Water Supply and Demand in Sri Lanka: Differences at District Level

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ABSTRACT

Several studies on water scarcities have identified that Sri Lanka has no water scarcity at present or in the future. Most of these studies are based on the national-level statistics and have ignored the spatial and seasonal variations of water supply and demand. This study focused on the water supply and demand variations at the district level in Sri Lanka. The results indicate wide spatial and seasonal variations.

On the supply side, the water resources per unit area between districts range from .05 meter (m) to 1.6 meters (m) in the *maha* (wet) season, and from 0.03 m to 1.9 m in the *yala* (dry) season. The maha season water resources per unit area in the dry zone, comprising two-thirds of the land area, constitute only 30 percent of the water resources per unit area in the wet zone while it is only 17 percent in the yala season. On the demand side, more than 90 percent of the total water withdrawals are for the dry zone, whereas only 44 percent of the 1991 population lived in this zone.

According to most water scarcity criteria, several districts in the dry zone are already facing either seasonal or year-round absolutely severe water-scarce conditions. At the current level of irrigation efficiency, several more districts enter into this category. Also, contrary to common belief, some districts in the wet zone are also identified as water scarce in the economic sense. Though these districts have ample water supply to meet their demand, they will have to at least double their withdrawals to meet the 2025 demand.

INTRODUCTION

Several studies on water scarcity using the national statistics rank Sri Lanka as a country with either little or no water scarcity at present or in the future (Falkenmark, Lundqvist and Widstrand 1989; Engleman and Leroy 1993; Raskin et al. 1997; Seckler et al. 1998). However, the national statistics of water supply and demand are misleading in the presence of significant spatial and seasonal variations. Due to bi-monsoon climatic patterns, Sri Lanka experiences high spatial and seasonal variations of rainfall. The main focus of this paper is to study the spatial and seasonal variations of water supply and demand, and also water scarcities, if any, at the district level in Sri Lanka.

The rainfall patterns divide the country primarily into two climatic zones: wet zone and dry zone. The wet zone, comprising one-third of the total land area receives an average of

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2,500 mm of annual rainfall, while the dry zone receives only about 1,450 mm of annual rainfall.

Sri Lanka has two seasons: maha season from October to March and the yala season from April to September. The annual rainfall in the wet zone is evenly distributed between the two seasons. However, more than 75 percent of the dry zone rainfall is received in the maha season, and more than 70 percent is received in the period from October to December. These points briefly indicate the variations of rainfall leading to the spatial and seasonal variations of water supply.

On the demand side, more than 96 percent of the 1991 water withdrawals are for the agriculture sector. The high demand for agriculture is mainly due to paddy irrigation. Of the 1991 paddy irrigated area, more than 85 percent is in the dry zone. Therefore, the majority of the water withdrawals at present are for the dry zone. However, only 44 percent of the population of 17 million people lived there in 1991.

These briefly illustrate the differences of supply and demand between the two zones. There are more water resources in the wet zone due to substantially high rainfall there. Though the total population is larger in the wet zone the total water withdrawal is lower than that in the dry zone. Therefore, there is water scarcity in the form of low-water supply per person, especially in the wet zone due to higher population, or low-water supply with respect to demand, especially in the dry zone due to high irrigation demand. The water scarcities, if any, in the two regions will have major consequences for meeting the additional food production requirements in the future, mainly due to the following reasons.

Rice is the staple food in Sri Lanka. More than three-fourths of the rice production in 1991was from irrigated agriculture, and the greater part of the irrigated land is in the dry zone. The recent trend shows that there is no increase in the rice-cultivated area under rain-fed conditions (Aluwihare and Kikuchi 1991). Also there has not been significant increase in rice yield, either under irrigation or under rain-fed conditions, in recent years (Wijayaratna and Hemakeerthi 1994). Therefore, if the recent trends in rice area and rice yield are indications of future development, the additional rice production will have to come totally from increasing the gross irrigated area, perhaps even at the expense of existing rain-fed areas. However, most of the lands that can be irrigated in the two zones, especially in the wet zone may have been already developed. The cost of developing more irrigation areas in the dry zone may be very high.

Also, the changing socioeconomic environments will increase the competition for water for the domestic and the industrial sectors. The priority of supplying water will always be to these two sectors. In this respect, it is of vital importance to understand the regional water scarcities and their impact on future food production.

An ideal unit for conducting a water resources analysis is a hydrological unit such as a river basin. However, some of the data (population, some water supply data and some water withdrawal data), which are important to such an analysis are available only at the administrative unit level. For this study, an administrative district is considered as our basic unit of analysis. Data on the water resources at a larger administrative unit or at the level of climatic zones can be obtained by summation of the data at districts level. Therefore, the major objective of this paper is to assess the present and future water scarcities that exist with respect to interannual variations in water supply and demand at district level

Sri Lanka's rainfall patterns show high interannual variations. Yet, most studies give the river discharges to sea (surface runoff) at the average rainfall conditions (Survey Department 1988). However, in most river basins the average rainfall even exceeds the median rainfall. This means that there is low probability in observing at least the average rainfall every other year. In view of the high interannual variations, rainfall estimates at the 75 percent exceedence probability level are used for most water resources analysis. In this study, the potentially utilizable surface runoff is considered to be the average river discharges estimated at the 75 percent exceedence probability rainfall.

The year 1991 is used as the base year for assessing the current status. The future demand projections and the scarcities are estimated for the year 2025. As will be discussed later, the agriculture sector, especially for paddy irrigation, consumes most of the current water withdrawals. The future demand of water is assessed under the assumptions that:

- the per capita paddy production demand in the future will be the same as at present
- there will be a small increase in paddy yields due to improved exogenous factors such as better fertilizer application, water management, etc.
- the additional rice production will totally come from the irrigation sector

The future water scarcity is assessed under two scenarios:

- The first scenario is that the irrigation efficiency, i.e., the ratio of net irrigation requirement to total irrigation withdrawal, in the future will be the same as at present.
- The second scenario assumes higher irrigation efficiency than at present.

It should be mentioned here that there are certain limitations to our analysis. Most of the data used for the analysis are from various secondary sources. No primary data collection was conducted for water withdrawals at district levels. Our estimates of water withdrawal data at district level may slightly differ from their actual values. However, we believe that the methodology used in the study enables us to compare the present and future water supply and demand at district level, and also allows us to illustrate the extent of water scarcities at district level.

In the next section we present the current status of water supply and demand at district level. In section 3, the demand projections are discussed. The water scarcities at district level are discussed in section 4. We conclude the paper by discussing the impact of water scarcities on future policy implications.

WATER RESOURCES AT DISTRICT LEVEL

There are 25 administrative districts in Sri Lanka. The wet zone contains 9 districts, mainly in the western, central, and southern regions. The seasonal water resources available for a district consist of the following components.

- the inflow (I), i.e., the precipitation within the district and the inflow from the neighboring districts
- the outflow from the district (O), i.e., the portion of the inflow getting out of the district
- the net groundwater recharge (G)
- the change in reservoir storage (R), i.e., the potential storage carried over from one season to another
- the net diversion (D), i.e., the diversions to the district minus the diversions from the district

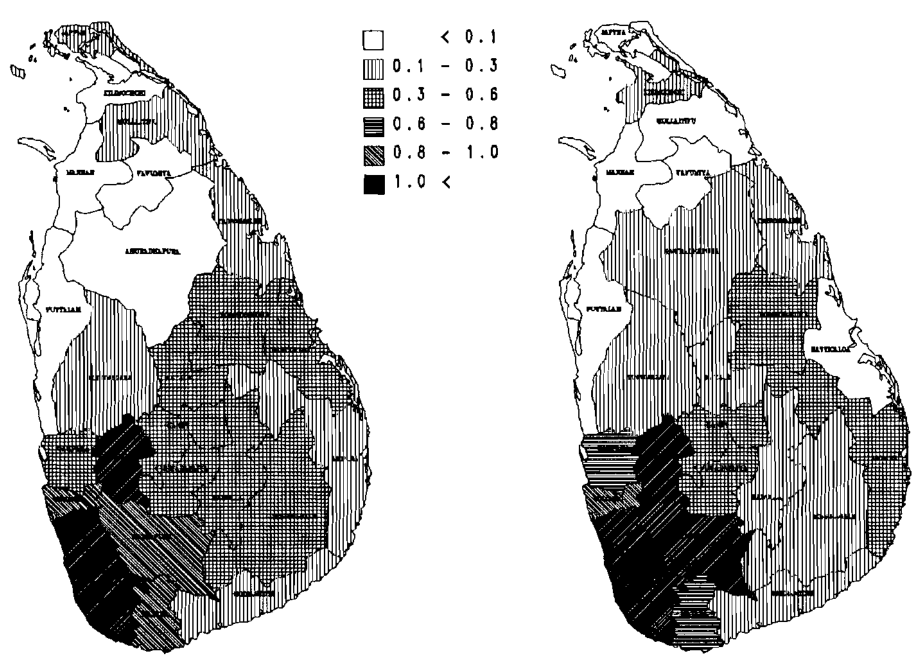
The total available water resources (T) are the aggregate of the net surface inflow (inflow minus outflow), groundwater recharge, and the change in reservoir storage, i.e., $T = I-O+G+R+D$. The surface inflow, outflow, and net groundwater recharge at the district level are not measured, and need to be estimated. Briefly, the methodology of estimating the net inflow is based on the computation of seasonal discharges of river basins[2] and apportioning them among the districts contributing to those discharges. The net groundwater recharge of each district is extrapolated by superimposing the district boundaries on the groundwater map produced by Fernando (1973). The details of the computations of these and other components can be found in Amarasinghe, Mutuwatta, and Sakthivadivel 1998.

The potentially utilizable water resources of the two seasons show vast differences between districts (figure 1). The maha season water resources per unit area (column 5 [C5], table 1) ranges from 1.56 m in the Kalutara district in the wet zone to 0.05 m in the Killinochchi district in the dry zone. The yala season water resources per unit area ranges from 1.9 m in the Kalutara district to 0.03 m in the Mullaitive district in the dry zone (C7, 1).

The total water resources of the two climatic zones in the maha season are similar (C4, table 1). However, the water resources per unit area in the dry zone are less than one-third of those in the wet zone. In the yala season, even the totals are different (C6, table 1). The yala season water resources in the dry zone are only half that in the wet zone. The yala season water resources per unit area in the dry zone are less than one-fifth of those in the wet zone.

[2] There are 103 distinct natural river basins covering more than 90 percent of the land area of Sri Lanka (figure 1). The remaining 94 coastal river basins make no significant contribution to the freshwater resources of Sri Lanka (Arumugam 1969).

Figure 1. Seasonal water resources per unit.



WATER WITHDRAWALS IN 1991

In the absence of primary data, we use the total withdrawals estimated for Sri Lanka by ESCAP (1995) for our analysis. Of the total withdrawals of 9.66 km^3 in 1991, while the agriculture sector has used 96 percent and the domestic and industrial sectors have used 2 percent each. As in the water supply, the distribution of water withdrawals at the district level is also not available. The estimation procedure is briefly explained below. (See Amarasinghe, Mutuwatta, and Sakthivadivel 1998 for more details).

Domestic Withdrawals

The domestic water withdrawal for each district is assumed to be proportional to the total population that is served with piped water. It was estimated that, in 1991, 70 percent of the urban population and only 15 percent of the rural population were served with piped water (ESCAP 1995). Based on these figures, Sri Lanka has withdrawn only 31 liters per person per day (l/p/d) for its domestic sector in 1991 (C8, table 1). The Colombo district in the wet zone has the highest withdrawals (65 l/p/d), while several districts in both zones have withdrawn less than 25 l/p/d, with Monaragala district having the lowest withdrawals of 19 l/p/d.

Table 1. Water resources and water withdrawals in 1991.

Unit	Land area	1991 population	Average rainfall	Utilizable water resources				Water withdrawals in 1991									
				Maha season		Yala season		Per capita per day withdrawals		Irrigation						Total withdrawal	
										Maha season			Yala season				
				Total	Depth	Total	Depth	domestic	industrial	Area	NET	Total	Area	NET	Total	Maha season	Yala season
	1000km²	millions	mm	km³	m	km³	m	liters/p/d	liters/p/d	1000ha	m	km³	1000ha	m	km³	km³	km³
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17
Sri Lanka	65.6	17.3	1672	25.19	0.38	23.2	0.35	31	31	376	0.22	4.11	266	0.39	5.27	4.31	5.46
Wet Zone (WZ)[1]	23%	56%	2353	51%	0.83	64%	0.97	35	49	12%	0.19	11%	14%	0.08	3%	14%	6%
Dry Zone (DZ)[1]	77%	44%	1465	49%	0.25	36%	0.17	26	8	88%	0.22	89%	86%	0.45	97%	86%	94%
Districts[1]-WZ																	
Colombo	1%	11%	2528	2%	0.85	3%	1.0	65	132	0%	0.22	0%	0%	0.10	0%	2%	1%
Gampaha	2%	9%	2210	4%	0.59	4%	0.6	35	105	1%	0.27	1%	1%	0.15	0%	2%	1%
Kalutara	2%	6%	2655	9%	1.56	11%	1.9	31	4	1%	0.18	1%	1%	0.07	0%	1%	0%
Kandy	3%	7%	2155	3%	0.34	3%	0.3	26	4	3%	0.18	3%	4%	0.08	1%	3%	1%
Nuwara Eliya	3%	3%	2122	3%	0.40	4%	0.6	22	33	2%	0.17	1%	1%	0.08	0%	1%	0%
Galle	3%	5%	2344	7%	1.09	9%	1.3	31	9	0%	0.20	0%	0%	0.08	0%	0%	0%
Matara	2%	4%	2217	4%	0.82	4%	0.8	25	7	2%	0.19	2%	2%	0.09	1%	2%	1%
Kegalle	3%	4%	2388	7%	1.07	10%	1.4	22	10	1%	0.20	1%	1%	0.10	0%	1%	0%
Ratnapura	5%	5%	2535	12%	0.92	15%	1.0	22	9	3%	0.16	2%	4%	0.07	1%	2%	1%
Districts[1]-DZ																	
Matale	3%	2%	1690	4%	0.45	2%	0.25	24	5	3%	0.23	3%	2%	0.35	2%	3%	2%
Hambantota	4%	3%	1691	3%	0.24	2%	0.22	24	1	9%	0.21	8%	9%	0.25	6%	8%	6%
Jaffna(1)	2%	5%	1104	1%	0.29	0%	0.06	38	3	1%	0.20	1%	1%	0.65	2%	1%	2%
Killinochchi	2%	1%	1102	0%	0.05	1%	0.13	23	27	3%	0.22	3%	1%	0.67	1%	3%	1%
Mannar	3%	1%	1072	0%	0.06	1%	0.07	26	21	1%	0.24	1%	0%	0.65	0%	1%	0%
Mullaitivu	4%	1%	1145	2%	0.15	0%	0.03	23	30	2%	0.21	2%	0%	0.69	1%	2%	1%
Vavuniya	3%	1%	1172	0%	0.05	1%	0.09	30	24	3%	0.21	3%	1%	0.60	1%	3%	1%
Amparai	7%	3%	1509	4%	0.20	6%	0.30	26	6	10%	0.20	10%	17%	0.49	21%	9%	21%
Batticaloa	4%	2%	1574	4%	0.32	1%	0.08	33	7	4%	0.18	3%	4%	0.57	6%	3%	6%
Trincomalee	4%	2%	1426	3%	0.28	2%	0.14	38	9	4%	0.19	4%	4%	0.65	6%	4%	6%
Kurunegala	7%	8%	1654	4%	0.21	4%	0.18	20	3	11%	0.27	13%	12%	0.31	9%	13%	9%
Puttalam	5%	3%	1478	1%	0.08	1%	0.09	25	17	3%	0.30	4%	2%	0.37	2%	4%	2%
Anuradhapura	11%	4%	1305	3%	0.10	5%	0.15	22	0	14%	0.23	16%	12%	0.54	16%	15%	15%
Polonnaruwa	5%	2%	1532	8%	0.60	5%	0.37	22	0	11%	0.21	11%	14%	0.52	19%	11%	18%
Badulla	4%	4%	1776	6%	0.54	3%	0.27	23	7	5%	0.19	4%	4%	0.26	3%	4%	3%
Monaragala	9%	2%	1587	8%	0.34	3%	0.10	19	40	3%	0.20	2%	2%	0.38	2%	2%	2%

Per person withdrawals in the wet zone and the dry zone are 35 l/p/d and 26 l/p/d, respectively. Because of the higher population (56 percent in 1991, [C2 table 1]), the total domestic sector withdrawal in the wet zone is almost twice that in the dry zone.

Industrial Withdrawals

The water withdrawals for the industrial sector in each district are assumed to be proportional to the total industrial output. Per capita withdrawals between districts vary significantly (C9, table 1). The Colombo and the Gampaha districts in the wet zone have withdrawn more than 100 l/p/d for their industrial sector, while several districts in the dry zone have had almost no withdrawals. Per person per day industrial withdrawals in the dry zone comprise only one-sixth of those in the wet zone. The total industrial withdrawals in the dry zone are only about one-tenth of those in the wet zone.

Irrigation Withdrawals

Irrigated agriculture accounted for 96 percent of the 1991 water withdrawals, or 9.38 km^3. The seasonal irrigation withdrawal for a district is assumed to be proportional to the total seasonal irrigation requirement for the area irrigated by the district. The total irrigation requirement is the product of irrigated area and net irrigation requirement (NET) of the season. The NET for a season is taken to be the net evapotranspiration of the first five months of the season. The net evapotranspiration of a month is the potential evapotranspiration minus the 75 percent exceedence probability level rainfall. (See Amarasinghe, Mutuwatta and Sakthivadivel 1998 for more details for computing seasonal irrigation requirements).

In the wet zone, the irrigation requirement per unit area, i.e., the NET per unit area (C11, table 1), in the maha season ranges from 0.16 to 0.27 m, with an average of 0.19 m. In the dry zone, this ranges from 0.18 to 0.27 m with an average of 0.22 m. Because of similar irrigation requirements in the two zones, the share of agricultural withdrawals, 11 percent in the wet zone and 89 percent in the dry zone (C10, table 1), is similar to the share of irrigated area, 12 percent in the wet zone and 88 percent in the dry zone (C12, table 1).

In the yala season, the picture is somewhat different. The NET in the wet zone is more or less uniform over all districts with an average of only 0.08 m/ha (C14, table 1). The irrigation requirement in the dry zone does vary from 0.25 to 0.67 m with an average of 0.45 m/ha. That is, the per unit area irrigation requirement in the dry zone is almost six times that in the wet zone. Because of these differences, the dry zone accounted for 97 percent of the agricultural withdrawals (C15, table 1), though it had only 86 percent of the irrigated area (C13, table 1).

TOTAL WITHDRAWALS

The dry zone accounted for the majority of the total withdrawals (86% in the maha [C16, table 1] and 94% in the yala [C17, table 1]). The five districts, Hambantota, Ampara, Kurunegala, Anuradhapura, and Polonnaruwa in the dry zone accounted for about 55 percent in the yala season and for about 70 percent in the maha season total withdrawals. The reason for higher withdrawals in these districts is their contribution to higher irrigation withdrawals. The actual irrigation withdrawals in these districts and also in other districts might or might not be higher than our estimates. The main reason for this is our assumption on *irrigation efficiency.*

IRRIGATION EFFICIENCY

The irrigation efficiency, i.e., the ratio of irrigation requirements to the irrigation withdrawals for the country is 20 percent. Because of the method used for estimating irrigation withdrawals, the irrigation efficiency of all districts is the same as the overall efficiency of the country. This is another major limitation in our analysis. The nonavailability of reliable withdrawal data at district levels forces us to assume the same irrigation efficiency for all districts and hence the proportionality of irrigation withdrawals with irrigation requirements. Until we obtain actual data on irrigation efficiency at district level, we use the same efficiency, i.e., 20 percent for projecting the future irrigation demand.

WATER DEMAND IN 2025: IRRIGATION DEMAND

The future demand for irrigation is assessed under two scenarios. In the first scenario, *the irrigation efficiency in 2025 is expected to be the same as at present.* In the second, we assume that *the irrigation efficiency in 2025 will double from the current level.* For both scenarios, we assume a growth in irrigated area. This is computed under the following assumptions:

- The level of per capita rice production (aggregate of irrigation and rain-fed) will remain the same through the period 1991 to 2025; this amounts to the assumption that, the rice self-sufficiency ratio in 2025 will be the same as in 1991.
- There will be a modest growth in rice yield, both under irrigated and rain-fed conditions, due to improved exogenous factors such as improved fertilizer, better technology, etc. We assume a 10 percent growth in rice yield.
- The additional rice production in 2025 will come totally from the irrigation sector. Here we ignore the possible reduction in rain-fed area due to irrigation development, and assume the same rain-fed cultivated area in 2025.

Under the above assumptions the irrigated area in 2025 is expected to increase by 42 percent (see Amarasinghe, Mutuwatta, and Sakthivadivel 1998 for detailed computations), which is slightly lower than the population increase (45%) projected by the United Nations medium projections (UN 1995).

DOMESTIC AND INDUSTRIAL DEMAND

The demand projections for the domestic sector are based on meeting at least the basic water requirement (BWR) for human needs and/or keeping at least the present level of per capita withdrawal level. Based on *drinking water for survival, water for human hygiene, water for sanitation services, and water for modest household needs for preparing food*, Gleick (1996) has suggested 50 l/p/d as the BWR for domestic needs. The present per capita domestic withdrawals in all districts except Colombo are below the BWR level. The 2025 domestic withdrawals are projected either at the BWR of 50 l/p/d or at the present level whichever is higher.

In this study, the per capita industrial withdrawals are also projected at the same level of BWR for domestic needs or at the present level of industrial withdrawals whichever is higher. The current per capita industrial withdrawals of Colombo and Gamapha districts are more than 50 l/p/d. Demand in these districts is projected at the 1991 levels.

TOTAL WATER DEMAND

The total water demands under the two scenarios are in table 2 (C1 & C2 for maha and C4 & C5 for yala). The water demand under the second scenario in almost all the districts in the dry zone is only half of the demand under the first scenario (C3 & C6, table 2). This is not surprising because most demand in the dry zone is for irrigation, and the water savings from the second scenario are completely due to irrigation.

The savings in the wet zone are comparatively low. Scenario 2 reduces the demand in the wet zone by 33 percent in the maha season and by 21 percent in the yala season. The low savings in the wet zone under the second scenario are due to higher domestic and industrial demands and very much lower irrigation demands than in the dry zone.

WATER SCARCITIES AT DISTRICT LEVEL

Water scarcities in the future can occur in two forms: absolute or economic. In an absolute scarcity situation, the demand with respect to utilizable water supply is high.. In the case of economic scarcity, there may be ample water supply to develop, but the required amount of increase in development may not be economically feasible. This section studies the water scarcities that exist at present and in the future at the district level.

Table 2. Total demand in 2025 and indicators of water scarcity under the two scenario.

Unit	Water scarcity indicators																	
	Total withdrawal demand projections in 2025 under the two scenarios S1 and S2						Per capita annual water resources		Withdrawal as a % of water resources						Change of 2025 withdrawals from 1991 withdrawals			
	Maha season			Yala season					Maha season			Yala season			Maha season		Yala season	
							1991	2025	1991	2025		1991	2025					
	S1	S2	S2/S1	S1	S2	S2/S1				S1	S2		S1	S2	S1	S2	S1	S2
	km³	km³	%	km³	km³	%	m³	m³	%	%	%	%	%	%	%	%	%	%
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
Sri Lanka	6.37	3.45	54%	8.01	4.27	53%	2802	1928	17%	25%	14%	24%	35%	18%	48	-20	47	-22
Wet Zone (WZ)[1]	15%	19%	67%	7%	10%	79%	2843	1957	5%	7%	5%	2%	4%	3%	62	9	80	42
Dry Zone (DZ)[1]	85%	81%	52%	93%	90%	51%	2750	1892	30%	43%	23%	61%	88%	45%	46	-24	45	-26
Districts[1]-WZ																		
Colombo	2%	3%	94%	1%	2%	98%	652	449	13%	19%	18%	11%	16%	15%	45	36	45	42
Gampaha	2%	3%	73%	1%	2%	85%	1265	871	10%	14%	11%	6%	9%	8%	50	10	55	32
Kalutara	1%	1%	69%	1%	1%	81%	4996	3438	2%	3%	2%	1%	2%	1%	88	29	139	93
Kandy	3%	3%	59%	1%	2%	67%	1042	717	18%	28%	17%	8%	15%	10%	62	-5	87	25
Nuwara Eliya	1%	1%	58%	0%	1%	73%	3119	2146	8%	12%	7%	2%	3%	2%	54	-11	79	30
Galle	0%	1%	97%	0%	1%	99%	4093	2817	0%	1%	1%	0%	1%	1%	235	225	252	247
Matara	2%	2%	58%	1%	1%	67%	2625	1806	8%	13%	7%	3%	6%	4%	59	-8	86	24
Kegalle	1%	1%	68%	0%	1%	77%	5572	3835	2%	3%	2%	1%	2%	1%	88	28	125	73
Ratnapura	2%	2%	59%	1%	1%	68%	6825	4697	3%	5%	3%	1%	2%	1%	62	-5	90	30
Districts[1]-DZ																		
Matale	3%	3%	53%	2%	2%	54%	3305	2275	15%	22%	12%	18%	27%	15%	48	-22	51	-18
Hambantota	8%	7%	51%	6%	6%	52%	2331	1604	54%	79%	41%	55%	80%	41%	45	-25	45	-25
Jaffna(1)	1%	2%	63%	2%	2%	56%	413	284	17%	29%	18%	190%	292%	164%	69	7	54	-13
Killinochchi	3%	2%	51%	1%	1%	51%	2215	1525	194%	277%	141%	39%	57%	29%	43	-27	44	-26
Mannar	1%	1%	52%	0%	0%	56%	1922	1323	41%	60%	31%	14%	21%	12%	46	-23	52	-15
Mullaitivu	2%	2%	51%	1%	1%	52%	4963	3416	24%	35%	18%	62%	89%	46%	43	-27	45	-25
Vavuniya	3%	3%	51%	1%	1%	52%	2435	1676	129%	185%	94%	24%	35%	18%	43	-27	45	-24
Amparai	9%	8%	51%	20%	19%	50%	4663	3209	44%	64%	32%	84%	120%	60%	44	-26	43	-28
Batticaloa	3%	3%	53%	5%	5%	51%	2771	1907	15%	22%	12%	128%	185%	95%	47	-23	44	-26
Trincomalee	3%	3%	52%	6%	5%	51%	3644	2508	20%	29%	15%	84%	120%	61%	45	-25	43	-27
Kurunegala	13%	12%	52%	9%	9%	53%	1328	914	55%	80%	42%	57%	84%	44%	47	-23	48	-22
Puttalam	4%	4%	53%	2%	2%	54%	842	579	80%	118%	62%	44%	67%	36%	47	-22	50	-19
Anuradhapura	15%	14%	51%	15%	14%	51%	2447	1684	90%	130%	67%	81%	116%	59%	44	-26	44	-27
Polonnaruwa	10%	10%	51%	18%	17%	50%	10008	6888	23%	33%	17%	82%	117%	59%	43	-27	43	-28
Badulla	4%	4%	53%	3%	3%	54%	3236	2227	12%	18%	9%	21%	31%	17%	49	-20	51	-19

ANNUAL PER CAPITA WATER SUPPLY

Several studies have ranked water scarcity of a country using the annual per capita water supply (Falkenmark, Lundqvist, and Widstrand 1989; Engleman and Leroy 1993). Per capita water supply (ws/pc) of 1,700 m^3 is considered to be the water-stress threshold of a country. Above this level, water scarcities are rare and, if these exist, are only in a few localities. Per capita water supply below 1,700 m^3 shows seasonal or regular water-stress conditions; below 1,000 m^3 water shortages begin to hamper health and human well-being. Below 500 m^3 is the severe water-scarce category.

Th current annual per capita water supply in Sri Lanka is 2,800 m^3 (C7, table 2). With the population increase, this decreases to 1,928 m^3 in 2025 (C8, table 2). Thus the national statistics show no present or future water scarcity under this criterion. The two zones as a whole also show no future water scarcity. But the distribution at district level shows a different picture (figure 2). Colombo and Jaffna districts will be in the severe water-scarce category in 2025. The ws/pc of the Gampaha, Kandy, Kurunegala, and Puttalam districts will be below 1,000m^3 by the year 2025. These 6 districts will have 44 percent of the 2025 population in 20 percent of the land area and, most importantly, will contain only 21 percent of the projected irrigated area. These districts will have a high dependency on the food supply from the other districts, which are relatively less water scarce according to per capita water supply criteria.

WITHDRAWALS WITH RESPECT TO SUPPLY

Figure 3 shows the current withdrawals as a ratio of supply between districts. A district may have a high per capita water supply as well as a high withdrawal ratio with respect to supply. For example, Killinochchi, Mannar, Vavunia, Anuradhapura, Kurunegala, Ampara, and Hambantota districts have more than 1,700 m^3 of annual water supply, but current withdrawals with respect to supply in the two seasons are also more than 40 percent (C9 & C11, table 2). A recent United Nations study (WMO 1997) used the ratio of withdrawal to supply to define water-scarcity thresholds.

According to this criterion, 8 districts (with 24% of the population and 54% of the irrigated area) in the maha season and 10 districts (with 33% of the population and 76% of the irrigated area) in the yala season were severely water scarce. If the ratio of withdrawal to supply is 20–40 percent, the water scarcity is medium to severe, and if it is 10–20 percents the scarcity is moderate, with no water scarcity below 10 percent. Figure 4 shows that even at present, most of the districts in the dry zone are either medium to severe or severely water scarce.

Figure 2. Per capita water supply.

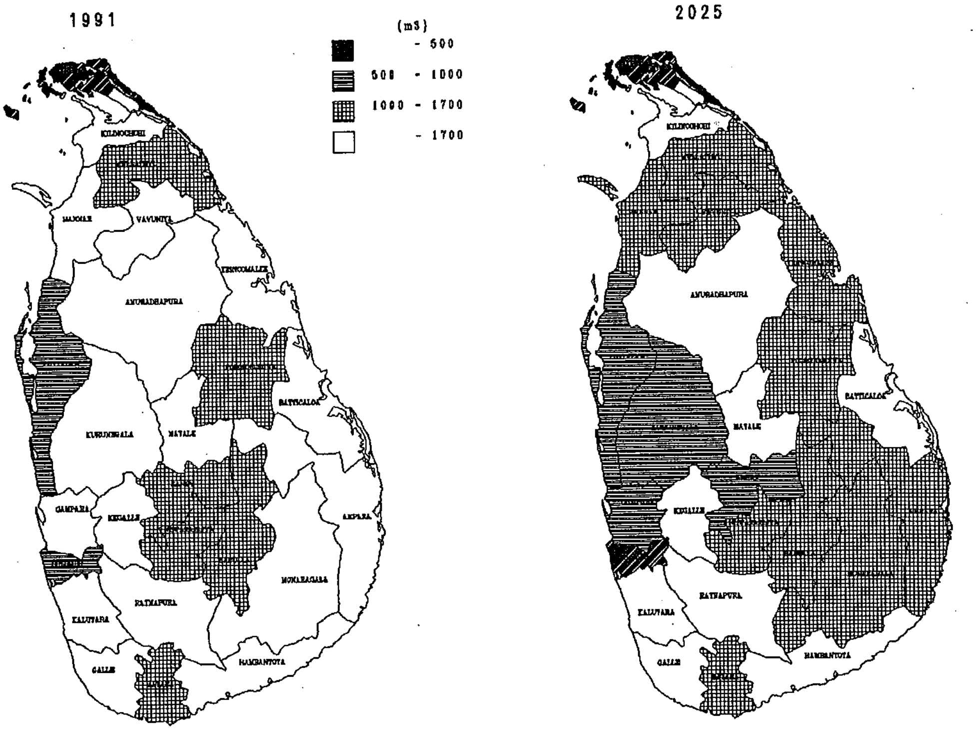
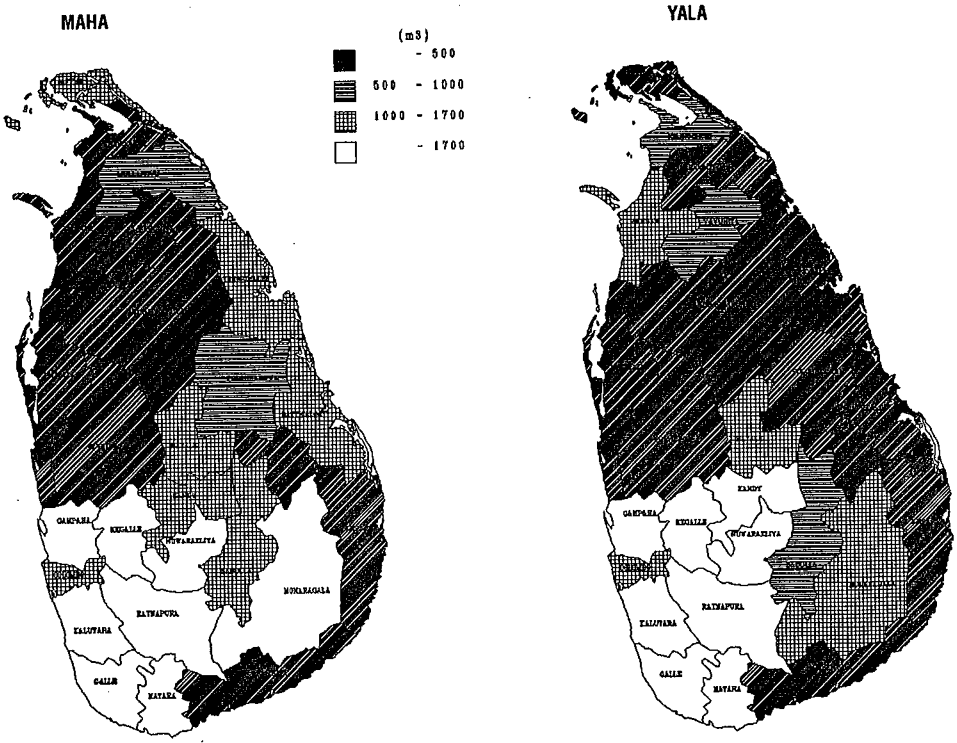


Figure 3. Ratio of withdrawals to supply, 1991.



WATER SCARCITY IN 2025

With population increase the per capita water supply will decrease and the total demand will increase. However, even with increasing population some districts may have a high per capita water supply and a low ratio of demand with respect to supply. Yet some of these districts may have to more than double, or in some cases treble, their current withdrawals for meeting future demand. Whether such an increase is economically feasible depends on many factors. If it is not possible, a district can be categorized as water scarce in the economic sense.

In a recent study by the International Water Management Institute (IWMI), the future water scarcity is defined in terms of the ratio of demand to water resources, and the percentage increase in demand from the current withdrawal levels (Seckler et al. 1998). We used this criterion for projecting the water scarcity in 2025.

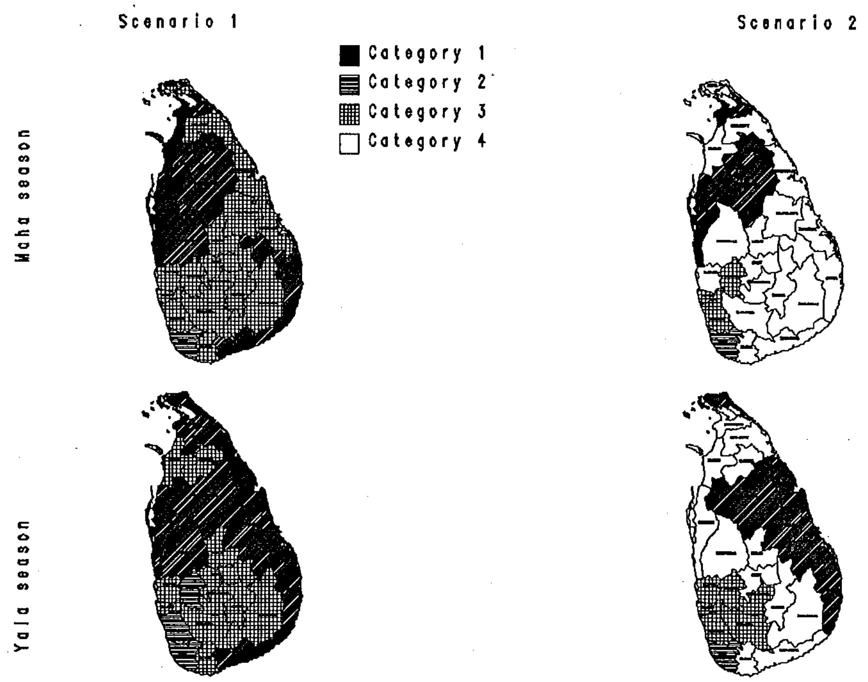
The future water scarcities are assessed under two scenarios. In the first, the irrigation efficiency (ratio of irrigation requirement to irrigation withdrawal) in 2025 is assumed to be same as in 1991. In the second, the irrigation efficiency is assumed to double in 2025. Water scarcities are grouped into four categories (figure 4). In category 1, the most severely water-scarce group, the 2025 demand exceeds 50 percent of the available water resources. This is the absolutely water-scarce group. The other categories are defined in terms of the increase in withdrawals. In category 2, severely water scarce in the economic sense, the withdrawals will at least have to be doubled to meet the 2025 demand. Category 3, moderately water scarce in the economic sense, contains districts having increases in withdrawals between 25 and 100 percent. Category 4, no water scarcity, contains withdrawal increases less than 25 percent.

Under the first scenario, the water demand of Sri Lanka in 2025 will be less than 35 percent of the water resources (C10 & C13, table 2), and increase in withdrawals from the current level will be about 47 percent (C15 & C17, table 2). Thus under the IWMI criterion, the country as a whole will not be in any danger of being in the absolutely or economically severe water-scarce category; but it will be in the moderately scarce category in the economic sense. However, the picture at the district level is quite different.

Figure 4 shows the seasonal water scarcities of districts under the IWMI criterion. According to the first scenario, some districts located in the dry zone and several areas in the dry zone (8 districts with 24% of the population, 54% of the irrigated area) in the maha season (C10, table 2) are identified as being absolutely severe water scarce. In the yala season, there are 11 districts (with 34% of the population, 77% of the irrigated area) in this category (C13, table 2).

All districts in the wet zone except Galle in the maha season, and Galle, Kalutara, and Kegalle in the yala season, will not have any form of water scarcity. The last three districts have ample water resources to develop their demand in 2025. But they will at least have to double or treble their 1991 withdrawal levels to meet the 2025 demand. These are categorized as severely water scarce in the economic sense.

Figure 4. Water scarcity in 2025.



Under the high irrigation efficiency scenario, the number of absolutely severe water-scarce districts will decrease. These include 4 districts (9% of the population, 24% of the irrigated area) in the maha season (C11, table 2), and 6 districts (18% of the population, 52% of the irrigated area) in the yala season (C14, table 2). It is however important to note here that these districts will not have to develop additional water supplies to meet their 2025 demand (C16 & C18, table 2). They will be in the severely water scarce category in 2025, because they were in this category in 1991. In fact, it is important to note that under the second scenario, the 2025 withdrawals in all districts in the wet zone will be below those in 1991. Under the second scenario, only the Galle district is considered to be economically severely water scarce.

CONCLUDING REMARKS

The study clearly illustrates that the national statistics are misleading indicators of water scarcities in Sri Lanka. A substantial amount of both spatial and temporal variations of water supply and demand do exist between regions. The average water supply per unit area in the dry zone is much less than that in the wet zone. However, due mainly to irrigation, the demand in the dry zone is much higher.

Various criteria show no present or future water scarcity at the national level. However, severe scarcities, seasonal or year-round, are already evident in various districts in the dry zone. Prominent among them is the year-round water scarcity in the Hambantota, Kurunegala, and Anuradhapura and, to some extent, in the Ampara and Puttalam districts. The Jaffna, Killinochchi, Vavunia, Batticaloa, Trincomalee, and Polonnaruwa districts have severe seasonal water scarcities.

The consequences of these scarcities in the Sri Lankan context are very important. The greater part of the irrigated area, and hence of irrigated paddy production is from these districts in the dry zone. The majority of the population live in the wet zone and depend heavily on the paddy production from the dry-zone districts. Therefore, the magnitudes of increasing scarcities will be a major constraint for meeting the additional paddy production requirement in the future.

Indeed, if the current rate of irrigation efficiency continues into the future, most of the districts in the dry zone will encounter absolutely severe year-round water scarcities. The water supply of these districts may not be adequate in meeting the projected 2025 demand. As a consequence, these districts will either have to reduce the withdrawal level, especially for irrigation, or import water from water-abundant areas or, as discussed in this paper, increase the irrigation efficiency.

This study shows that by doubling the irrigation efficiency from the current level of 20 percent, the total demand in 2025 can be reduced by half. In most of the irrigation-intensive districts, especially in the dry zone, no additional developments are required for meeting the increasing demand. Whether the country has the capacity to meet the necessary institutional and physical changes for such increase in efficiency is not clear. However, at the current rate of irrigation efficiency, the majority of the dry-zone districts will face year-round water scarcities.

In the presence of substantial spatial and temporal variations, the national statistics only may not be the best indicators for policy making in water resources. Most of the dry-zone districts in Sri Lanka are already facing either seasonal or year-round severe water scarcities. At present, most of the paddy is produced in these districts and distributed to other districts, mainly in the wet zone. In the future, water-scarce districts may need to increase irrigation efficiency or transport water from water-abundant districts to maintain the required production levels. Or these districts may opt for less-water-demanding crops, with an increase in paddy imports. The costs and benefits, both social and economic, of increasing efficiency, transporting water, or importing food, are not studied in this paper. However, future water scarcities at regional and national levels have to be assessed in conjunction with all the above factors.

Our study considered two scenarios in assessing the future water scarcity at the district level. Yet, as we mentioned before, there were certain limitations in our analysis. The data from several secondary sources were used, and several assumptions were also made on various factors in arriving at the above conclusions. These were mainly due to the nonavailability of reliable data at the district level. Even with these limitations, the results certainly indicate likely problem areas in the future under these scenarios. The exact magnitudes of the problems can only be identified with further research.

Therefore, a thorough water resources analysis of supply and demand for future food production at the district level has to consider the following factors:

- collection of data on current actual withdrawals (without reuse) for the domestic, industrial, and irrigation sectors at the district level
- knowledge of current irrigation efficiency at the district level
- potential increase in irrigation efficiency in each district
- potential for additional irrigation developments
- potential for yield increase in paddy production
- possible decrease in rain-fed area, and hence rain-fed production, due to new irrigation developments (we have ignored this in our calculations)
- differences of increase in population between districts
- change in consumption patterns (which most likely will be the case with increasing income)

More research is required to identify the most realistic scenario that Sri Lanka will be facing in the future. Under such scenarios, the demand and supply of the regions should be assessed. Such an analysis can accurately illustrate the extent and the magnitude of the future water scarcities in Sri Lanka.

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