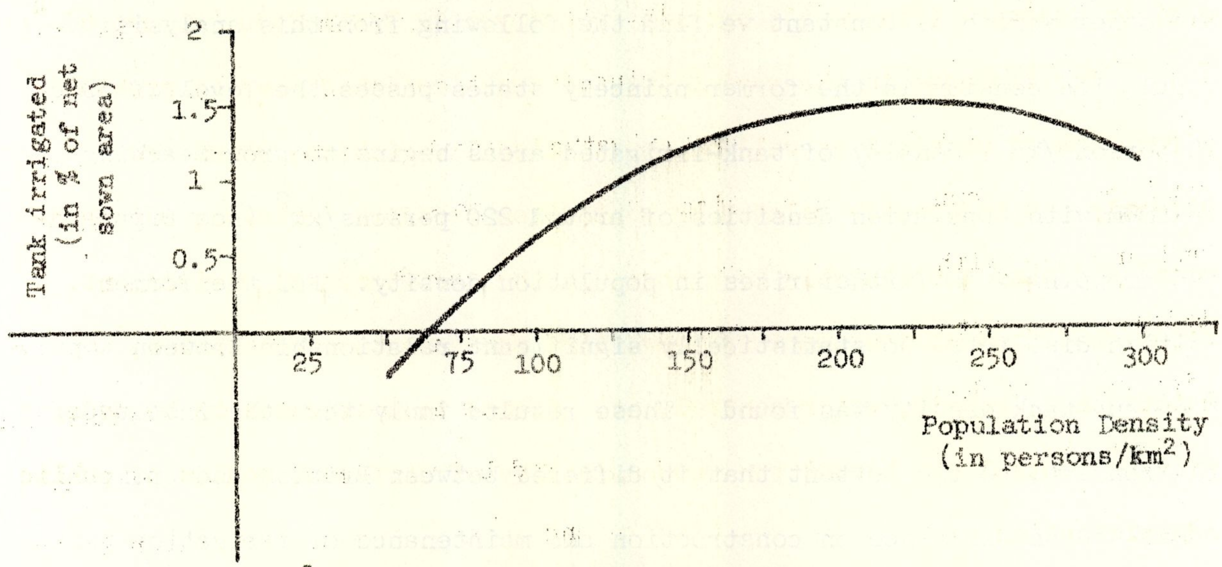
The observed decrease in tank irrigation with population increase from a

---

[2]For details see M. von Oppen and K.V. Subba Rao 1980.

[3]See also footnote 6, p. 13.

Figure 3. Tank Irrigation as a function[1] of population density in formerly princely ruled districts in India



[1]Keeping physical factors constant

certain "optimum" point of population density in the former non-British districts of India would seem to be related to another phenomenon: the increasing instability in tank-irrigated areas and production in certain regions of India. District analysis of the variability of tank-irrigated areas, using a moving coefficient of variation (MCV) over 8 years (moving from 1958-1965 up to 1968-1975), shows the following: in the districts of Telengana, e.g. in Warangal, the variability of tank-irrigated areas had earlier been well below the variability of rainfall, while in the later part of the period, during which rainfall variability remained at about the same level, the variability of tank-irrigated area went up considerably (Figure 4). This observation is true also for districts in Rayalseema, e.g. in Cuddapah (Figure 5), but not or not yet in Tamil Nadu (Figure 6).[4]

The increase in the variability of tank-irrigated area is probably a function of physical as well as institutional variables, which are directly and indirectly related to population pressure (erosion, encroachment) and also attributable to changes in the institutional environment. After abolition of zamindari systems, tank management, organization, maintenance, repair, water control, etc. ceased in most cases to be under private control but became the responsibility of different bodies of public administration.

The amount of money available to the Public Works Department for tank repairs has always been claimed to be insufficient for proper maintenance. Considering that the water rates the Revenue Department is receiving in the form of the difference between land revenue from dry land *vs.* wet land are only around 14 Rs/acre of command area, the rate

---

[4]For details see M. von Oppen 1978.

Figure 4. Indices (mean area and rainfall = 100) and variability of rainfall and tank-irrigated area, Warangal District.

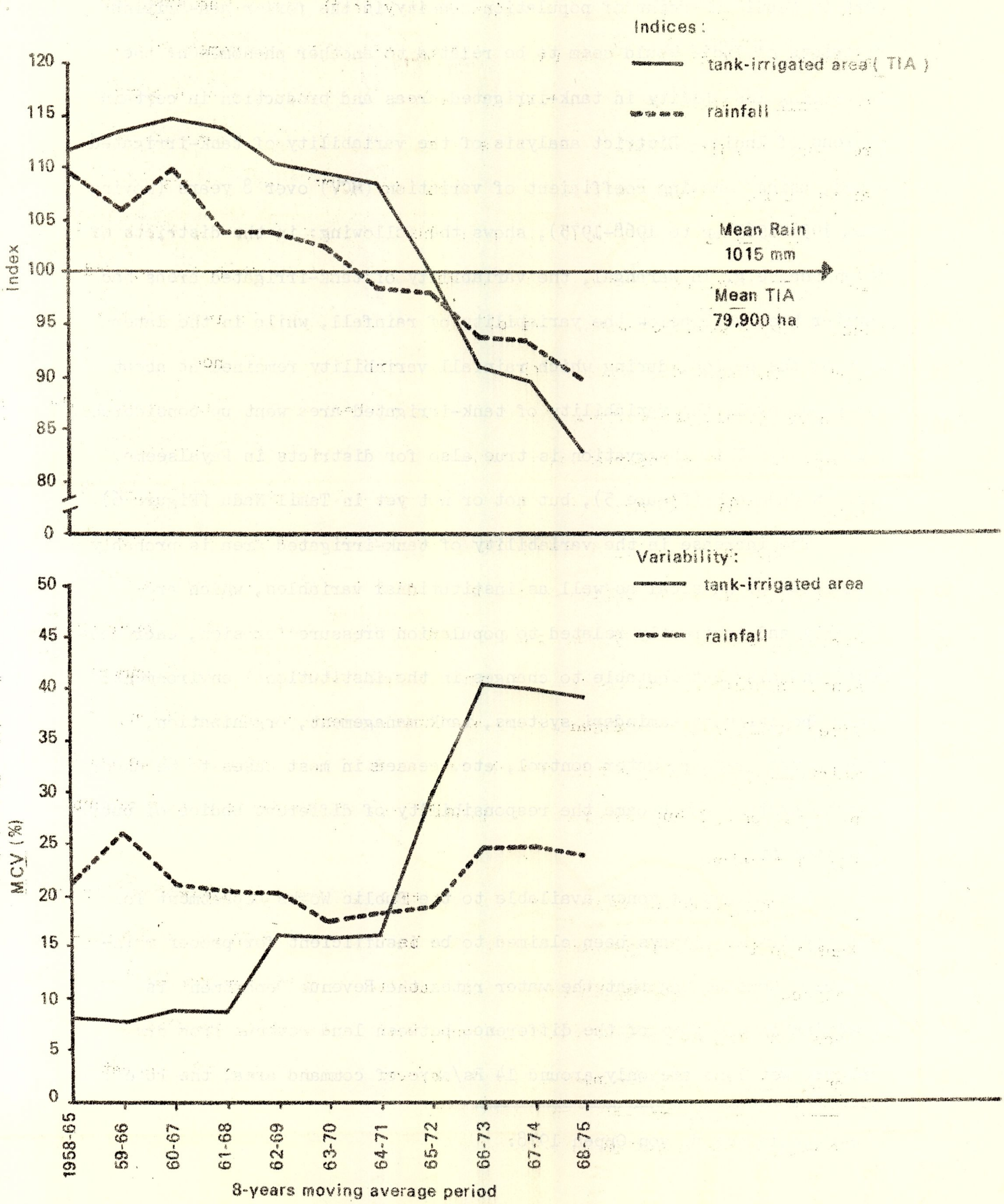


Figure 5. Indices (mean area and rainfall = 100) and variability of rainfall and tank-irrigated area, Cuddapah District.

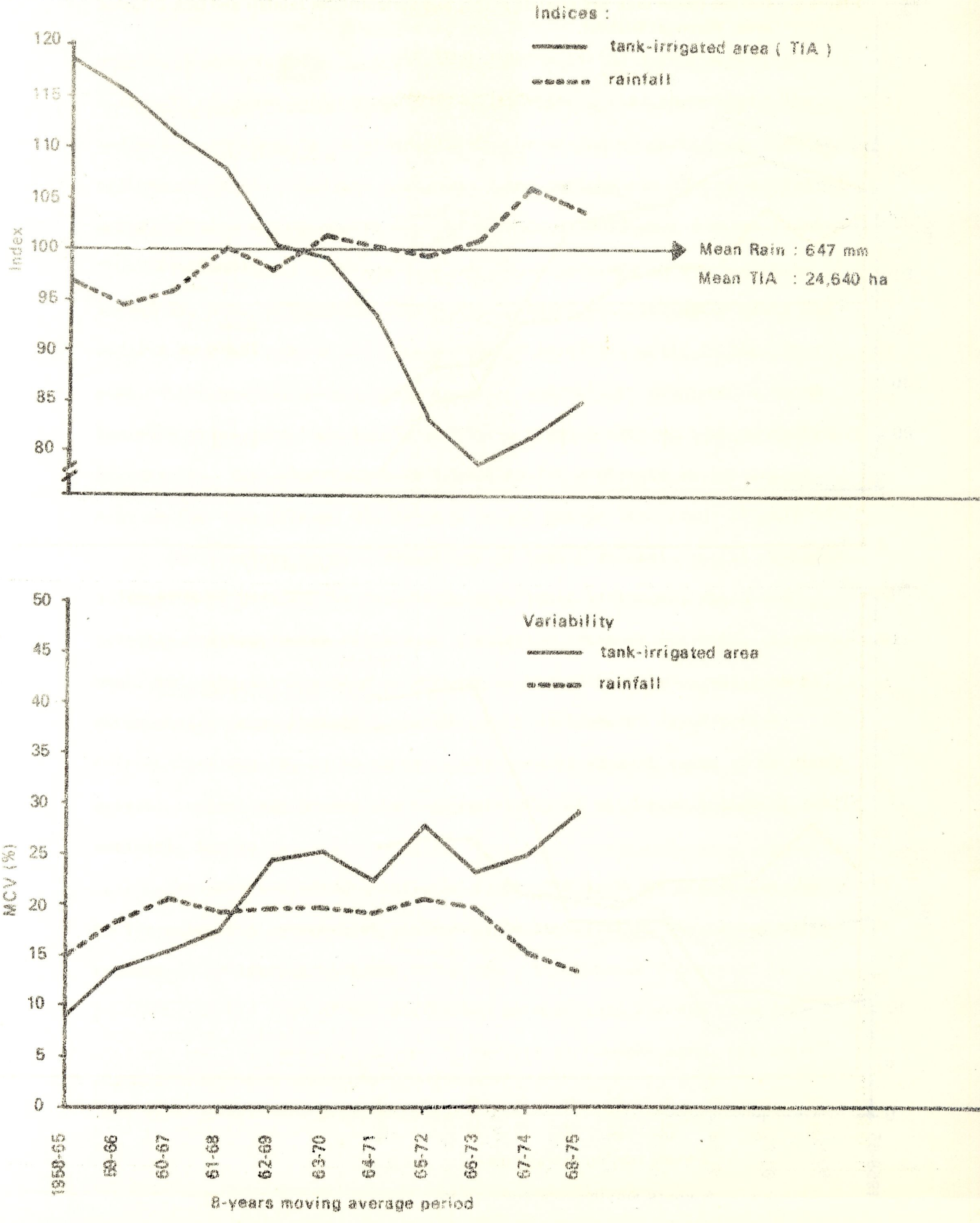
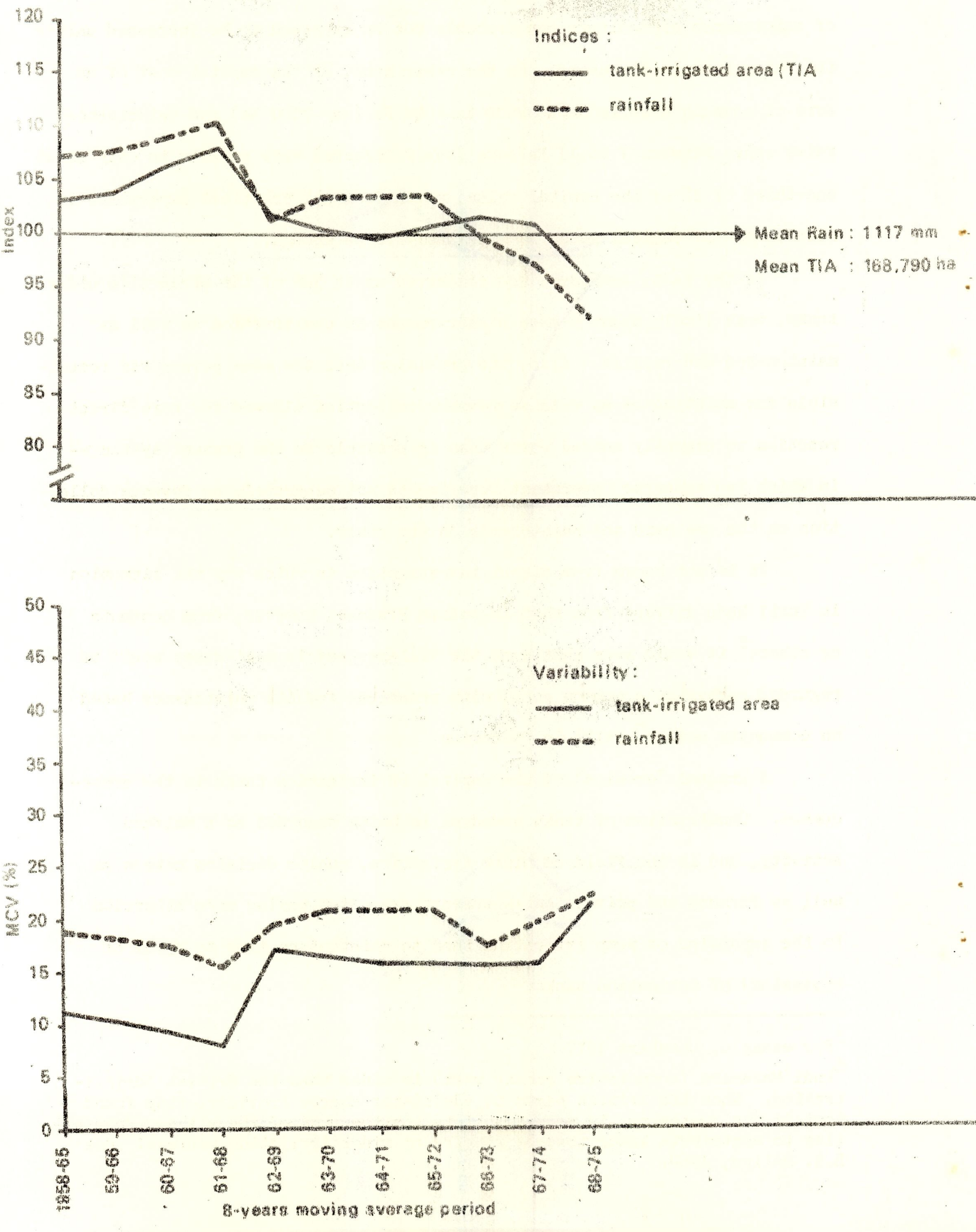


Figure 6. Indices (mean area and rainfall = 100) and variability of rainfall and tank-irrigated area, Chingleput District (Tamil N



of maintenance expenditure can probably not be expected to be increased unless the water rate is increased. On the other hand, as the capital cost of an acre of command area is about 2000 to 4000 Rs (say 3000 Rs) and maintenance rates range between 7 to 11 Rs/acre (say 9 Rs/acre) this amounts to only about one-third of 1% of the capital value, which from all practical experience in maintenance of capital goods is not likely to be enough.

In the past, Zamindars who collected up to 50% of the production under tanks, most likely spent a much higher amount on construction as well as maintenance and repairs. Also, the provision that the same person was responsible for maintenance as well as revenue collection allowed for more direct reaction to urgently needed works than is possible in the present system -- in which two separate Government Departments act separately on revenue collection on the one hand and maintenance on the other.

It is not known from direct investigation in which way the situation in Tamil Nadu differs from that in Andhra Pradesh; however, from accounts by others[5] it would seem that here the village tank in most cases would be regarded rather as a common good, with practices for its maintenance based on community action[6] still in operation.

A gradual "erosion" of the capital of irrigation tanks is the consequence. Construction of tanks nowadays is being regarded as a welfare activity, and in the field of minor irrigation, public decision makers as well as farmers and private entrepreneurs are often paying more attention to the expansion of pump irrigation than to maintenance (not to speak of expansion) of irrigation tanks.

---

[5]For example, Chambers 1977

[6]Kudi Maramath (cooperative repair work) is older than the British Administration. When the British began to administer Madras Province, they found that it was customary, in many districts, on the part of the village communities to contribute labor towards repairs of minor irrigation sources. See B.S. Baliga, 1960.

Measures for rehabilitating irrigation tanks are required. In view of the economics of tank irrigation (where it still exists and functions) and the potential productivity of this technology, such rehabilitation measures would have considerable payoff.

ECONOMICS OF EXISTING TANK IRRIGATION

The costs and benefits fo tank irrigation can be measured at several levels (Table 2): (1) at the farmer's level, (2) at the level of the "Project Authority", responsible for construction and operation of the tank, and (3) at the national level.

Table 2 indicates the factors constituting the costs and benefits at each of these levels and the source of data available (or not available)[7]. The benefit-cost ratios at the farmer's level (Table 3) indicate that against farmer's costs -- the water fees he pays in one season of about 13 to 16 Rs/acre -- his net benefits due to tank irrigation are about 20 to 30 times that amount. However, these benefits accrue only on actually irrigated areas, and there is an increasingly high probability for a particular acre to remain non-irrigated. Even if therefore the benefits are discounted by an arbitrary 50% risk factor, the farmer's net benefits due to tank irrigation would still be in the order of 10 times or more of the water fees.

To the project authority (an imaginary body) the water fees paid by the farmer constitute its returns. In comparison to the annual costs (in terms of present value plus cost of maintenance) of 400 to 600 Rs/acre, these returns are almost negligible (Table 4). However, one might argue that the capital costs of tank construction should be written off as most of the tanks have been constructed long ago; and that only the maintenance costs should be counted.

---

[7]For details see M. von Oppen and K.V. Subba Rao 1980a.

Table . Comparisons of benefits and costs of irrigation tanks accruing to different participants

Participants	Benefits	Costs	Comparison Criteria
I. Farmer	1.Private net returns at villages prices due to irrigation** 2.Increase in land value** 3.Reduction in Risk*	1.Irrigation charges** 2.Obligations to contribute labor# 3.Uncertainty of water availability*	Financial cost/benefit ratio
II. Project Authority	1.Irrigation fees** 2.Income from fisheries, brick making#	1.Land acquisition** 2.Construction** 3.Maintenance** 4.Water fee collection#	Financial cost/benefit ratio
III. Nation	1.Additional production at average prices** 2.Additional employment** 3.Safety in food production* 4.Higher water table# 5.Less soil erosion#	1.Opportunity cost of capital invested (Interest)* 2.Submerged land*	Economic internal rate of return

*indicates information from other sources is available
**indicates survey data are available
#indicates data or information are not available

Table 3. Farmer's private/direct benefits, costs and benefit-cost ratios (Rs/acre), for tank irrigation

Tank code	Settled command area (Acres)	Net Returns: At village prices: Tank irrig.	Net Returns: At village prices: Rain-fed	Net Returns: At village prices: (3)/(4)	Net Returns: At average prices: Tank irrig.	Net Returns: At average prices: Rain-fed	Net Returns: At average prices: (6)/(7)	Increase in Land Value: Land value (Rs./acre): Tank irrig.	Increase in Land Value: Land value (Rs./acre): Rain-fed	Increase in Land Value: Ratio (9)/(10)	Benefits: Net benefit due to tank irrig. at vill.prices (Rs)	Benefits: Net benefit due to tank irrig. at av. prices (Rs)	Cost: One sea irrig. per ac excl. assessm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
AA	363	241	-19	241	409	-42	409	5400	1188	4.55	260	451	16.5
AB	719	206	186	1.11	394	186	2.12	6175	2010	3.07	20	208	12.5
BA	465	309	225	1.37	559	264	2.12	5340	1500	3.56	84	295	14.5
BB	161	546	61	8.95	794	113	7.03	5720	1670	3.43	485	681	14.1
CA	499	328	62	5.29	527	60	8.78	4200	1320	3.20	266	467	16.0
CB	257	650	1	650	824	9	91.5	8600	1750	4.90	649	816	14.0
DA	307	496	189	2.62	590	212	2.78	4750	1400	3.40	307	378	13.3
DB	242	840	207	4.06	922	228	4.04	4375	1350	3.20	633	694	15.8
EA	223	329	325	1.01	412	332	1.24	5000	2040	2.45	4	80	14.4
EB	163	774	170	4.55	832	160	5.20	5250	2050	2.56	604	672	13.0
MEDAK	340	472	141	3.35	626	142	4.40	5481	1628	3.37	331	474	14.4
FA	102	721	273	2.64	737	224	3.29	4417	1667	2.65	448	513	14.9
GA	290	960	329	2.92	953	276	3.45	5215	2125	2.45	631	677	14.7
GB	398	657	134	4.90	598	110	5.44	5500	2050	2.68	523	487	16.3
HA	736	531	140	3.79	609	55	11.7	4330	1820	2.38	391	554	12.2
HB	107	550	103	5.34	567	79	7.18	3833	1714	2.24	447	488	13.0
JA	103	705	52	13.6	884	57	1.55	5125	2025	2.53	653	826	13.9
KA	140	208	141	1.48	285	165	1.73	4165	1670	2.49	67	119	11.5
KB	161	380	102	3.73	506	103	4.91	4420	1870	2.36	278	403	14.5
LA	141	324	80	4.05	454	99	4.59	4000	1875	2.13	244	355	11.8
LB	147	325	174	1.87	620	183	3.39	4060	1720	2.36	151	437	10.9
MAHBUBNAGAR	233	536	153	3.50	621	135	4.60	4506	1854	2.43	383	486	13.4
MA	1112	587	307	1.91	691	336	2.06	9500	2000	4.75	280	355	16.8
NA	927	409	163	2.51	622	193	3.22	5000	1500	3.33	244	428	16.0
NB	442	402	202	1.99	669	191	3.50	5500	1610	3.42	200	479	16.5
ANANTAPUR	827	466	224	2.08	661	240	2.75	6667	1703	3.91	242	421	16.4

Table 3 continued ...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PA	319	439	141	3.11	650	146	4.45	5000	1450	3.45	298	504	13.5
QA	1067	665	389	1.71	812	435	1.87	6600	2100	3.14	276	377	13.5
KURNOOL	693	552	265	2.08	731	291	2.52	5800	1775	3.27	287	441	13.5
RA	1001	103	88	1.17	134	93	1.44	1000	1000	1.00	15	41	21.3
RB	1100	88	149	0.59	76	116	0.66	1063	na	na	-61	-40	25.2
SA	759	331	425	0.78	354	361	0.98	2500	2500	1.00	-94	-7	24.5
TA	425	348	348	1.00	353	348	1.01	5000	na	na	0	5	21.3
AKOLA	821	217	253	0.86	229	230	1.00	2390	1750	1.37	-35	0	23.1
UA	593	446	95	4.69	339	79	4.29	na	na	na	351	260	34.1
VA	484	53	-114	0.53	8	-114	8.00	na	na	na	53	8	13.5
VB	1779	517	59	8.80	531	46	11.5	na	na	na	458	485	18.8
SHOLAPUR	952	339	14	24	293	4	73	na	na	na	325	251	22.1

na Not available

Table 4. Costs and benefits to the Project Authority

Tank code	Settled command area (Acres)	Cost: Total cost of bund (------	Cost: All other costs in '000 Rs	Cost: Total cost of the project ------)	Cost: Cost/per acre of SCA (Rs)	Cost: Present value per acre cost assuming 22 years life at 10% interest rate	Cost: Total cost/acre incl Rs.10/acre maint. and repairs (Rs)	Benefit: Revenue collected per acre of SCA (Rs)	Benefit cost ratio (9)/(8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AA	363	1244	575	1819	5012	616	626	16.5	0.026
AB	719	1244	801	2045	2843	349	359	12.5	0.035
BA	465	1128	640	1768	3802	467	477	14.5	0.030
BB	161	453	286	739	4591	564	574	14.1	0.025
CA	499	813	667	1480	2966	364	374	16.0	0.043
CB	257	623	421	1044	4063	499	509	14.0	0.028
DA	307	660	483	1143	3721	457	467	13.3	0.028
DB	242	762	401	1163	4808	591	601	15.8	0.026
EA	223	540	376	916	4107	504	514	14.4	0.028
EB	163	866	289	1155	7083	870	880	13.0	0.015
MEDAK	340	833	494	1327	4300	528	538	14.4	0.027
FA	102	254	190	444	4354	535	545	14.9	0.027
GA	290	792	462	1254	4323	531	541	14.7	0.027
GB	398	724	580	1304	3276	402	412	16.3	0.039
HA	736	1298	806	2104	2859	351	361	12.2	0.034
HB	107	266	199	465	4348	534	544	13.0	0.024
JA	103	256	192	448	4352	535	545	13.9	0.025
KA	140	694	253	947	6765	831	841	11.5	0.014
KB	161	585	286	871	5409	664	674	14.5	0.022
LA	141	456	254	710	5040	619	629	11.8	0.019
LB	147	458	264	722	4913	603	613	10.9	0.018
MAHBUBNAGAR	233	579	348	927	4564	560	570	13.4	0.024
MA	1112	2258	889	3147	2830	343	358	16.8	0.047
NA	927	2904	866	3770	4067	500	510	16.0	0.031
NB	442	983	620	1603	3627	446	456	16.5	0.036
ANANTAPUR	827	2049	791	2840	3508	431	441	16.4	0.037

contd...

Table 4 continued ...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PA	319	790	491	1281	4031	495	505	13.5	0.027
QA	1067	1792	887	2679	2511	308	318	13.5	0.042
KURNOOL	693	1291	692	1983	3271	402	412	13.5	0.033
RA	1001	1237	882	2119	2117	260	270	21.3	0.079
RB	1100	1325	888	2213	2012	247	257	25.2	0.098
SA	759	1275	818	2093	2757	339	349	24.5	0.070
TA	425	713	605	1318	3102	381	391	21.3	0.054
AKOLA	821	1138	798	1936	2497	307	317	23.1	0.073
UA	593	1004	733	1737	2929	360	370	34.1	0.092
VA	484	823	655	1478	3053	375	385	13.5	0.035
VB	1779	2263	820	3083	1733	213	223	18.8	0.084
SHOLAPUR	952	1363	736	2099	2572	316	326	22.1	0.068

It is not clear, however, what the appropriate costs of maintenance should be. For instance, in Andhra Pradesh the Public Works Department is being allocated an amount of about Rs. 10/acre; this implies only one quarter of 1% of the actual capital investment in the tank. By any standard, spending only about one-fourth of 1% of the value of any building or construction work implies almost certainly its progressive decay. For appropriate maintenance of relatively durable buildings, such as irrigation tanks, probably at least about 2% of the capital value would be required.

If we compare the total construction costs with farmers' net benefits and compute the internal rate of return, we arrive at a measure of social returns to the nation (Table 5).

This analysis of the social returns from tank irrigation indicates the variability in the performance of tanks. On the basis of average prices, about 15 of the 28 tanks surveyed produce internal rates of return of above 5% and of those only 8 tanks produce internal rates of return above 10%. All tanks, however, show considerable employment effects, tank-irrigated agriculture employing about 2 to 5 times the number of work hours of rainfed agriculture on the same farms.

THE CONCEPT OF A TANK IRRIGATION AUTHORITY

Tank irrigation in parts of India is presently decreasing in extent and reliability, despite the fact that it has the potential of being socially and economically beneficial: the question arises of how to ensure that the existing capital of irrigation tanks can be preserved and possibly expanded.

Table 5. Social benefit-cost analysis of tank irrigation projects to the nation

Tank code	At village prices		At average prices		Employment (Hrs/acre)		Addl. employment due to tank irrig. (Hrs/acre)	Proportion of tank irrigated employment over rainfed (6)/(7)	Net present worth	
	BCR	IRR (%)	BCR	IRR (%)	Tank irrig.	Rain-fed			Village prices (--in '000 Rs--)	Average prices
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
AA	0.42	0.9	0.71	5.5	527	187	340	2.8	-1077	-537
AB	n	n	0.68	5.0	570	146	424	3.9	n	-663
BA	0.27	n	0.90	8.4	488	64	424	7.6	-1344	-189
BB	1.10	11.5	1.54	17.7	487	241	246	2.0	77	409
CA	0.96	9.4	1.68	19.6	841	326	515	2.6	-59	1041
CB	1.91	22.8	2.36	29.2	750	230	520	3.3	974	1446
DA	0.21	n	0.31	n	626	126	500	5.0	-915	-815
DB	0.55	2.5	0.59	2.9	601	142	459	4.2	-532	-487
EA	n	n	0.14	n	402	139	263	2.9	n	-799
EB	0.46	0.8	0.52	1.8	729	140	589	5.2	-627	-567
MEDAK					602	174	428	3.9		
FA	0.81	6.9	0.90	8.4	411	160	251	2.6	-88	-45
GA	1.03	10.4	1.10	11.6	381	162	219	2.4	36	132
GB	1.20	13.4	1.12	12.0	386	124	262	3.1	268	158
HA	0.95	9.2	1.34	15.3	326	81	245	4.0	-111	744
HB	0.91	8.5	0.99	9.8	447	115	332	3.9	-44	-6
JA	0.88	8.1	1.12	11.5	473	73	400	6.5	-56	436
KA	0.04	n	0.08	n	492	67	425	7.3	-918	-885
KB	0.10	n	0.15	n	395	55	340	7.2	-795	-755
LA	0.34	n	0.49	1.3	313	77	236	4.1	-479	-367
LB	0.19	n	0.54	2.3	487	64	423	7.6	-598	-341
MAHBUBNAGAR					411	98	313	4.8		
MA	1.57	18.3	2.04	24.0	506	159	347	3.2	1957	3359
NA	0.42	n	0.70	5.3	329	96	233	3.4	-2221	-1097
NB	0.32	n	0.77	6.2	354	90	264	3.9	-1112	-379
ANANTAPUR					396	115	281	3.5		

contd...

Table 5 continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
PA	0.21	n	0.35	n	620	112	508	5.5	-1043	-854
QA	0.50	0.9	0.68	4.5	497	139	358	3.6	-1388	-879
KURNOOL					558	125	433	4.5		
RA	na	na	na	na	267	276	-9	1.0	na	na
RB	na	na	na	na	230	344	-114	0.7	na	na
SA	na	na	na	na	423	368	55	1.2	na	na
TA	na	na	na	na	271	337	-66	0.8	na	na
AKOLA					298	332	-34	0.9	na	na
UA	0.43	0.5	0.32	n	2	197	48	1.2	-1005	-1212
VA	n	n	n	n	230	260	-30	0.9	n	n
VB	0.68	4.9	0.67	4.7	242	175	67	1.4	n	n
SHOLAPUR					239	211	28	1.2	-1046	-1079

Notes: Social rate of discount = 10%
Life period = 22 years
BCR Benefit cost ratio
IRR Internal rate of return
n Negligible
na Not available

A "Tank Irrigation Authority" might ensure that conditions are fulfilled which lead to productively activate and enhance the capital invested in irrigation tanks in India. Irrigation tanks -- unlike canal irrigation -- can easily be administered by involving local communities. Rather than putting anonymous bodies in charge of repairs and collection of fees, such as the Public Works Department and the Revenue Department, a state corporation representing a "Tank Irrigation Authority" could be established; this corporation would form "Tank Committees" with elected and appointed members from the farmers' community and representatives of Government bodies. The "Tank Committee" would employ "Tank Controllers" who have the authority to allocate and distribute water, advise on need for repairs and new construction works and identify water users for collection of fees according to amount of water used. The "Tank Controllers" would be transferred every 3 to 5 years to other locations (similar to market secretaries in some states).

Under such a framework tank irrigation can be a profitable and self-maintaining proposition if the following conditions are fulfilled.

CONTROL OF WATER DISTRIBUTION

The water-use efficiency of a tank depends largely upon the water management. The more judiciously water is being used and distributed during the two growing seasons, the larger will be the area that can be served from a particular tank. Even a high water consumptive crop such as paddy covering the entire tank command area does not require the same amount of water day after day. Instead, the water flow needed varies with the growth stage of the crop and with weather and wind conditions. Theoretical calculations show that a tank in which a water manager allocates water optimally by taking these variables into account can increase its command area significantly.

Naturally, if crops are grown that consume less water -- such as groundnuts, hybrid sorghum, cotton, etc. -- the water-use efficiency can be increased still further. However, such a step to increase efficiency requires also considerably higher costs of more sophisticated water allocation; for instance, for irrigated rainfed crops and supplementary irrigation the entire canal system has to be physically designed so as to allow "flushing" of the whole command area within a few days during which the dry spell occurs. Larger and, because of the wider command area, longer channels are required which have to be lined and provided with adjustable outlets. Staff to supervise the flushing operation has to be provided during those days.

It is not likely that radical shifts away from paddy can be achieved easily, because of relatively high investment costs in physical and institutional terms. Instead, water allocation by a Tank Controller and a system of fixing water-charges according to actual water use might allow less extreme and therefore more feasible solutions, i.e. land-use patterns, where perhaps the higher outer fringes of a command area are being planted under irrigated dry crops while the lower wetter areas are cultivated with paddy. Depending upon the water availability from year to year, farmers could be induced to shift larger or smaller proportions to irrigated dry crops so as to make best use of the water and the land.

A solution has to be found that maximizes the difference between the increase in productivity due to improved water use efficiency and the costs at which such improved water management can be provided. This point, where marginal costs of improved water management is equal to its marginal benefits, is difficult to determine as it varies from year to year.

Prelimi ary model calculations using 70 years of daily rainfall to simulate a water storage system have shown that for an average tank a simple rule of keeping the sluice closed on rainy days would increase the irrigated area by more than 20% and reduce by about half the number of years the tank runs dry during the cropping season. It should be possible to implement such a simple control function by a public authority at relatively low costs.

REGULAR MAINTENANCE AND REPAIR

Any tank constitutes an artificial obstacle to a natural waterway and as such it is permanently subject to destructive forces which would eventually lead to its breaching and washing away, unless it was continuously repaired by hand and well maintained. Thus tanks, as old as some of them may be, cannot be regarded as permanent and stable features *per se* (such as perhaps mountains or river beds).

To maintain irrigation tanks requires annual inspection and regular repair works. The amounts spent for repair have to be kept at levels sufficiently high to preserve the capital value of a newly constructed tank, which amounts to about 3000 to 4000 Rs. per acre of command area.

REVENUE COLLECTION AND TANK MANAGEMENT

Water rates levied in the tanks under study amount to something in the order of 14 Rs/acre. These water charges are collected by the Revenue Department and amount to a tax drawn from people who own irrigated land. Whenever the Public Works Department comes (on five-year cycles) to work on the tank, this activity is financed out of the water rates previously collected. However, this link is too indirect to be understood by the farmer; moreover, political pressure is often needed to get repairs done and this further obscures the rationale in decisions guiding tank maintenance.

Instead, a tank controller could report annually the amount of works that need to be done and, in the light of such reports, repair works should be carried out according to actual needs, keeping in mind also the potential revenue loss of a particular tank if it is left unrepaired. Such a rational system of repairs would be appreciated by the farmers.

NO CULTIVATION IN TANK BEDS

Tank beds should be kept free from cultivation so that desiltation can be carried out in an uninhibited way; tank beds could be used for grazing or in the upper fringes to grow trees. Cultivation and the subsequent acquisition of ownership rights by individuals in tank beds is likely to lead to endless disputes over the water storage level to be reached, and thus has the overall effect of reducing the capacity of a tank.

DESILTATION OF TANK BEDS

Under controlled erosion, the siltation of the tank bed will be minimized, but even then silt is likely to be accumulating, which over time reduces the storage capacity of the tank. Regular desiltation of existing tanks should be the responsibility of a public body. By digging the fertile silt and redistributing it on the uplands from where much of it probably originated, the value of these uplands could be upgraded, while the storage capacity of the tank would be restored.

EROSION CONTROL

Catchment areas should be kept in a state that prevents soil erosive runoff. Natural vegetation on the one hand or artificial soil preparation on the other, including bunds or broadbed and furrow cultivation combined with grassed waterways, are effective means to reduce the speed of the runoff.

CONCLUSIONS

Tank irrigation is an economically and socially profitable technology; but under present conditions of management tank irrigation is deteriorating rapidly. Extent as well as reliability of tank irrigation are decreasing.

In view of this decay of valuable capital, the creation of an authority that would be responsible for revenue collection as well as of repairs and overall tank management, including identification of water users should be considered. Under such a Tank Irrigation Authority it is logical that the farmers could be charged higher water rates because a better service would be provided, upgrading the performance of irrigation tanks to the benefit of every individual.

The level at which these rates would be fixed largely depends upon political considerations. However, as a principle, the Tank Irrigation Authority should operate on a no-gain, no-loss basis similar to other state corporations. A detailed study of the legal and administrative feasibility of a Tank Irrigation Authority is required.

REFERENCES

Baliga, B.S. 1960. *Studies in Madras Administration, Vol. II,* Government of Madras.

Chambers, R. 1977. "Men and water: The organization and operation of irrigation" in B.H. Farmer (ed.) *Green Revolution?* The Macmillan Press Ltd., London, pp. 340-363.

Davies, Collin C. 1976. *An Historical Atlas of the Indian Peninsula.* Second edition, Oxford University Press, Madras, p. 73.

Government of India, Ministry of Agriculture. *Indian Agriculture in Brief.* Various issues.

Ludden, David. *Ecological Zones in the Cultural Economy of Irrigation in Southern Tamil Nadu.* Photocopy.

von Oppen, M. 1978. Instability of area and production under tank irrigation in selected districts of Andhra Pradesh and Tamil Nadu. ICRISAT Economics Program discussion paper 9, Patancheru, Andhra Pradesh 502 324, India.

von Oppen, M., and Subba Rao, K.V. 1980. Tank irrigation in semi-arid tropical India. Part I : Historical development and spatial distribution. ICRISAT Economics Program progress report 5, Patancheru, Andhra Pradesh 502 324, India.

von Oppen, M., and Subba Rao, K.V. 1980a. Tank irrigation in semi-arid tropical India. Part II : Technical features and economic performance. ICRISAT Economics Program progress report 8, Patancheru, Andhra Pradesh 502 324, India.

REFERENCES

[illegible] Studies in Madras Administration, Vol. [illegible] Government [illegible]

[illegible] and water: The organization and operation of [illegible] W.H. Parker (ed.) Green Revolution? The Macmillan [illegible] Ltd. [illegible] pp. 540-563.

[illegible] An Historical Atlas of the Indian Peninsula. [illegible] Oxford University Press, Madras, p. 73.

[illegible] Ministry of Agriculture. Indian Agriculture [illegible]

[illegible] Zones in the Cultural Economy of Irrigation [illegible] Southern [illegible] India. Photocopy.

[illegible] Instability of area and production under [illegible] districts of Andhra Pradesh and Tamil Nadu. [illegible] Economics Program discussion paper 9, Patancheru, [illegible] 502 324, India.

[illegible] K.V. 1980. Tank irrigation in [illegible] historical development [illegible] Economics Program progress report [illegible] Patancheru 502 324, India.

[illegible] K. [illegible] 1980. [illegible] Economics Program progress report [illegible] 324, India.