Wastewater Agriculture in Kurunegala City, Sri Lanka

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WASPA Asia Project Report 8

This report in one in a series of project reports written by the Wastewater Agriculture and Sanitation for Poverty Alleviation in Asia (WASPA Asia) project. The WASPA Asia project aims to develop and test solutions for sanitation and wastewater management, to reduce the risks form wastewater use in agriculture. The approach involves the development of stakeholder coalitions at town and national level, called Learning Alliances, which will bring together the main stakeholders into a participatory process through which actions will be planned and implemented in a sustainable manner.

These project reports are essentially internal documents intended to inform the future activities of the project, particularly in relation to the development of Learning Alliances and participatory action plans. The reports have been made publicly available as some of the information and findings presented in them may be of use to other researchers, practitioners or government officials.

The WASPA Asia project is funded primarily under the EU Asia Pro Eco II Programme of the European Commission. It is being undertaken by the International Water Management Institute (IWMI), Sri Lanka; COSI, Sri Lanka; the International Water and Sanitation Centre (IRC), the Netherlands; NGO Forum for Drinking Water Supply and Sanitation, Bangladesh; and the Stockholm Environment Institute (SEI), Sweden. The project pilot cities are Rajshahi City in Bangladesh and Kurunegala City in Sri Lanka.

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Acronyms, Abbreviations and Sinhala Terms

Ca	Calcium
CW	Clean water
DoA	Department of Agriculture
DS	District Secretary
ECL	Engineering Consultants Ltd.
FGD	Focus Group Discussion
FO	Farmers' Organization
GIS	Global Information Systems
IWMI	International Water Management Institute
K	Potassium
MOP	Muriate of Potash
TSP	Triple super phosphate
N	Nitrogen
NWSDB	National Water Supply and Drainage Board
P	Phosphorus
PRA	Participatory Rural Appraisal
RRDI	Rice Research and Development Institute
S	Sulfur
WASPA	Wastewater Agriculture and Sanitation for Poverty Alleviation
WW	Wastewater

Sinhala Terms

Anicut	Weir, usually used for irrigation
Ela	Stream
Grama Niladhari	Lowest level of local government
Liyadda	Agricultural plot of land
Maha	Season based on the monsoon which brings rain from November to February
Wewa	Tank, like a lake, usually used for irrigation
Yala	Season based on the monsoon which brings rain from May to June

1 Introduction

This report presents an assessment of agricultural practices in Kurunegala City, Sri Lanka, which was undertaken as part of the Wastewater Agriculture and Sanitation for Poverty Alleviation in Asia (WASPA Asia) project, funded by the European Commission under its Asia Pro Eco II Program. The WASPA Asia project developed out of a global survey on wastewater irrigation and agricultural practices, which was conducted for the Comprehensive Assessment program of the International Water Management Institute (IWMI). As a result, Kurunegala City, and Rajshahi City in Bangladesh, were chosen to be pilot study cities under the WASPA Asia project.

The objective of the project is to improve the livelihoods of urban and peri-urban farmers who are using wastewater in agriculture; and the communities who are responsible for producing the wastewater or consuming the agricultural produce. To do this a holistic approach and sustainable solutions are required along the whole chain of wastewater production, management and use; from improved sanitation to contaminant reduction, waste treatment, disposal, safe use in agriculture and promotion of hygiene behavior.

Before any such changes can be proposed or implemented it is necessary to have an understanding of the current conditions prevailing in the urban and peri-urban area of the two project research cities. These include: current agricultural practices; the quality of wastewater being utilized for agriculture; the impact of that use on agriculture and potential risks to health; sanitation conditions in the city; and the institutional and policy setting within which this takes place. To achieve this, a number of related studies have been undertaken under the WASPA Asia project, the results of which have been presented in a series of reports. This report presents the findings for the agricultural assessment conducted in Kurunegala in 2006-2007. The findings of this study will also be combined with the findings of the stakeholder analysis, the water quality assessment and the sanitation assessment, to produce a more comprehensive report for Kurunegala City.

The WASPA Asia project will work with relevant stakeholders to develop participatory action plans to address issues relating to wastewater agriculture in Kurunegala and Rajshahi, and to learn lessons for other similar cities across Asia. This agricultural survey report will provide important information for the development of those participatory action plans. It will also provide a baseline against which to monitor the impacts of project interventions or other changes that may take place in the city during the project period.

Objectives

The specific objectives of the agricultural assessment were to:

- Understand the activities and practices of farmers in the urban and peri-urban areas of Kurunegala, including farmers who irrigate with wastewater and canal water (also referred to in this report as clean water).

- To investigate the differences between the practices, if any, of these two farming groups and to determine whether there are additional constraints to wastewater irrigation as compared to canal water irrigation.
- To understand the problems of nutrient management in the field when nutrient concentrations in irrigation water are highly variable, and to consider whether or not fertilizer application is already modified as a result of this, or whether there is potential to alter fertilizer practices to obtain the most benefit from the wastewater nutrients.
- To investigate whether current agricultural practices are optimal and are taking advantage of the benefits of using wastewater whilst mitigating the potential negative impacts, or whether suggestions could be made to improve them.

2 Background

Climate and Characteristics

Sri Lanka is divided into three major climatological zones where Kurunegala District falls partly in the dry zone and partly in the intermediate zone. The dry zone receives a mean annual rainfall of less than 1750 mm with a pronounced dry season, while the intermediate zone receives a mean annual rainfall of between 2500 and 1750 mm (Survey Department 1988). Kurunegala District is also classified as low country being less than 300 m in elevation; and covers two of the 24 agro-ecological zones identified for Sri Lanka based on soil types (Table 2.1). The wastewater and clean water paddy areas covered in this study are within the intermediate zone low country 1 classification. Most of the plots that are irrigated with clean water have sandy or mixed soil but in the wastewater area around 60% of plots have highly sandy soil and 40% have clay soils. This may be because the wastewater agriculture area is situated in the upland area whereas the clean water area is situated in the valley where silt deposits are likely to be higher. All these soil groups are suitable for paddy but the highly sandy soil needs more water.

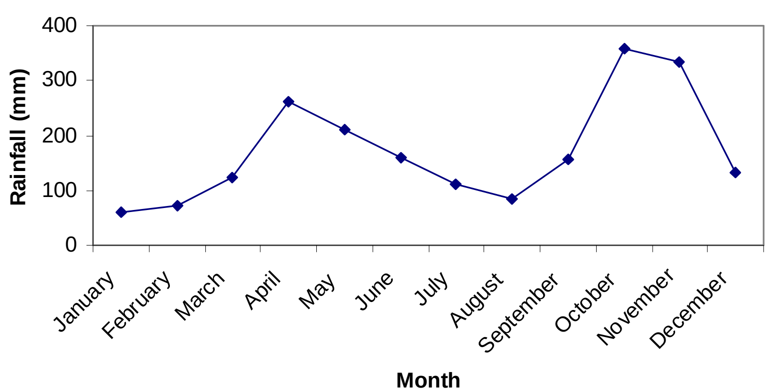
Table 2.1: Kurunegala District agro-ecological zones

Agro ecological zones	Rainfall	Soil Type
IL_1 – Intermediate zone low country 1	>1020 mm	Red-Yellow Podzolic soils (RYPS) with strongly mottled Sub soils, Low Humic Gley soils, RYPS with soft and hard laterite and Regosoles on old Red and Yellow sands
IL_3 – Intermediate zone low country 3	>900 mm	Reddish brown earths, Non Calcic Brown soils and Reddish Brown Earth
DL_1 - Dry zone low country 1	>775 mm	Reddish Brown Earths, Low Humic Gley

Source: Survey Department, 1988

Sri Lanka receives rainfall from two monsoons: the North-East monsoon brings rain from November to February called the *maha* season; and the South-West monsoon occurs in May to September called the *yala* season (Survey Department 1988). This periodicity can clearly be seen in the long-term average monthly rainfall data provided by the meteorological station in Kurunegala City (Figure 2.1).

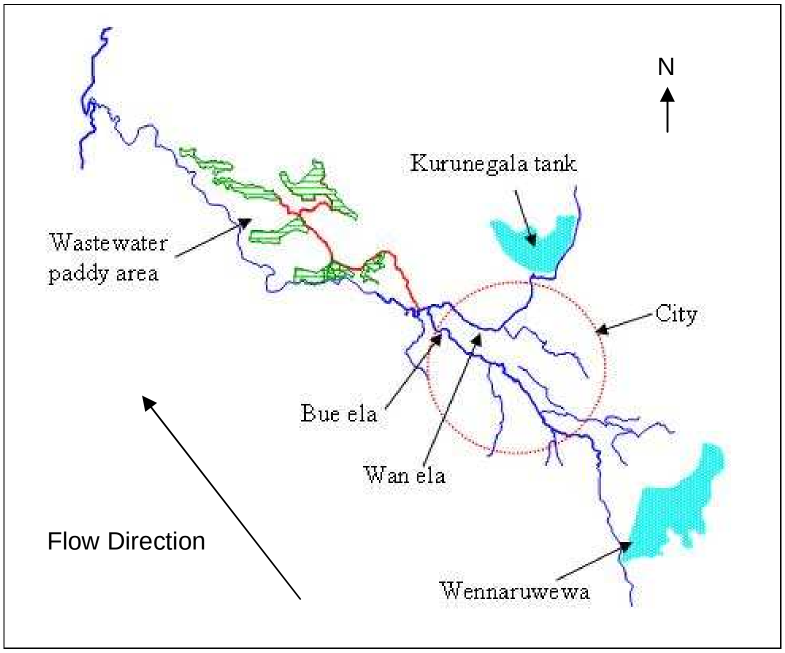
Figure 2.1: Long-term monthly average rainfall data for Kurunegala (1971-1998)



Irrigation System and Command Area

Within the Kurunegala Divisional Secretariat (DS) Division there are three ancient tanks of which Wennaru Wewa and Thiththawella are used for irrigation, and Kurunegala Wewa is used for recreation and sometimes for drinking water. Wennaru Wewa, which is situated at the southern end of Kurunegala DS Division, has a capacity of 1.8 million m^3 (1490 acre feet) and serves a command area of 186 ha in both *yala* and *maha* seasons. There are two main canals that provide water for downstream irrigation from wastewater. The left bank main canal irrigates 93 ha via the Beu Ela. The right bank canal provides irrigation water to an area upstream of the city and is therefore not covered by this study (Figure 2.2).

Figure 2.2: Schematic diagram of the study site



About 78% of the town area of Kurunegala is drained by the Beu Ela and another stream, the Wan Ela. These streams flow approximately 6 km via cultivated land and then through residential and commercial areas, collecting agricultural drainage and urban wastewater[1] that is discharged into the canals. There is little industrial effluent as the city is not very industrialized but the canal does receive commercial waste including effluent from hotels, schools and clinics. The teaching hospital discharges wastewater to the Beu Ela via a treatment plant which is not currently functioning. Further details about the sources of wastewater can be found in Dissanayake at al. (2007).

The two *elas* join within the city and flow on to the Maguru Oya at Watawehera Estate, just outside the western boundary of the Municipality (NWSDB 2005; ECL 2000). There is an *anicut* located at Wilgoda after the confluence of the drains, which irrigates 53.4 ha of paddy fields in Aswadduma Grama Niladhari Division. According to the Agrarian Services

[1] This includes sullage and some sewage, because, although the drain is not designed to receive sewage and officially it does not, unofficially the Municipal Council officials admit that there are illegal sewage connections.

Department, this land, which is divided into five areas, Nelligahapitiya, Illukpitiya, Kahatagaha, Galeyaya and Pallepotta, is cultivated by 137 farming families (Figure 2.3). They cultivate paddy twice a year and hardly grow any other crops.

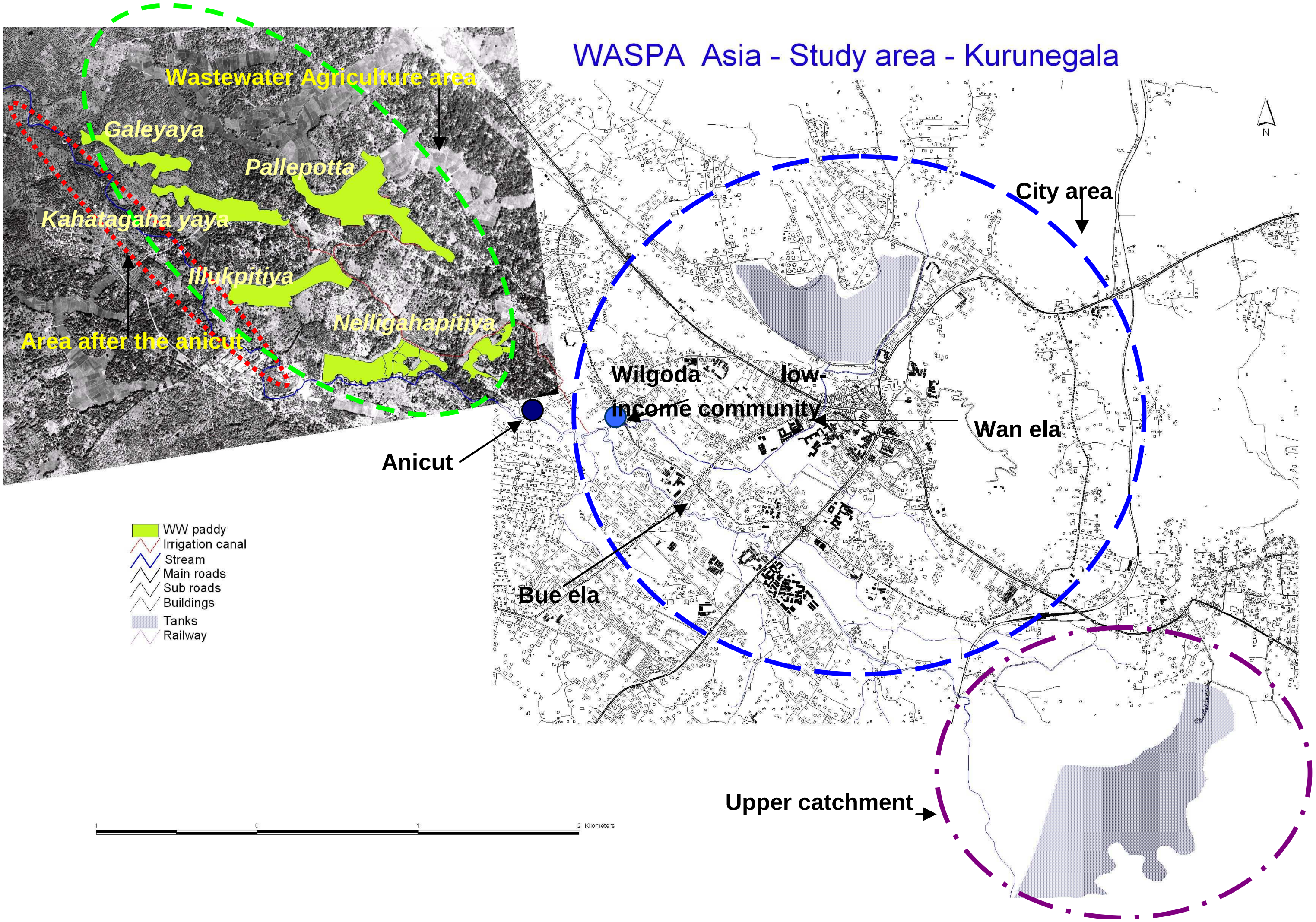
In conventional *anicuts* in Sri Lanka irrigation canals start very near from the dam but Wilgoda *anicut* deviates from the conventional design in that the irrigation canal starts approximately 10 m upstream of the *anicut*. It is not entirely clear why this has been done but it may be because Kurunegala is extremely rocky and the location of the rocks has determined where the *anicut* and irrigation channels can be placed. Since the irrigation canal is upstream of the *anicut* and at a slightly higher elevation, the water level near the *anicut* needs to be raised up so that the irrigation water can flow. This results in stagnant water near the dam which, according to local community members, creates environmental problems such as bad odors, ground water pollution and mosquito breeding, leading to filariasis in the locality (ECL 2000; Nishshanka et al. 2006). Consequently the Municipal Council has taken over the regulation of the *anicut* and only stores water just prior to irrigation (Municipal Council Engineer, Mr. S.M.B. Dissanayake, *perss. comm.* 14th September 2006).

Situated close to the *anicut* there are some drinking water wells that have apparently been abandoned due to groundwater pollution as a result of this prolonged stagnation of polluted water (ECL 2000).

In addition to these problems solid waste like polythene bags, plastic cans, and food packing is carried in the canal. As there are no traps or filters along the canal to collect this waste, it flows to the fields (Nishshanka et al. 2006). Originally, when the irrigation system was designed the problems of wastewater and solid waste entering the canal did not exist or were much less, and as a result it would not have seemed necessary to construct filters; now however things appear to have changed.

Some of these problems are addressed by the work of the two Farmers' Organizations (FOs) in the study area: Wilgodaamuna FO in the wastewater area and Thithawella FO in the adjoining canal water area. They appoint office bearers each year and use the monthly membership fees of Rs 10 per member to organize maintenance work, such as bund and canal clearing, through collective actions called "Shramadana". These fees are supplemented by payment received from the government for development activities such as road improvement, and they use the funds for rehabilitation and welfare activities. The FOs are also responsible for controlling the irrigation flow along the canals below the main gate (which is controlled by the Irrigation Department or in the case of Wilgoda Anicut the Municipal Council). Any disputes over irrigation water allocation or other issues are resolved by the FO. During severe drought periods in both clean water and wastewater areas decisions about rotation are taken by farmers during FO meetings.

Figure 2.3: Kurunegala study area including aerial views of the wastewater paddy area



Source: Original layers and Arial photographs are from Survey Department of Sri Lanka

Agricultural Practices and Nutrient Requirements

A claim often made by researchers working on wastewater irrigation is that since wastewater contains various nutrients (nitrogen (N), phosphorus (P) and potassium (K)) it has the potential to reduce artificial nutrient inputs if managed effectively. To achieve this, an understanding of the different stages of growth and development of the crop, and its nutritional requirements at the important stages is a pre-requisite for nutrient management. In the case of N, accumulation in the vegetative body is high during the initial growth stages and declines with age towards the later growth stages. Nutrient mobility in the rice plant is in the sequence P > N > K. The elements that form immediate components of proteins have a high rate of mobility, while those that are continuously absorbed until senescence have a relatively low mobility. Thus, N, P and sulphur (S), which are essential constituents of proteins, are absorbed rapidly during the active vegetative growth stage and are subsequently trans-located to the grain after flowering. Other nutrients like Ca and K are absorbed at a rate matching the rate of dry matter production over the growth period (Fink 2006).

Nutrient uptake at different growth stages is therefore as follows:

- The percentage contents of N, P and K at the seedling stage increase progressively with growth and then decrease after reaching a maximum.
- The percentage of N in the plant decreases marginally after transplanting and then increases until the initiation of flowering. Subsequently the N content decreases continuously until the dough stage and then remains constant until ripening.
- The percentage of P declines rapidly after transplanting, then increases slowly and reaches a peak at flowering and then decreases until the dough stage.
- The percentage of K decreases gradually during the earlier growth of the plant but increases from flowering until ripening.

The Department of Agriculture (DoA) provides guidance to farmers regarding fertilizer application requirements depending on their location. The recommendations for Low Country Dry and Intermediate Zones, which includes Kurunegala District, are provided in Annex I.

They also provide cropping calendars to advise farmers of the best time to prepare land, sow seeds, transplant and harvest, based on the time of the rains. The cropping calendars for the paddy seed varieties grown in the study area in Kurunegala (3-3.5 month varieties) are provided in Table 2.2.

Table 2.2: Cropping calendar for seed varieties grown in the study area

Details	Yala 2006 Dates	Maha 2006 Dates
“Kanna” meeting	03.04.2006	
First canal clearance	10.04.2006	05.11.2006
First water supply	16.04.2006	05.11.2006
Last date of sowing	05.05.2006	20.11.2006
Last water supply	05.08.2006	25.02.2007
Harvesting	15-21 days after last water supply	15-21 days after last water supply

3 Methodology

Situation Analyses and Mapping

A detailed map of the project area was produced using Arc View 3.2 GIS software by incorporating available maps, aerial photographs and GPS readings (Figure 2.3). This was used to identify the wastewater and canal water irrigated areas.

A situation analysis was then conducted using Participatory Rural Appraisal (PRA) tools such as Focus Group Discussions (FGDs) and mapping. The FGDs were conducted with the farming community, including the President and Secretary of the FO, as well as field level government officials and village leaders. Two transect walks were carried out with the same group along the wastewater agricultural area to gain an initial understanding of the system. Cropping patterns, seasons and irrigation activities were documented during these visits and key informant interviews were undertaken in parallel to the transect walk to confirm some of the observations.

Questionnaire Survey

Using the knowledge from the PRA exercises a questionnaire was designed to better understand the socio-economic characteristics of the users; history and pattern of wastewater use; land holding; land use; cropping patterns; plot sizes; farm inputs (water, fertilizer and pesticides) and outputs (yields or returns); comparative prices of wastewater and non-wastewater produce where available; and farmer perceptions of the advantages and disadvantages of wastewater use. The detailed questionnaire for Kurunegala is provided in Annex II.

The farmers were split into three groups:

1. Those who use clean water for irrigation (CW);
2. Those who irrigate from the upper part of the irrigation canal (WW upper); and
3. Those who receive water further down the irrigation canal (WW lower).

The purpose of this was to compare practices and yields within the wastewater area and between the wastewater and clean water area to see whether or not the quality of the water affected them.

A 30% sample of the farmer population was randomly selected in each of the five wastewater paddy areas, and a sample of a further 20 farmers was selected from the adjoining canal water irrigated area, where similar socio-economic conditions exist and where agricultural patterns appeared to be similar except for the source of irrigation water used. SPSS 10 software was used to select this random sample. In practice not all farmers were willing to answer the questions and the total number of interviewees was 17 in the upper wastewater area, 21 in the lower area and 20 in the clean water area (Table 3.1).

Table 3.1: Sample farmers for wastewater area

Paddy area name	Location	Number of farmers	Number of farmers selected for survey	Number of farmers actually interviewed	Extent (ha)
Thiththawella	Clean water area	**	20	20	
Nelligahapitiya	Upper	15	5	17	13.7
Illukpitiya	Upper	30	9		9.0
Kahatagaha	Lower	32	10	21	8.3
Galeyaya	Lower	13	4		5.2
Pallepotta	Lower	47	15		17.1
Wastewater area total		137	43	38	53.4

**The number was not counted because there are hundreds of farmers spread over a large area. A random selected was made of those cultivating near the wastewater area to reduce differences in other factors such as soil type and socio-economic status.

Descriptive statistics were performed on the data using Microsoft Excel and univariate analyses were conducted with SPSS 10 statistical software.

4 Results and Discussion

Household Information

In the majority of farming households interviewed the household head was male (over 80%). In households in which the household head was female the agricultural work was mainly undertaken by male household members. In both areas the age structure was also similar with around 50% of household heads being over 60 years of age. In the wastewater area, most of the farmers (75%) have cultivated in this area for over 20 years; this proportion is slightly lower in the clean water area (60%). Family sizes vary from 2-6 in the wastewater area and 3-7 in the canal water area, with over 60% having five or more members. Considering the small areas of land already being cultivated there is the potential for difficulties in the future if the land is sub-divided between children. However, given the fact that the land is adjacent to a city there are perhaps other opportunities for employment and in both areas many people were found to have more than one income generating activity. In addition to paddy farming some work as drivers, carpenters or small scale businessmen. Some family members also migrate temporarily to the Middle-East and send money back to their families.

In Sri Lanka, as in other developing countries, farmers use family labor to reduce the cost of cultivation. In the wastewater area 66% of the dependents help with farming fully or partially but only 55% of dependents help with farming in clean water areas. This means that several household members may come into contact with the wastewater, which could pose a risk to their health. As labor is predominantly conducted by males, it may also be assumed that males are at greater risk than females, though females are more likely to spread infections to other family members because of their role in the household with children and food preparation.

Consumption or Sale

How produce is consumed is important for two reasons: it shows how much the farming population may be at risk from consuming wastewater irrigated crops; and it shows how much these crops contribute to household income, which has implications for interventions that may alter agricultural outputs (either by reducing yields or attempting to change crop type). In the case of Kurunegala the first point is of less importance as the main crop is paddy; if the produce had been vegetables it could be conceived that health risks may be greater from consumption than from agricultural activities, but in the study area exposure during cultivation is likely to be of greater concern.

Most of the farmers in the wastewater agriculture area use their paddy yield for home consumption. As an example in *maha* 92% of the farmers in the wastewater area consumed at lease 50% of their yield and 46% of farmers used the entire yield for home consumption (Table 4.1). This suggests that if wastewater farming is prevented these families may not have adequate quantities of food to meet their dietary needs.

For those farmers that sell their product in the market some difference was observed between the prices for rice grown with wastewater and canal water, however it was not significant and the differences in price were not because buyers were aware that it was produced with wastewater. The small price differences depend on the moisture content of the paddy and percentage of inert material, such as sand and straw dust mixed with the paddy.

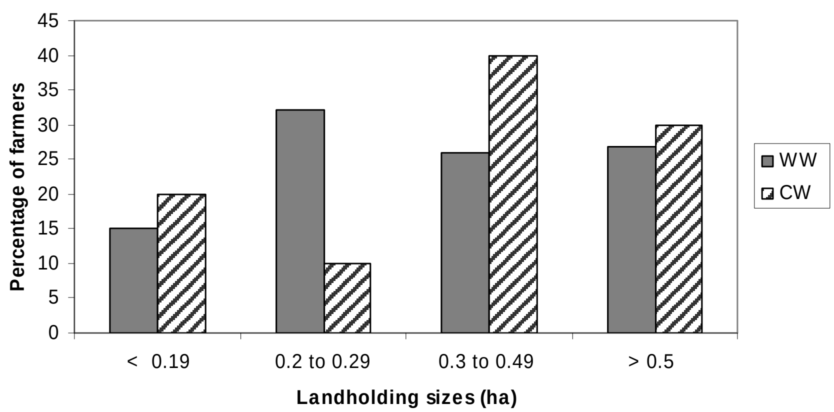
Table 4.1: Home consumption and price if sold

Irrigation water source	Season	Percentage of households that consume at least half the yield	Percentage of these household that consumed their total yield	Sale price (Rs/kg)
Wastewater	*maha*	92%	46%	14.30
	yala	72%	42%	14.90
Clean water	*maha*	60%	44%	16.20
	yala	60%	44%	15.90

Land Ownership and Landholding Size

Farmers in the wastewater agriculture area have small holdings compared to major schemes in Sri Lanka: as an example the average landholding size of the Udwalawe major irrigation scheme in the south of Sri Lanka is 0.8 ha (Hussain et al. 2003), whereas the average landholding size is 0.5 ha in the project area, and the range is 0.12 - 2 ha. The land holdings in the clean water area are also quite small but are on average larger than in the wastewater area (Figure 4.1).

Figure 4.1: Distribution of landholding[2] sizes for farmers in Kurunegala



Land under the wastewater area previously belonged to a single landlord who gradually sold his shares to the tenant farmers. Currently around 55% of the farmers are tenants and they have cultivated these lands for more than 30 years. In the clean water areas only 25% of these farmers are tenants. Whether or not this influences agricultural practices was not directly investigated but the long term nature of the lease agreements could result in practices similar to those of land owners, for example in terms of soil amendments or fertilizer application. It has also been seen in other studies that landowners or long lease farmers are more willing to invest in measures that minimize risk if they can see the long term benefit to themselves.

[2] This includes both land that is owned and land that is leased in.

Tenant farmers give shares of the produce to the owner depending on the tenancy agreement. Two types of tenants exist: those who receive inputs such as seed, fertilizer and pesticides from the landlord and in return give 50% of their yield; and those who do not receive inputs and give 25% of their yield. Normally owners pay land tax of 22.5 Rs/ha and the tenant does not pay any taxes. There is no observed difference in tenancy agreements between the clean water areas and wastewater areas.

Cropping Pattern, Irrigation and Yield

Farmers grow paddy twice a year in the *yala* season and *maha* season. The majority of the farmers grow 3.5 month short term rice varieties in both seasons in the wastewater area. They start their cultivation in accordance with the scheduled times provided by the DoA (Annex I). As a result of city water flows in to the wastewater area, farmers are able to achieve this timely cultivation (see section 4.6) but in some seasons clean water farmers wait for the monsoonal rain to start their cultivations and therefore can not always start at the ideal time.

As wastewater farmers have a regular wastewater supply from the city, their irrigation intervals are short at 7 days in the upper parts and 10 days in the lower parts. In the clean water areas the reliance on the limited water available in the small tank means that they only irrigate once every 15 days. The lower frequency of irrigations may also reflect the less sandy soil type on the clean water area but in the wastewater area 83% of farmers say that they have enough water whilst in the clean water area only 68% have enough. The reasons for shortages were said to be poor management of wastewater and scarcity of canal water. This is not severe though as none of the plots in the area have been abandoned as a result of water scarcity.

In Sri Lanka the average rice yield varies from 6 to 8 tons/ha and in the IL1 agro-ecological zone average paddy yields expected under good management are 4-5 tons/ha (RRDI 2001). A study conducted in Kurunegala district found *maha* yields to be 4.6 tons/ha in major irrigated areas, 3.2 tons/ha in minor irrigated areas and 3.6 tons/ha in rainfed areas (Aheeyar, Henegedara and Rupasena 2005). It was observed in the survey that the average yield from the wastewater agriculture area is 2.3 in *yala* and 2.8 tons/ha in *maha*; and in the clean water area yields were 2.4 tons/ha in yala and 2.8 tons/ha in maha, which is very low (Table 4.2).

Univariate analyses were carried out to compare the yield between the two areas and to see whether there were seasonal variations. The results showed that there was no significant deference ($P<0.05$) between clean water and wastewater yields (Table 4.2). In both areas the yield is higher in the *maha* season than the *yala* season, which is to be expected as the rainfall received in *maha* is greater than in *yala* and is adequate for paddy cultivation. The yields reported at the time of the study seem not to be negatively impacted by the use of wastewater for irrigation.

Table 4.2: Yield difference between wastewater plots and clean water plots

Area		Maha	Yala	P<0.05
Clean water	Mean paddy yield (kg/ha)	2810	2396	0.39
	Standard deviations	1352	1698	
Wastewater	Mean paddy yield (kg/ha)	2830	2348	0.28
	Standard deviations	1830	1950	
	P<0.05	0.96	0.92	

Analysis between upstream and down stream areas was also conducted. This was considered important because the quality of the irrigation water could improve or worsen depending on whether natural purifying process are taking place or if more pollutants are being added. A significant difference in yield (P< 0.05) was found between these two areas in *maha,* with the lower areas achieving 38% higher yields. The difference is reduced in *yala* but the lower area still attains 28% higher yields (Table 4.3). As these areas are in close proximity it can be assumed that physical factors such as soil are similar and therefore do not substantially affect yield. Likewise the management practices, varieties and fertilizer applications are observed to be comparable. Consequently, it may be assumed that the upper plots receive wastewater of a quality that is less suitable for irrigation and that the quality improves as it flows through the system. This scenario needs to be strengthened through water quality monitoring throughout the fields and along the canals.

Table 4.3: Yield difference between upper and lower wastewater plots

Area		Maha	Yala
Wastewater upper	Mean paddy yield (kg/ha)	1968	1942
	Standard deviations	1167	1340
Wastewater lower	Mean paddy yield (kg/ha)	3172	2690
	Standard deviations	1178	2328
	P<0.05	0.004	0.49

Seeds

There is no clear difference in seed types or sources used by wastewater and non-wastewater farmers. Both groups either use their own paddy to produce seed, share seed with neighbors or buy it from the DoA. Land preparation is also similar in both areas. These factors are therefore unlikely to contribute to yield differences between areas. They are also not likely to influence the level of risk from wastewater farming, between the upper and lower wastewater farmers as exposure to soil, which may be contaminated, will be similar in both sites.

Fertilizer Management

A baseline water quality survey of the wastewater irrigation canals shows that it caries nutrients (Dissanayake 2006) but further studies are required on this. The questionnaire was designed to identify whether or not farmers benefited from these incoming nutrients through either increased yields or a reduction in the use of fertilizer and the associated costs and labor. The data shows that fertilizer use among the farmers is highly varied. Comparisons were carried out for three fertilizer categories:

- Urea, which contains nitrogen;
- Muriate of Potash (MOP), which contains potassium; and
- Triple super phosphate (TSP), which contains phosphorous.

No statistically significant difference ($P<0.05$) was found between the practices of wastewater farmers and clean water farmers (Figure 4.2) or between wastewater farmers in the upper and lower areas (Figure 4.3). However simple comparison of the mean values suggests that fertilizer use is very slightly lower in the wastewater irrigated areas than the canal irrigated areas; and in the upper wastewater areas than the lower wastewater areas.

Figure 4.2: Fertilizer use in wastewater and clean water areas

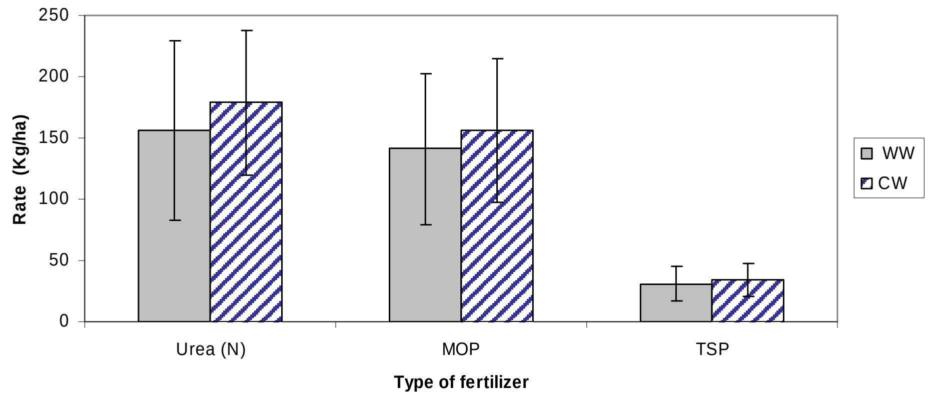
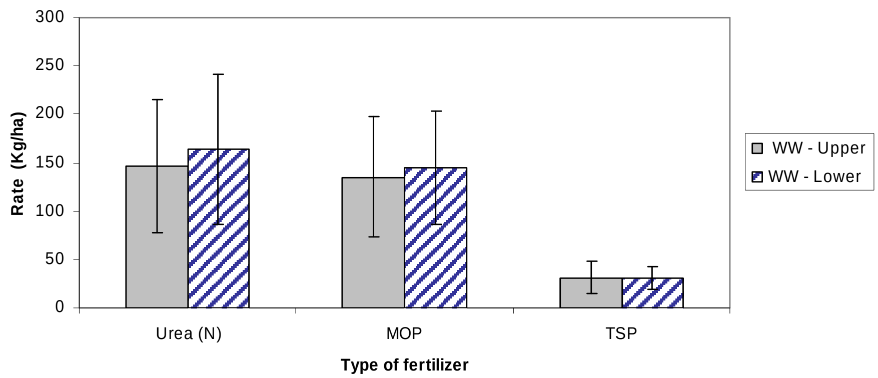


Figure 4.3: Fertilizer use in wastewater upper and wastewater lower areas



This difference within the areas (which can be observed in the high standard deviation figures) contributed to the lack of statistical difference between the three key groups. This was investigated further and it was found that farmers who have plots very near the canal and irrigate with wastewater use less fertilizer than those farmers with plots located further from the canal who tend to apply more than the recommended. It appears that farmers near the wastewater canals recognize that wastewater contains nitrogen and apply less urea to their plots leading to some savings. This was also confirmed in FGDs. However, since the farmers do not know the exact nutrient content of the water they make crude adjustments based on previous yields. Whilst this may be adequate it is also quite a risky strategy because of the variation in water quality.

Current fertilizer application rates were plotted against the recommended application rates (Annex I) and the results show that in both clean water and wastewater areas the majority of farmers apply fertilizer with a substantial deviation from the recommendations (Figure 4.4, Figure 4.5 and Figure 4.6).

Figure 4.4: Current urea application rates and recommended level

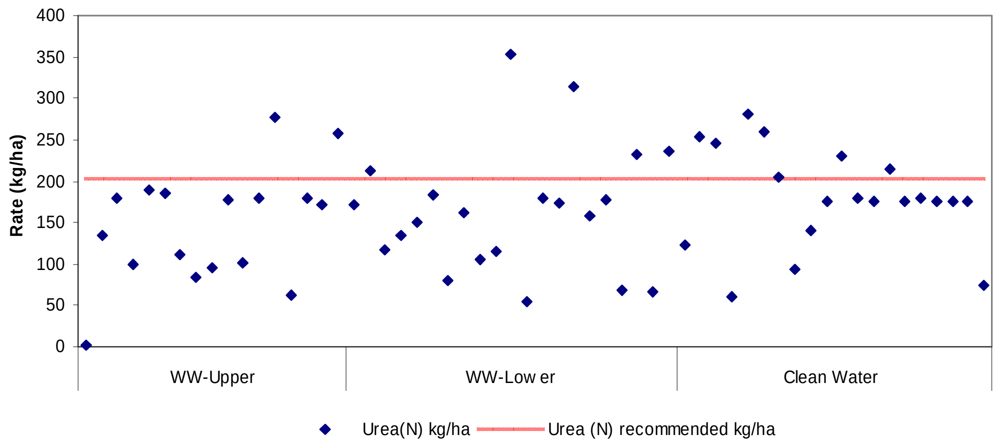


Figure 4.5: Current MOP application rates and recommended level

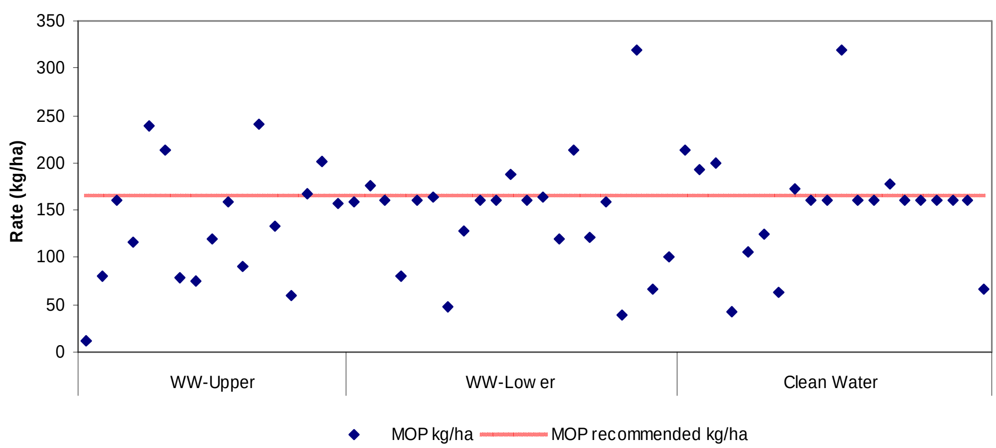
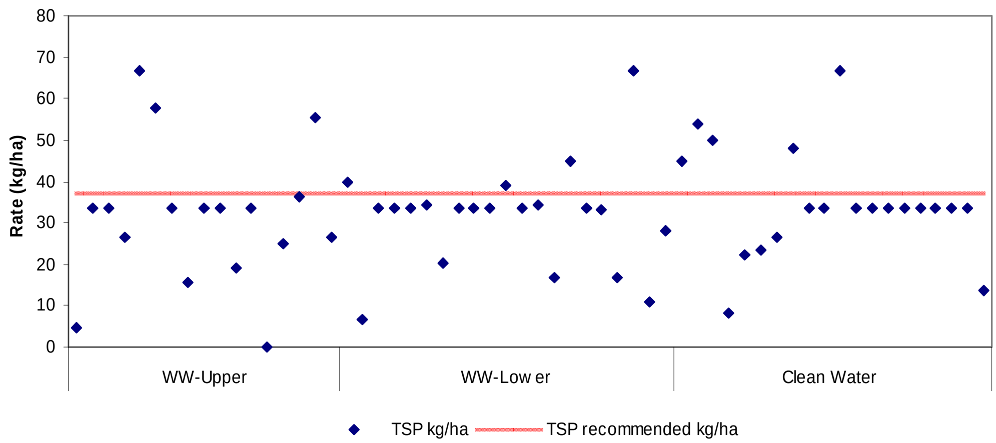


Figure 4.6: Current TSP application rates and recommended level



Only a few farmers (16%) said that they deliberately add less fertilizer although many more under-apply (Table 4.4). The percentage of farmers under-applying urea was similar in all areas (50-62%) but the percentage under-applying MOP was much less in the clean water area (25%) than in the wastewater area (45%); and in the lower-wastewater area (38%) than the upper wastewater area (53%). Under-application of TSP was above average in the clean water area, and over application was above average in the lower-wastewater area.

Table 4.4: Application of fertilizer relative to recommendations by the DoA

	Percentage of farmers		
	Apply recommended amount	**Apply more than recommended**	**Apply less than recommended**
Urea Application			
All farmers	24%	19%	57%
All wastewater farmers	26%	16%	58%
All clean water farmers	25%	20%	55%
Upper wastewater farmers	37%	13%	50%
Lower wastewater farmers	19%	19%	62%
MOP Application			
All farmers	36%	26%	38%
All wastewater farmers	39%	16%	45%
All clean water farmers	55%	20%	25%
Upper wastewater farmers	24%	23%	53%
Lower wastewater farmers	52%	10%	38%
TSP Application			
All farmers	26%	57%	17%
All wastewater farmers	30%	57%	13%
All clean water farmers	20%	55%	25%
Upper wastewater farmers	38%	44%	18%
Lower wastewater farmers	26%	74%	10%

Source: Farmer interviews and DoA discussions

It is not entirely clear why fertilizer is applied so erratically by the farmers. The under-application of urea is particularly unexpected as it is subsidized and costs Rs 350 per 50 kg bag.

Discussions suggest that the guidance they are provided is too general and not specific to the area. The farmers prefer to base their application rates on their knowledge of the plots that they cultivate. However, they also admit that this does not always result in a good yield.

A better understanding of the nutrient content of the soil and water may help the farmers to make more informed decisions. However, this could be highly variable across the area, not least because the land is irrigated from plot (known as “liyadda”) to plot. This could potentially result in nutrient concentrations declining with distance from the wastewater canal, but more detailed analysis would be required to confirm this.

Organic fertilizer

Organic fertilizers play an important role in maintaining the long term fertility of rice fields through improvement of the physical and biological properties of the soil. The majority of farmers in both areas apply organic fertilizers to their paddy lands and straw application is common among farmers despite that fact that many are not land owners (Table 4.5).

Table 4.5: Percentage of farmers who apply organic fertilizer

Type of organic fertilizer	Wastewater	Clean water
Straw	63%	70%
Green manure (Gliciridia)	16%	21%
Cow dung	2%	0%
Paddy husk (burnt)	5%	0%
Not apply	14%	9%

Source: Farmer interviews, 2006

Agrochemicals, Pests and Diseases

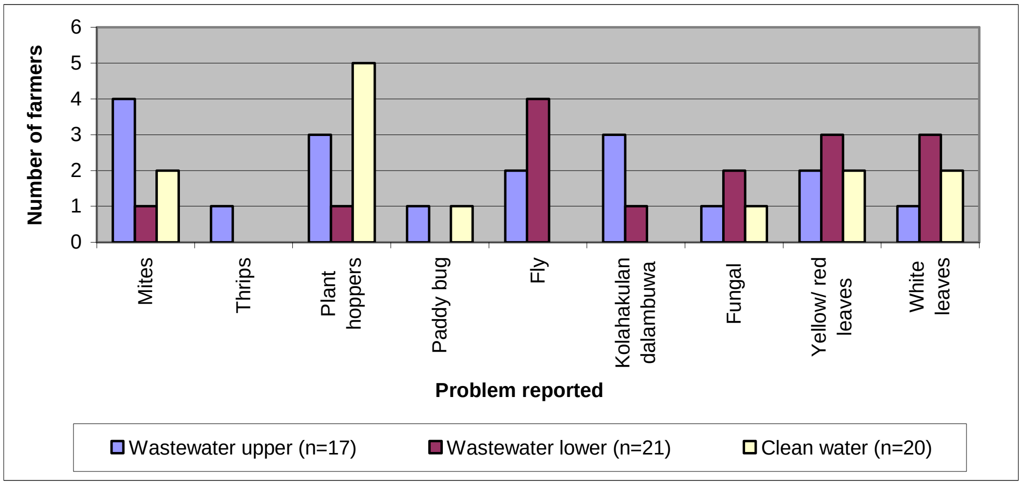
In both areas herbicide application is similar with 73% of farmers applying some sort of herbicide to their lands. There is however a difference in insecticide application as only 46% of farmers apply insecticide in clean water areas while 88% apply it wastewater areas. It is often found that pest attacks are higher in areas where wastewater is used for irrigation due to the high vegetative growth caused by the presence of excess nutrients (IRRI 2003). Discussions with farmers revealed that excessive vegetative growth did appear to be the cause of the problem.

Fungicide application is minimal in both wastewater and clean water areas; only five farmers use fungicide in their lands for both samples.

These figures reflect national trends in that national consumption of insecticides and herbicides is relatively similar but that fungicide use is much lower (Pesticide Registrar, Sri Lanka, cited in: Mott MacDonald, IWMI and DRI 2006). The figures for the clean water area are also similar to those found in another study undertaken by IWMI in the south of Sri Lanka where 79% of the 70 farmers interviewed used herbicide and 50% used insecticide, but none used fungicide (Mott MacDonald, IWMI and DRI 2006). This further confirms the high insecticide consumption of the wastewater farmers interviewed in Kurunegala (88%).

The responses to questions concerning pest and disease outbreaks confirmed that incidents of insect attack are comparatively higher in the wastewater area (Figure 4.6). In the wastewater upper area between 6% and 24% of farmers reported some form of pest or disease outbreak, whilst in the lower area this was reduced to 5-19%. Of the overall attacks reported 77% were pests, especially mites and paddy bugs (Figure 4.6).

Figure 4.7: Number of pest and disease attacks reported



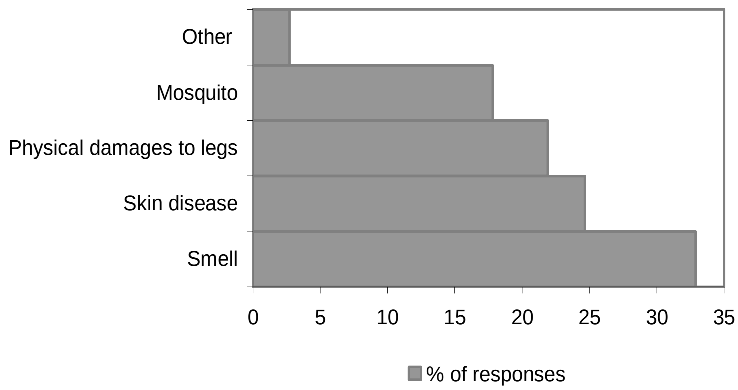
Source: Farmer interviews, 2006

Farmers Opinions of Wastewater Issues

Issues raised by the farmers in FGDs and transect walks were further researched in the survey. From the sample, 95% of farmers said that incoming wastewater contains oil and grease but that they do not know the impact of it on agriculture. Only one farmer felt that it affected his yield. The majority of farmers (60%) said that solid waste in the irrigation canals is a problem because it blocks the canals and sharp objects cut their feet and legs (Figure 4.8). It is also time consuming to remove the waste from their land, increasing labor requirements and reducing time for other activities.

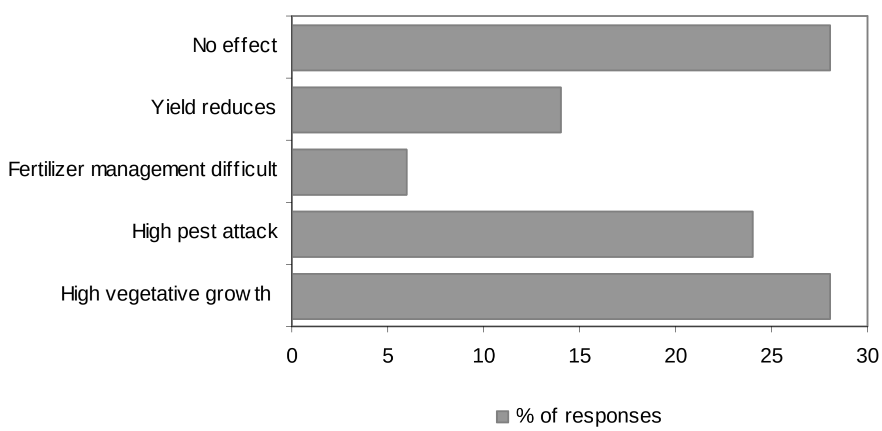
Fecal matter in the wastewater was not mentioned by most farmers but 35% say that it is present in the water, which smells and causes skin rashes (Figure 4.8). Some farmers say that it increases the vegetative growth of the plant.

Figure 4.8: Farmers' opinions on problem they faced due to wastewater irrigation



During the survey farmers were asked about their opinions on how wastewater affects land productivity. Most said that it affects the vegetative phase of the crop and increases pest attack and some said that it reduces the yield, although this is not substantiated by yield data (Figure 4.9). For the moment farmers believe that there is no effect on soil.

Figure 4.9: Impact of wastewater use on paddy



The discussions revealed that farmers are unhappy with the wastewater. They feel that in a monsoon region with high rainfall they should receive good quality irrigation water, but because of the lack of irrigation infrastructure and the unplanned and often illegal connection of drains and sewers to what was originally an irrigation canal, they now have no alternative but to use urban drainage water. Consequently the farmers are eager for regulations to be enforced that will prevent or reduce pollution of the water in the Beu Ela and the Wan Ela, and for proper treatment to remove residual pollutants. The majority do not perceive any benefits from the nutrient availability of wastewater but they do accept that the constant availability of the wastewater is beneficial.

5 Conclusions and Recommendations

The use of wastewater is not the preference of the farmers but is brought about by the fact that the irrigation channels flow through the city and over the years they have been increasingly used as a drain for the city's waste. On the positive side this means that there is ample water for irrigation at times when the farmers need it and as a result they irrigate more often than farmers in the clean water area, who sometimes face water shortages or a mismatch between times of water availability and crop requirements. However, on the negative side farmers receiving the wastewater from the city are unhappy with its quality and would like to see measures taken up-stream to prevent the pollution of the irrigation channel.

Yields in the study area are low compared to regional averages, but there is no significant difference between yields in the canal and wastewater irrigated areas. There is however a difference in yield between the area irrigated near the *anicut* and the area further downstream. The lower area had a yield of more than 1.5 times that of the upper area in *maha* and 1.2 times higher in *yala.* This may be because natural treatment processes in the channel have improved the water quality by the time it reaches the lower fields. Irrigation frequency is also higher in the upper area, which may result in excessive nutrient loading, leading to high vegetative growth rather than seed formation. Further analysis is needed to confirm this.

Fertilizer application rates did not reveal any clear link to yield. There was no significant difference between the wastewater and clean water areas, and application rates varied markedly from farmer to farmer. More than 50% of farmers applied less than the recommended quantities of urea, but it is not clear why, especially as it is subsidized. It may be because they are not aware of the guidelines or because they have based their application rates on their existing knowledge based on many years of farming in the area. To fully understand this it is necessary to have more detailed discussions with farmers and to link this with water quality and soil monitoring at the field level.

The study did not spatially link each farmer to his specific plot but the discussions revealed that farmers with plots near to the canals applied less urea. This may be due to attenuation of nutrient concentrations in the wastewater as it flows from field to field. If investigated further, this could be converted into a typology of nutrient content with distance from the irrigation source and could result in simple but meaningful fertilizer application guidance to supplement the generic guidance given for an area.

Collaboration between the agriculture extension service and the National Water Supply and Drainage Board (NWSDB) could benefit the farmers by providing information on water quality that could be translated into fertilizer recommendations and improve farmers' decision making capabilities.

Pest attacks were reported to be higher in the wastewater area. This appeared to be linked to excessive growth of vegetation and could also be improved by more accurate fertilizer management.

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Annex I: Fertilizer Recommendations for Paddy in Kurunegala District

	Kg/ha			Kg/ac			
	N	P_2O_5	K_2O	Urea	TSP	MOP	$ZnSO_4$
Yield Level -5000kg/ha (100 bu/ac)							
Basal	5	30	20	5	25	15	2
3 Month Age							
1st top dressing (2 WAS/2 WAP)	40	-	-	35	-	-	-
2nd top dressing (6 WAS/5 WAP)	55	-	15	50	-	10	-
3 1/2 Month Age							
1st top dressing (2 WAS/2 WAP)	30	-	25	-	-	-	-
2nd top dressing (5 WAS/4WAP)	45	-	40	-	-	-	-
3rd top dressing (7 WAS/ 6WAP)	20	-	15	20	-	10	-
4 - 4 1/2 Month Age							
1st top dressing (2 WAS/2 WAP)	25	-	-	20	-	-	-
2nd top dressing (5 WAS/5 WAP)	30	-	-	30	-	-	-
3rd top dressing (8 WAS/7 WAP)	40	-	15	35	-	10	-
Yield Level -6000kg/ha (120 bu/ac)							
Basal	5	40	20	5	35	15	2
3 Month Age							
1st top dressing (2WAS/2WAP)	45	-	-	40	-	-	-
2nd top dressing (6WAS/5WAP)	70	-	20	60	-	15	-
3 1/2 Month Age							
1st top dressing (2WAS/2WAP)	35	-	-	30	-	-	-
2nd top dressing (5WAS/4WAP)	55	-	-	50	-	-	-
3rd top dressing (7WAS/6WAP)	25	-	20	20	-	15	-
4 - 4 1/2 Month Age							
1st top dressing (2WAS/2WAP)	30	-	-	25	-	-	-
2nd top dressing (5WAS/5WAP)	35	-	-	30	-	-	-
3rd top dressing (8WAS/7WAP)	50	-	20	45	-	15	-
Yield Level – 7000kg/ha (140 bu/ac or above)							
Basal	5	50	20	5	45	15	2
3 Month Age							
1st top dressing (2WAS/2WAP)	55	-	-	50	-	-	-
2nd top dressing (6WAS/5WAP)	80	-	30	70	-	20	-
3 1/2 Month Age							
1st top dressing (2WAS/2WAP)	40	-	-	35	-	-	-
2nd top dressing (5WAS/4WAP)	60	-	-	55	-	-	-
3rd top dressing (7WAS/6WAP)	35	-	30	30	-	20	-
4 - 4 1/2 Month Age							
1st top dressing (2WAS/2WAP)	35	-	-	30	-	-	-
2nd top dressing (5WAS/5WAP)	45	-	-	40	-	-	-
3rd top dressing (8WAS/7WAP)	55	-	30	50	-	20	-

Notes: WAS - Weeks after seeding; WAP - Weeks after trans-planting

Source: RRDI, 2001

Annex II: Survey Questionnaire

Assessment of Agriculture and Water Management in Wastewater Irrigated areas in Kurunegala

This questionnaire is based on the two studies conducted in the wastewater irrigation sites in Vietnam and Pakistan. Previous two questionnaires were merged and then adjusted according to the Sri Lanka and Bangladesh situations.

Objectives of the survey

- To understand the current water management in the wastewater irrigation area especially to:
  - Compare the current water usage with the recommended usage and make suggestion for improvement;
  - Understand the irrigation barriers to nutrient management in the field; and
  - Identify the constraints in wastewater irrigation in the field compared to clean water irrigation.

- To understand the current agriculture practices:
  - Understand the crop choices;
  - Deviation between current and optimal practices. Also compare with clean water production;
  - Quantify the differences between wastewater (wastewater) and canal water (clean water) or ground water (GW) fertilizer application and compare the current fertilizer application with standard application; and
  - Estimate and compare cost of production of the wastewater and clean water or GW irrigation.

- To understand the positive /negative impacts of wastewater irrigation on agricultural production.

Instructions to the enumerators

- Please fill in questions where relevant. If you do not have the data, or cannot estimate please indicate as such. Always specify the “other” and write down the explanation.
- In every section please read all the questions before asking the questions from the farmers and make certain that the answers fit together. There are footnotes explaining certain items.
- Some questions require descriptive answers. If the space reserved is insufficient, please use additional sheets and mark the question number.
- Some questions offer a choice – please underline the answer given.
- Some data/responses may require estimations, please explain to the farmer exactly what is required and help him to give you an accurate answer. It may take some time to explain it but it is very important that he fully understands.
- If you do not use metric units then you must clearly define the units used e.g. 1 bigha = xx ha , 1bucket = xx liters
- Interviews always should be conducted with the head of the household.

Terms and Definitions that you will need to know when conducting this interview. You will need to explain them to the interviewee to ensure that they have exactly the same understanding as you, so that the interview responses can be compared.

Irrigation definitions

***Surface irrigation**:* method of irrigation in which water is applied to the land by allowing it to flow by simple gravity before infiltrating.

***Furrow irrigation**:* method of surface irrigation in which feeding narrow furrows very close to one another are used to guide water across the field.

***Sprinkler irrigation** :* method of irrigation under pressure in which water is sprinkled in the form of artificial rain through lines carrying distribution components

***Manual irrigation with watering cans or buckets**:* Human energy is used to manually carry the watering can and spray water on the crops or pour water at the roots of the plants

***Drip irrigation**:* method of irrigation in which water is applied directly to the root zone of the plant in small but frequent quantities in such a way as to maintain the most active part of the soil at a quasi-optimum moisture.

Land ownership definitions

Owner (Cultivator): You own the land and cultivate it yourself

Owner-cum-Tenant: Land belongs to you but you lease the land to somebody and still you cultivate the same land as a tenant farmer. Farmers do this when they go through financial crisis.

Tenant (for Lessee): you are a tenant on the land that someone is already leasing from the original owner.

Tenant (for Owner): you are the direct tenant to the owner (there is no lessee in between)

Tenant : someone who pays rent or share of the crop to use the land

Lessee: person who leases the land from owner

Definitions for soil conditions

Saline: Soil containing soluble salts in such quantities that it can interfere with plant growth

Sodic: Soils containing sodium as a significant proportion of their total exchangeable cations. Sodic soils tend to have poor drainage due to poor soil structure

Waterlogged: Soil saturated with water. This will occur due to poor drainage system.

Location: Kurunegala
Name of the Enumerator:
Date:

Section A: Basic household information

1. Name of the household head: …………………………………….Male / Female

2. Age:……

3. GN name: ……………… ………………………..

4. Village name: ………………………………………..

5. Name of the Paddy area:
(eg.Nelligahapitiya)………………………………………………………………..

6. Household size and labor at interview time.

No	Family members	M/F	Age	Employment	Help in farming*
6.1	Father	M		Farming	
6.2					
6.3					
6.4					
6.5					
6.6					
6.7					
6.8					

* 1 Full time, 2 Part time, 3 Not at all

7. How many years have you been farming?...

Section B: Land and land ownership: the purpose of this section is to better understand patterns of land ownership; the costs of agriculture in relation to land prices; and land quality.

8. Land Ownership for the cultivated lands (if farmer has lands in different locations under the wastewater canals , please note all)

Type of land	Extent (ha)	Soil types (only for cultivated lands)[a]	How many years	Location to wastewater canal (top, middle, tail)	Payments (Taka/ha/ year)	Comments
Owned (cultivated by you)						
Tenant (for Lessee)						
Tenant (for Owner)						
Other (specify)						

a. Example: 50% of cultivated land is sandy and rest is the clayey (Visual observation is enough)

9. Did you leave any land fallow in the past two year? Yes / No

10. If yes, what were the reasons for this and how much land did you leave fallow for each reason?

Section C Cropping: The purpose of this section is to understand the costs and benefits from agriculture. If we can get a clear understanding of this then we can help to look for ways to improve the benefits and reduce the costs. Please be as accurate and clear in your responses as possible as this will help us to get an accurate picture and hopefully suggest meaningful changes.

11. Crops grown and inputs (crop calendar for the last one year).

Period	2005/06 Maha	2006 yala
Extent (ha)		
Yield (kg/ha)		
Amount sold (kg)		
Selling price (taka/kg)		
Amount consumed (kg) *(do not calculate, ask from the farmer)*		
Gross income from the crop (Rs)		
Total cost for seeds /plant materials (Rs)		
Land preparation		
Machinery cost (taka)		
Number of labor days hired		
Wage rate per labor		
Number of family labor days		
Number of labor days for seed establishment		
Wage rate per labor day		
Number of family labor days		

Fertilizer inputs	2005/06 Maha	2006 yala
Urea (kg)		
Price per (kg)		
1st application (date & amount kg)		
2nd application (date & amount kg)		
3rd application (date & amount kg)		
TDM (kg)		
Price per (kg)		
1st application (date & amount kg)		
2nd application (date & amount kg)		
3rd application (date & amount kg)		
MOP (kg)		
Price per (kg)		
1st application (date & amount kg)		
2nd application (date & amount kg)		
3rd application (date & amount kg)		
Other inorganic – type used *(write name and ingredients)*		
Quantity (kg)		
Price per (kg)		
1st application (date & amount kg)		
2nd application (date & amount kg)		
3rd application (date & amount kg)		
Organic fertilizer type used *(name)*		
Quantity (kg)		
Price per (kg)		
1st application (date & amount kg)		
2nd application (date & amount kg)		
3rd application (date & amount kg)		
Number of labor days for fertilizer applications		
Wage rate per labor day		
Number of family labor days		
Inputs for the pest & diseases control and sanitation	**2005/06 Maha**	**2006 Yala**
Weedicide used *(name)*		
Amount used (kg)		
Dates of applications		
Total cost for weedicide		
Insecticide used *(name)*		
Amount used (kg)		
Dates of applications		
Total cost for Insecticide (taka)		

Fungicide used *(name)*		
Amount used (kg)		
Dates of applications		
Total cost for fungicide		
Number of labor days hired for spraying		
Wage rate per labor		
Number of family labor days		
Number of labor days hired for manual weeding and crop sanitation		
Wage rate per labor		
Number of family labor days		
Irrigation	**2005/06 Maha**	**2006 Yala**
Maintenance fee		
Irrigation fee		
Fee for the controller		
Irrigation intervals (days or hours per week)		
Harvesting	**2005/06 Maha**	**2006 Yala**
Machinery cost (taka)		
Number of labor days hired		
Wage rate per labor		
Number of family labor days		
Other activities	**2005/06 Maha**	**2006 Yala**

12. Crops grown and disease

Days After Establishment	Major disease or pest attack	% yield lost	Remedial measures	Reasons and seasonality

13. Who gives you advise on pest and disease control

Extension officers	elder farmers	friends	FO leader	other (specify)

Section D Irrigation: This section is important to understand the quality and availability of the water that you use. It will help us to work with you to identify ways to improve irrigation management and possibly water quality.

14. Do you have enough water through out the year Yes / No

15. If no please mention the time, reasons, and strategy to over come water shortages.

16. Is there a rotation system? Yes / No
17. If Yes, what is you time?..

18. Who define the rotation?

19. Who control the gates?

20. Do you receive water as define?

21. Is there any water theft?

22. What are the water management conflicts in distribution?

23. Who involves resolving conflicts?

24. How do you maintain your canals?

25. What are the problems that occur in wastewater irrigation? *(Tick all that apply)*

Smell ϶
Skin diseases ϶
Physical damaged to the legs ϶
Mosquito ϶
Other (specify) ϶

26. Please can you give us some details about the problems that you encounter?

27. Waste water is not good because it contains

Yes (please tick)	It contain	impacts
	Oil and grease	
	Solid waste	
	Fecal matters	
	Harmful chemicals	
	Other ………….	
	……………..	
	…………………..	

28. What are the problems you faced with regard to agricultural production as a result of application of wastewater to the fields?

High vegetative growth ϶
High pest attack ϶
Fertilizer cannot be controlled ϶
Yield is reduced ϶
Other (specify) ϶

29. Please can you give us some details about the problems that you encounter? If the yield is reduced, please estimate by how much.

30. What is the effect of wastewater on soil?
Improves the soil ϶ No Effect ϶ Worsens the soil ϶ Don’t know ϶

31. If it worsens the soil, what are the impacts? (please tick)

Soil clogging	Poor drainage	Salinity increased	Soil cracks	Debris accumulations	Other (specify)

32. What do you see as the positive impacts of wastewater use for irrigation? *(Tick all that apply)*

	Tick	If no, why not?	If yes, how much less do you use?	How much more yield do you get?
Available through out the seasons/year			Do not fill	Do not fill
Savings on fertilizer				
Give higher yields			Do not fill	
Other (specify)				Do not fill

33. Name of the farmer organization:
34. Membership fee:
35. Frequency of the elections :
36. Activities of the farmer organization:
37. Write down all the anecdotes arise from your interviews