Potential to Increase the Area under Paddy Cultivation with Domestic and Municipal Wastewater Irrigation in Kurunegala District

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Abstract

Use of domestic wastewater for agriculture was a traditional practice in Sri Lanka where leafy vegetables and medicinal plants were cultivated in backyards. The use of domestic and municipal wastewater could be an environmentally sound means of wastewater disposal and could reduce environmental pollution if utilized for paddy irrigation. This practice could also help to increase the economic productivity of the water and land. Therefore a study was conducted in selected Divisional Secretariat Divisions in Kurunegala District in order to explore the potential for land to be brought under paddy cultivation with the utilization of municipal and domestic wastewater. The quantity of wastewater generated was estimated based on the population and water consumption data. Data on the extent of paddy land under minor irrigation and rain-fed agriculture, potential cultivable land extent (known as asweddumized area), land area cultivated in *maha* (wet) and *yala* (dry) seasons, and the areas harvested were collected from the District Agriculture Department. It is noted that not all the available lands were cultivated and harvested in both the *maha* and *yala* seasons. The area of land that is not used for any crop production is higher in the *yala* season than in the *maha* season. In addition, only a part of the land area is harvested from the total area sown. Major reasons for crop failure are inadequate rainfall and shortage of supplementary irrigation water. The difference between the cultivable (asweddumized) extent and harvested extent shows the land that can potentially be brought under irrigation using municipal and domestic wastewater. The amount of land that can be so irrigated is much higher closer to the city where the storm water and other forms of wastewater are drained through common canal systems. Depending on the quantity and quality, and the availability of fresh irrigation water, municipal wastewater can be either diluted with irrigation water to meet the total irrigation water requirement, or can be used without any dilution. In addition to the increment of the land area under cultivation, there is a possibility of increasing the cropping intensity.

Introduction

Traditionally, domestic wastewater generated in villages in Sri Lanka, especially grey-water from kitchens, bathrooms and washrooms, flows along open unlined wastewater drains and is collected in a pool, before being used to irrigate leafy vegetables and medicinal plants. The crops benefited not only from the water but also the nutrients that the wastewater contained. Such a system of wastewater disposal and utilization was separated from the black-water (toilet water) disposal system so that the grey-water used for wastewater irrigation would not be contaminated with harmful deposits (pathogens). Urbanization has increased concerns over the effects of expanding cities, principally on human health, livelihoods and the environment. Water supply and waste disposal systems are unable to keep pace with the development under resource-poor environments, as is the case in developing countries. Once urbanization starts, land becomes too limited for the traditional wastewater disposal mechanisms that are practiced in rural areas. The grey-water that is generated is disposed of mostly into storm water drains, irrigation canals or natural waterways. The wastewater collected in the drains or canals gets diluted with the storm water or irrigation water during certain periods of the year but is concentrated at other times, depending on the amount of rain received and irrigation water releases.

An emerging issue in such areas is the use of diluted wastewater in irrigation, resulting from wastewater pollution of the original irrigation water sources (Raschid-Sally et al. 2006). Using such wastewater in urban and peri-urban agriculture may support the livelihoods of the urban poor and improve productivity, which in turn improves food supplies to cities, despite the health and environmental risks associated with this practice. The common attraction of such a system of diluted wastewater irrigation is not just that it provides a source of water for irrigation, but also that it offers a source of nutrient value. Wastewater use in agriculture in the context of less-developed countries is clearly, therefore, the result of poor urban sanitation. However, the use of wastewater in agriculture offers economic and environmental benefits relative to the costs of not using it.

Insufficient information is available in Sri Lanka on the quantities of wastewater generated and extent of wastewater irrigation in the country as a whole. Therefore, as part of a global survey on wastewater irrigation and agriculture practices, three cities in Sri Lanka were studied, namely Anuradhapura, Kandy and Kurunegala, to quantify the extent and significance of wastewater use. The study also looked at the effect on livelihoods and the range of conditions and factors that influence wastewater use in agriculture (Raschid-Sally and Jayakody 2008).

Urban wastewater is used in agriculture as an alternative to its direct disposal to the sea or surface water bodies. Urban wastewater may be a combination of some or all domestic effluent consisting of black-water (excreta, urine and associated sludge) and grey-water (kitchen and bathroom wastewater), water from commercial establishments and institutions, including hospitals, industries, storm-water and other urban runoff (Van der Hoek 2004). Wastewater agriculture is viewed as a hazard to the health of irrigators as well as the consumers of wastewater irrigated products; and wastewater agriculture may affect the environment too.

Based on a hypothetical consumptive use of 20-40 % for urban areas, it can be assumed that on average 70 % of urban water returns as wastewater, which is an internationally accepted figure for wastewater return flows. There can be variations in this amount according to factors such as the geographical location of cities, the climate, people's behavior, level of industrialization and the number of people served with pipe-borne water. According to the Sri

Lanka Standard (SLS) 745-2003 for 'design and construction of septic tanks and associated effluent disposal systems' (Sri Lanka Standards Institution, SLSI 2003), average wastewater generation is 240-160 liters/capita/day (lcd), of which 75 % is grey-water and 25 % is black-water. This figure can be used to estimate the quantity of wastewater that is potentially available for use per capita, based on consumption data. On average, the National Water Supply and Drainage Board (NWSDB) consider water consumption to be 120 lcd. The estimate of the annual total wastewater generation in the country is, therefore, 273 million cubic meters (MCM) according to a study by Jayakody et al. (2006). A major part of this volume is diverted to the sea or surface water bodies.

Wastewater use is viewed as a benefit providing livelihoods and perishable food to cities. Leafy vegetable cultivation with wastewater is reported in peri-urban areas around Colombo using wastewater that is derived mainly from water in drainage canals. In Kurunegala, peri-urban paddy cultivation using diverted municipal wastewater takes place in both cultivable areas of land and surrounding areas. It is noted that not all the available lands were cultivated and harvested in both the *maha* (wet) and *yala* (dry) seasons (Jayakody et al. 2006). The land area which is not used for any production is very high in the *yala* season compared to the *maha* season. As an example, cultivable lands available near Kurunegala City are 2,002 ha but only 1,971 ha are sown in *maha* and 1,143 ha in *yala*. About 1,675 ha in *maha* and 1,052 ha in *yala* reached harvest stage, and the rest failed due to water scarcity (inadequate rainfall and irrigation water). Therefore, a study was conducted in selected Divisional Secretariat (DS) Divisions in the Kurunegala District in order to explore the potential increase in land that can be brought under paddy cultivation with the utilization of municipal and domestic wastewater.

Methodology

Kurunegala District, which is one of the major paddy growing areas within the intermediate zone, was selected for this study. Data from all the DS Divisions within Kurunegala District was collected from different sources such as the Provincial Agriculture Department, the Department of Census and Statistics (DCS), and published literature. Data on the extent of paddy lands under major and minor irrigation and under rain-fed agriculture, their potential cultivable extent, land area cultivated in maha and yala seasons and the areas harvested were collected from the DCS.

Wastewater generation in each DS Division was estimated based on the population and water consumption data. The population data (2001 census) was collected from the DCS and was combined with the NWSDB water consumption to estimate the quantities of probable grey-water discharges.

The water requirement of paddy for Kurunegala District was estimated using data on the rate of evaporation in Kurunegala and the paddy crop coefficient using the peak water requirement at the mid-season stage. It is assumed that the water required for land preparation is supplied mainly by rainfall.

Results and Discussions

Kurunegala District and the Climatic Zones

Kurunegala District is located mainly within the intermediate zone of Sri Lanka, (the area that is defined by climatic conditions that vary between dry and wet in terms of rainfall). It has an annual rainfall of 1,450 mm to 2,400 mm. The major rainy seasons in Kurunagala are April to June (*yala*, dry season) and September to December (*maha*, wet season), with most rain being received during March to May and October to December. Other months are mainly considered to be dry months. The intermediate climatic zone receives more rainfall than the other parts of the District, which fall within the dry zone. The rainfall received in a month within the rainy seasons varies widely and the rainfall received in certain months is not sufficient to fulfill the crop water requirement. As such the need for a supplementary source of water for irrigation becomes essential during such periods.

Paddy Cultivation in the Kurunegala District

There are 77,690 ha of cultivable paddy lands in Kurunegala District of which 12,928 ha are under major irrigation schemes, 34,576 ha are under minor irrigation schemes and the remainder (30,186 ha) are under rain-fed paddy cultivation (Table 1). In the maha season 94.4 % of the area is cultivated but only 45.2 % is cultivated in the yala season. In the yala season 80.3 % of the major irrigated areas are cultivated but the area under cultivation is very low for the minor irrigated areas (49.8 %) and rain-fed areas (24.8 %), mainly due to water shortages. This is seen by the fact that even in the few areas that are cultivated, almost 100 % are harvested in the maha season, as there is no water shortage during that time that could cause crop failure, but during the drier yala season, 95 % of the area is not harvested.

The extents of land that are not sown in the maha season under the minor irrigation schemes and under rain-fed cultivation is 5.4 % and 7.4 %, respectively (Table 1). Under the major irrigation schemes the extent not sown is very low and is mainly due to poor availability of sufficient supplementary water for irrigation under the irrigation tank scheme or the river water diversion scheme.

During the *yala* season, the extent of land under the major schemes that is not sown increases from 1.8 % to 19.7 % (Table 1). This considerable increase is mainly due to the shortage of water in the reservoir or the insufficiency of water in the river for diversion. Under the minor irrigation schemes, the extent of lands not sown increases from 5.4 % to 50.2 %, mainly due to insufficient irrigation water in the minor tank systems or the anicut schemes. The low rainfall in the area contributes to the lower water level in the minor reservoirs. The rain-fed agriculture is the worst affected sector in the *yala* season, where 75.2 % of the lands are not cultivated (Table 1). This is mainly due to insufficient rainfall for a paddy crop.

Table 1. Extent of lands in *maha* and *yala* in Kurunegala District.

		Asweddumized	Sown	Not Sown	Harvested	Not Harvested
Maha	Major (ha)	12,928	12,691	237	12,691	0
	(%)		(98.2)	(1.8)	(100.0)	(0.0)
	Minor (ha)	34,576	32,699	1,877	32,636	63
	(%)		(94.6)	(5.4)	(99.8)	(0.2)
	Rain-fed (ha)	30,186	27,942	2,244	27,879	63
	(%)		(92.6)	(7.4)	(99.8)	(0.2)
	Total	77,690	73,332	4,358	73,206	126
	(%)		(94.4)	(5.6)	(99.8)	(0.2)
Yala	Major (ha)	12,928	10,387	2,541	9,868	519
	(%)		(80.3)	(19.7)	(95.0)	(5.0)
	Minor (ha)	34,576	17,221	17,355	16,360	861
	(%)		(49.8)	(50.2)	(95.0)	(5.0)
	Rain-fed (ha)	30,186	7,484	22,702	7,110	374
	(%)		(24.8)	(75.2)	(95.0)	(5.0)
	Total	77,690	35,092	42,598	33,338	1,754
	(%)		(45.2)	(54.8)	(95.0)	(5.0)

Wastewater Generation in the Kurunegala District

The NWSDB takes 120 lcd as the water consumption figure. According to the Sri Lanka Standard Institution (SLSI), the amount of grey-water generated is 75 % of the water used (SLSI 2003). Considering these two values, the amounts of grey-water generated at each DS division is estimated and given in Table 2.

Table 2. Estimated wastewater generation in DS Divisions in Kurunegala District.

DS Division	Population	Amount of grey-water generation (Liters/Day)	Amount of grey-water generation (m^3/Day)	55 % of grey-water that can be diverted (m^3/Day)
Alawwa	59,082	5,317,380	5,317.38	2,924.6
Ambanpola	19,964	1,796,760	1,796.76	988.2
Bamunakotuwa	20,702	1,863,180	1,863.18	1,024.7
Bingiriya	55,763	5,018,670	5,018.67	2,760.3
Ehetuwewa	23,076	2,076,840	2,076.84	1,142.3
Galgamuwa	47,844	4,305,960	4,305.96	2,368.3
Ganewatta	36,812	3,313,080	3,313.08	1,822.2
Giribawa	28,093	2,528,370	2,528.37	1,390.6

(continued)

Table 2. Estimated wastewater generation in DS Divisions in Kurunegala District. *(continued)*

DS Division	Population	Amount of grey-water generation (Liters/Day)	Amount of grey-water generation (m^3/Day)	55 % of grey-water that can be diverted (m^3/Day)
Ibbagamuwa	76,344	6,870,960	6,870.96	3,779.0
Katupotha	27,575	2,481,750	2,481.75	1,365.0
Kobeigane	32,230	2,900,700	2,900.7	1,595.4
Kotavehera	19,273	1,734,570	1,734.57	954.0
Kuliyapitiya East	46,966	4,226,940	4,226.94	2,324.8
Kuliyapitiya West	71,483	6,433,470	6,433.47	3,538.4
Kurunegala	88,944	8,004,960	8,004.96	4,402.7
Maho	50,576	4,551,840	4,551.84	2,503.5
Mallawapitiya	46,575	4,191,750	4,191.75	2,305.5
Maspotha	18,850	1,696,500	1,696.5	933.1
Mawathagama	56,820	5,113,800	5,113.8	2,812.6
Narammala	51,244	4,611,960	4,611.96	2,536.6
Nikaweratiya	36,370	3,273,300	3,273.3	1,800.3
Panduwasnuwara	69,888	6,289,920	6,289.92	3,459.5
Pannala	114,438	10,299,420	10,299.42	5,664.7
Polgahawela	58,762	5,288,580	5,288.58	2,908.7
Polpithigama	67,263	6,053,670	6,053.67	3,329.5
Rasnayakapura	18,814	1,693,260	1,693.26	931.3
Rideegama	80,473	7,242,570	7,242.57	3,983.4
Udubaddawa	48,800	4,392,000	4,392	2,415.6
Wariyapola	56,880	5,119,200	5,119.2	2,815.6
Weerambugedara	30,311	2,727,990	2,727.99	1,500.4
Kurunegala District	1,460,215	131,419,350	1,31,419.35	

In Kurunegala DS Division, the grey-water generated is estimated to be 8,005 m^3/day and the amount of grey-water generated in Kurunegala City is 4,620 m^3/day, approximately 55 % of the total (Ranaweera 2005). This wastewater flows through storm water drains or natural streams that pass through the city and could be collected and diverted to irrigate paddy fields.

Paddy Water Requirement

For a 110 paddy variety, the crop water requirement is 445 mm in *yala* season and 325 mm in *maha* season. The seepage and percolation loss is about 4 mm/d, amounting to about 380 mm for a cropping season. The peak irrigation water requirement is 7.72 mm/d in *maha* and 8.08 mm/d in *yala* in Kurunegala. The crop water requirement is estimated based on the crop coefficients given in Allen et al. (1998) and average pan evaporation values in Kurunegala (Imbulana et al. 2006). Due to the dry climatic conditions, the crop water requirement in *yala* season is more than the *maha* season. This is one of the reasons why the extent of paddy cultivated is less during *yala* as the available water in the reservoirs is limiting. The amount of rainfall received is also less during the *yala* season.

Potential Paddy Cultivable Area with Grey-water Irrigation

Considering the peak irrigation water requirement, the extent of extra land that can be cultivated in *yala* and *maha* is given in Table 3. About 20 % of the uncultivated lands in *maha* can be brought under cultivation if 55 % of the grey-water generated is collected and diverted to irrigate paddy fields. In the *yala* season, only a very small portion of uncultivated land (2.2 %) can be brought under cultivation with grey-water irrigation.

Table 3. Extent of extra land that can be cultivated with grey-water in Kurunegala District.

DS Division	Harvested / Diverted Grey-water (m^3/d)	Cultivable extent (ha) *Yala*	*Maha*
Alawwa	2,924.6	37.9	36.2
Ambanpola	988.2	12.8	12.2
Bamunakotuwa	1,024.7	13.3	12.7
Bingiriya	2,760.3	35.8	34.2
Ehetuwewa	1,142.3	14.8	14.1
Galgamuwa	2,368.3	30.7	29.3
Ganewatta	1,822.2	23.6	22.6
Giribawa	1,390.6	18.0	17.2
Ibbagamuwa	3,779.0	49.0	46.8
Katupotha	1,365.0	17.7	16.9
Kobeigane	1,595.4	20.7	19.7
Kotavehera	954.0	12.4	11.8
Kuliyapitiya East	2,324.8	30.1	28.8
Kuliyapitiya West	3,538.4	45.8	43.8
Kurunegala	4,402.7	57.0	54.5
Maho	2,503.5	32.4	31.0
Mallawapitiya	2,305.5	29.9	28.5
Maspotha	933.1	12.1	11.5
Mawathagama	2,812.6	36.4	34.8
Narammala	2,536.6	32.9	31.4
Nikaweratiya	1,800.3	23.3	22.3
Panduwasnuwara	3,459.5	44.8	42.8
Pannala	5,664.7	73.4	70.1
Polgahawela	2,908.7	37.7	36.0
Polpithigama	3,329.5	43.1	41.2
Rasnayakapura	931.3	12.1	11.5
Rideegama	3,983.4	51.6	49.3
Udubaddawa	2,415.6	31.3	29.9
Wariyapola	2,815.6	36.5	34.8
Weerambugedara	1,500.4	19.4	18.6
Total		936.5	894.5

Potential Risks of Wastewater Irrigation and Possible Mitigation Measures

Using wastewater to cultivate leafy vegetables may cause many health risks to the consumers as well as the producers. The risks could be mainly due to the contamination of wastewater with black-water or faecal matter. The major health risks would be diarrheal diseases, skin diseases and worm infections for consumers and producers.

In many towns there is a risk of contamination where the municipal wastewater is a mixture of grey-water, yellow-water, and black-water and in some instances industrial wastewater. Industrial wastewater generated by certain industries might contaminate the water with heavy metals that could bio-accumulate in the products consumed.

In addressing these health risks, the state and local government authorities have to play a major role. Sanitation infrastructure needs to be planned, installed and maintained according to the standards set and infrastructure and facilities must comply with environmental regulations. In order to make the agricultural use of wastewater possible, the authorities have to prevent black-water and industrial wastewater from contaminating the viable grey-water and storm water.

The authorities could also regulate crop selection for wastewater irrigation, in that the growth of vegetables with wastewater, especially leafy vegetables, should be discouraged or prohibited while the cultivation of cereals should be encouraged, as the product of the latter is not in direct contact with the wastewater and is never eaten uncooked. Further, the farming community who utilizes wastewater for agriculture should be made aware of the health risks they face and empowered with the knowledge to minimize such risks.

Conclusion

Wastewater agriculture is practiced in very few localities in Sri Lanka, and where it is, it is practiced informally. There are a few places where wastewater is diverted to cultivate paddy but the extent cultivated is very small. This study shows that if the wastewater generated in cities, especially the grey-water from domestic water use, can be collected and diverted for agricultural production, areas that are uncultivated due to water shortage can be brought under cultivation. The land extent that can be brought under paddy cultivation is about 936 ha in the *maha* season and 895 ha in the *yala* season in the Kurunegala District. The authorities must, however, ensure that the grey-water that is diverted for agricultural production is not contaminated with black-water and hazardous industrial wastewater in order to minimize the adverse health risks that could affect farmers using wastewater agriculture and consumers using the products of wastewater agriculture.

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