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Annex S

Sewage Irrigation by Peri-Urban Farmers of Hubli-Dharwad

C. S. Hunshal and G. H. Yogesh

Introduction

Use of sewage for growing crops by the peri urban farmers has been practiced for decades as a non-official procedure in the semi arid tropics, where there is a shortage of water for agriculture (Also see Annex B, plate B27 and B28). Apart from this, since the sewage is found to contain heavy loads of nutrients (Brar *et al.,*2000) the farmers need to supply low quantities of fertilizers, thus saving costs. Sewage disposal was not such a big problem earlier, as the cities generated manageable quantity of waste, but with the migration of people into cities the volumes of sewage have increased enormously thus making the life of city planners difficult and still worse for those people who live in peripheral villages through which the sewage flows, due to the foul smell, mosquitoes and sewage borne pathogens.

The studies were conducted in and around Hubli-Dharwad, the twin-city. Today, the twin-city is a transport hub and home to 800,000 people. Hubli, the larger of the two cities, is a regional centre for ommerce, trade and industry, while Dharwad, located 20 km to the north-west, is host to several higher educational institutions. The city has a rapidly expanding information technology sector alongside well-established commerce and service sectors, but despite this the traditional practice of agriculture in and around the city remains strong and continues to play an important social and economic role.

The climate of Hubli-Dharwad is semi-arid and the rainfall across the peri-urban area varies, exceeding 1,000 mm to the west of Dharwad but less than 700mm to the east; the mean annual rainfall is 800mm distributed in a weakly bimodal pattern, the bulk of rain falling in the south west monsoon (June to September), otherwise known as the *kharif* season. Within the twin city an estimated 60 million liters of wastewater is generated per day: this flows, untreated, via sewers and *nallas* (open drains) into natural watercourses that flow into the hinterlands. In Dharwad, the main easterly sewer emerges at Madihal (joins *nalla* Chaul Halla), once an outlying village but now incorporated as a suburb due to the expansion of the city. The waste-water which flows northerly and emerges at Hosayallapur, is now lying within the suburbs. This waste-water joins *nalla* Chaul Halla, 3 km from the city centre. From Madihal the Chaul Halla flows east passing eight other villages (Table). In Hubli, the main wastewater *nalla* (Hire Halla) flows to Bidnal. From Bidnal the *nalla* flows south-to-south west passing by the peripheries of nine villages. The main areas of wastewater–irrigated agriculture are to be found along these two main *nallas. Nallas* flow through deep, moderately well drained, cracking montmorillonitic clay soils (black-cotton soils or vertisols), which are characterized by high water holding capacity (Soil Survey Staff, 1999). The soils in Hubli beyond Gabbur are mixed red and black and well drained.

Due to pumping out, the volume of water decreases with distance from the urban centres, with larger volumes usually received by the nearer peri-urban villages. The

cropping along the sewage channel depends on the amount of irrigation water available, labour availability, farm size, market access, village-specific practices and soil types (Bradford *et al*., 2003). Thus using sewage for irrigation of crops has been an opportunity for farmers in the peri-urban villages and has improved their livelihoods by growing crops all round the year giving employment to many villagers and also provides fodder to cattle, milch animals. Crop production in the peri-urban area is also demand driven by urban growth, especially concerning perishables.

Thus, an investigation was carried out to test the hypothesis that urbanisation influences farming system, and to gain a better understanding of the spatial distribution of crops across the sewage *nalla* in the peri-urban villages. The study also looked at preferences in growing of crops by different land holding categories of farmers.

Methodology:

The study was carried out during July to November 2003 by transecting the villages along the sewage *nalla* in Hubli and Dharwad. The survey began first with peri-urban villages starting from the outskirts of Dharwad i.e. Madihal. After surveying all villages in Dharwad peri urban villages of Hubli were surveyed starting with Bidnal. A summary of the villages surveyed along the *nalla* is presented in Table 1.

Data collection process

Structured questionnaires were developed and modified after a pilot survey was carried out by interviewing five sewage irrigated farmers of Madihal village. Villages were not spaced at fixed intervals; hence the exact distance from centre of the city was recorded. In each such village, a focus group interview with farmers (approx. ten) in a common place during evening hours was held, to draw up the list of all the farmers who used the sewage water for crop production in 2002-03. During this process, in half of the villages several farmers declined to provide any information as they thought that the survey was conducted mainly to prepare a list for irrigation water tax in Hubli-Dharwad. In addition, Hubli farmers were reluctant to provide information as they thought that their land may be acquired for construction of large water storage reservoir, which is being planned by the government. However, further discussions with the farmers convinced them about the academic nature of the study. Farmers who were available at their farm were interviewed there, but farmers who were not available at their farm were interviewed in their respective villages. It was found that it was easier locating farmers in further villages compared to villages immediately adjoining the city (Madihal, Hosayallapur in Dharwad and Bidnal, Halehubballi in Hubli) since they had grown in size, making it difficult to locate the houses of sewage irrigating farmers. On average, five to ten farmers were interviewed in a days visit.

The information gathered from individual farmers included distance from the source city to farm; characteristics of the households (farmer's name, education, number of family members, number of family members working on the sewage irrigated farm). Farming system information collected included total cultivated land (owned & leased in), soil type, number of months of sewage flow, number of bullocks, cows, goats, sheep and poultry birds, number of tractors, method of sewage pumping, years of use

of sewage irrigation, type of the pump and year of installation; cropping details in terms of crops grown, season, area and pesticide use on each crop. In the case of tree fruit crops, details collected included area, year of planting, previous crop(s) before fruit crop in addition to marketing and mode of transport of the produce. Part of the data collected has been utilized to write this paper.

The average rainfall of Dharwad is around 800 mm of which most of it is received during *kharif season* (Jun-Sept) rather than *rabi* (Oct-Jan) (Table 2). Thus the interval of irrigations for vegetables (6-7 days) is larger in *kharif* than in *rabi* (3-4 days). Whereas in summer the interval is every alternate day since there is no other source of water except sewage irrigation. Thus cultivated area during summer is very much restricted to sewage irrigation and also to borehole irrigations.

Results and Discussion

The long term average rainfall of Hubli-Dharwad is 800 mm with a weakly bimodal distribution with two peaks in July and October. Since 1999 the rainfall has been quite erratic and unevenly distributed during both the growing seasons of *kharif* and *rabi* (Table 2). Due to this, water flow in the sewage channels declined, so the farther away areas or tail enders who supplemented through sewage irrigation, had to change to rain fed cropping patterns. This was because the water in reservoirs which supply water to Hubli –Dharwad have fallen to very low levels. Thus the Hubli Dharwad Municipal Corporation (HDMC) has been supplying tap water once in 7-10 days. Due to this the waste water generated also reduced to a greater extent. Consequence of this shortage the cropping pattern changed and in Hubli a number of boreholes were drilled between 7-9 km distances. Although the rainfall received was not normal but the sewage irrigated farmers could sow the crops on time and this is an opportunity for the peri urban farmers that he need not depend on rains. However his livelihood is much better compared to non sewage irrigated farmer when the rains are erratic and poor.

Although the sewage channel runs for a distance of 27 km from Dharwad, it had a lower area under sewage irrigation compared to Hubli which ran for 15 km. This is because Hubli is a much larger city than Dharwad producing larger volumes of sewage. In Hubli the sewage *nalla* runs up to 15 km only for the reason that a larger area is being irrigated in the initial distances eg., upto 9 km distance Dharwad irrigates 823 ac whereas Hubli irrigates 1723 ac. This has been possible because some of the large farmers have pumped water from the *nalla* to a distance of 2 km. This kind of investment people have made because they know the benefits of using sewage for growing crops and the market is not a problem since they are much near to Hubli.

The irrigated area and number of small farmers are more nearer to the city whereas the large land holders are at the farther distance in case of Dharwad. But in case of Hubli it is the reverse wherein the larger farmers are more nearer to Hubli and small farmers tend to be more at farther end. In case of Dharwad the number of people who commute to work in urban area is much less than Hubli and it is the family labour completely involved in sewage farming. Whereas in Hubli many small farmers have leased out their lands to large land holders since they commute to Hubli which is more industrialized city.

In almost all the categories of land holding Dharwad had a greater number of sewage irrigated farmers than Hubli except in more than 10 ac category. Of the total sewage irrigated area in Dharwad 27% was owned by >10 ac land holders whereas in Hubli it was 52%. Maximum were in the category of 1.1-2 ac followed by 3, 4, 5, and 6 ac. Nearly 59% of farmers in Dharwad and 50% in Hubli owned up to 4 ac (1.6 ha). Thus sewage irrigated farming is largely practiced by small land holders. In case of Hubli of the remaining 50% land holders above 4.1 ac, 19% of them owned more than 10 ac. Nearly 50% of this category land holding (> 10 ac) was seen within 5 km from Hubli. The villages nearer to the city have large holding farmers. This greater number of farmers in > 10 ac category could also be attributed to leasing in land from small land holders in lieu of debts owed to the larger scale farmers until the borrower repays the loan. The leasing in farmers cultivate the land (till the loan is returned without interest by the borrower) mostly with inorganic fertilizers rather than organics, preferring to grow as much as possible from the leased in land. He does not use organic amendments, since the response is not seen in a short period. The small farmers are the most vulnerable group because they are the most affected in the process of urbanization. Although they have an opportunity to work in urban areas but lack particular trade skill due to which they are paid less than skilled workers. Secondly they sometimes have large families to maintain, old aged parents who are completely dependent, ceremonies to be performed for their children, being nearer to the city there are many a times relatives coming in to stay for few days if they have any work in the city area e.g. visiting a hospital, picking up documents from the district head quarters, making purchases for the marriage etc. All these will have impact on the economic conditions of the small farmer. Thus he is forced to borrow money from the big farmers in turn lease out his land. There are a times when the vegetables are brought into the market during surplus production and the small producer is forced to sell at a throw away price and he is put into loss.

The cropping system is determined by food habits, soils, climate, market and availability of irrigation and transport. The soils of Dharwad being vertisolic and deep have a high moisture holding capacity. Thus annual vegetables, oilseeds, pulses and cereals dominated. Onion and chilli are particularly suited to these soils and have better markets and hence larger areas are found under these two annual vegetables. Chilli is usually sold as green chillies due to which the farmer gets money for every picking (3-4) that he sells like any other vegetables. Groundnut is another important cash crop that is suited to this area. Most of the groundnut is concentrated between 2-3 km since it is assured of water and yields higher under irrigation. Green gram, a short duration crop (catch crop), performs well to give good yields. Maize is usually grown for grain which is all marketed for industrial use or as animal feed, and has a better price than any other cereal grown during *kharif*. Maize is being grown since it responds well to sewage irrigation and nutrients apart from it being a high yielder compared to other cereals and suffers less from pests and diseases compared to other crops. Thus maize is replacing some of the other crops. Onion is grown beyond 9 km as this crop is not a high water demanding crop. The sewage is used to supplement the monsoon rains. The deep black soils having high water holding capacity permits this crop to grow successfully. All of these crops fetch a higher price and produce better yields when given sewage irrigation. During *rabi* wheat occupies 60% of *rabi* cereal area. Although sorghum is the staple food crop, it occupies only 20% of the area. The farmers prefer wheat to sorghum since wheat yields best under irrigation and fetches higher market value. However, the local variety of sorghum is less

responsive to irrigation and yields are low coupled with lower market value, so farmers prefer to grow the local variety of sorghum in the rainfed area. Chickpea (*Cicer arietinum*) is the only pulse grown in the *rabi* season, as it forms a part of the farmers diet and also has a good market price. It is grown beyond 9 km and reaches a maximum at 15 km, as it is less responsive to irrigation, irrigations being sufficient. The bore holes at 15 km could also supplement irrigation.

Similarly in Hubli *kharif* cropping was dominated by cereals, oilseeds and annual vegetables. Maize occupied the major area grown up to a distance of 12 km wherein the farmers are assured of sewage water if there are no sufficient rains during *kharif*. This crop is mostly grown for commercial purposes and the fodder is used for livestock including milch animals. A large area is under maize which represents a shift from more pesticide intensive vegetables production to pesticides free and less labour-requiring crop production. Soybean, a recently introduced crop, is also grown for commercial purpose. Farmers have found that compared to any other pulse in the *kharif* season, soybean yields better and fetches a better price. During *rabi,* wheat and sorghum, which form the principle diet of villagers, were the dominant cereals. Sunflower was grown exclusively for commercial purpose and has gained more importance recently since it is a high value crop with greater yield potentialities. It was produced up to 9 km where there is an assurance that it gets irrigation regularly.

Vegetables form an important part of cropping especially for the resource poor who usually depend on short term gains. The vegetables both annual and leafy vegetables occupied less area in Hubli, but in Dharwad they occupied a major portion of annual vegetables by virtue of growing onion. In terms of diversity, 8 leafy and 16 annual vegetables were grown in Dharwad whereas 6 leafy and 16 annual vegetables were grown in Hubli. Most of these leafy vegetables were concentrated nearer to the city (up to 6 km) since they have to be transported to the city by road. The annual vegetables were grown up to 12 km distant.

The only source of water during summer is the sewage and therefore the cropping is very much restricted. Hence there is greater demand for water. During summer the availability of sewage for farther areas is less due to intensive pumping by the near-urban farmers and thus cropping is restricted to vegetables and also to groundnut in Hubli. Since groundnut yields are the best during summer when there are fewer pests and diseases, farmers have taken benefit of sewage irrigation for growing groundnut up to 7 km which gives higher returns, besides the large amount of organic matter through leaf fall and root decomposition which add to the soil. Almost all the leafy vegetables are grown in summer up to 2 km from Dharwad, and mostly up to 5 km from Hubli but with some at 7-9 km due to the availability of boreholes in Hubli. Only four of the annual vegetables are grown both in Hubli and Dharwad due to restricted availability of sewage irrigation.

With regard to the preference of crops grown by different land holding categories of farmers it was seen that of all the crops, leafy vegetables were much preferred by small land holders (<3 ac) whereas annual vegetables were less preferred. We find that more area is under leafy vegetables in Dharwad than Hubli nearer to the city which is cultivated by small farmers due to more availability of water and family labours which is the reverse in Hubli. In Dharwad farther end the large farmers do not cultivate vegetables since there is lesser availability of water coupled with poor

transport. Whereas in Hubli farther farmers cultivate vegetables due to availability of water supplemented with bore wells and easy transport. The leafy vegetables nearer to Hubli city is much lesser due to low availability of labour (commuting to Hubli is large) and the leafy vegetables require more labour for frequent harvests unlike that of annual vegetables where the harvests are one or two times.

With respect to the annual vegetables Dharwad has a larger cultivated area than Hubli. Small farmers cultivate nearer to city (other than onions) whereas larger farmers at farther distance in Dharwad grow onions. In Hubli it is generally the large farmers. Small farmers tend to cultivate more leafy vegetables since they could harvest crops frequently unlike once or twice in the case of annual vegetables in order to have a regular flow of money rather than earning once or twice in a season. This group of farmers is vulnerable since they are more prone to risks compared to the large holding farmers. Usually the family labour is used for all operations in the field since leafy vegetables production is very intensive, especially removal of weeds, cutting, cleaning (removal of soil) and tying leafy vegetables in bundles on a daily basis. Jansen *et al*. (1996) found that vegetable crops required 2.5 to 6 times more labour than rice, which limited the amount of land to be brought into vegetable production. The dynamics of labour were not determined during this study. Weed seeds are deposited with every irrigation, and since the irrigation frequency is much higher in vegetable cultivation, the weed infestation is also high. The leafy vegetables were found to be restricted to land holding categories up to 8 ac in Dharwad and 6 ac in Hubli during *kharif*. Since there are plenty of vegetables coming into the market during the monsoon season, those land holders with more than 6 ac concentrate on other commercial crops. During the summer, it is these small land holders who produce the major leafy vegetables who get much higher prices for their vegetables. These are grown much nearer to the city since the sewage water is more available than in more distant areas. On the other hand, the major portion of annual vegetables are produced by large farmers who cannot cope up with intensive cultivation of leafy vegetables due to shortage of casual labour due to proximity to the urban centres, where wages are higher. So they prefer to harvest once or twice in the season. Similar reports were made by Midmore *et al.*(2003) wherein the smaller farms had higher crop intensity and limits the extension of these vegetables into larger holdings for want of labour who have better paid employment in industry or commerce.

The soils of Dharwad are black and yield little water at great depths whereas in Hubli the soils are red and black mixed to red which yield water. Thus Dharwad has hardly any area under fruit crops since the vertisolic soils do not suit the growth of these crops, coupled with absence of boreholes. Thus the small land-holders (1-3 ac) have taken risks in drilling boreholes and repaying the loan by growing fruit crops and vegetables. In fact more bore wells are seen between 8-12 km wherein farmers with large holdings have started fruit cultivation. However small farmers have also begun cultivation of fruits since it increases their risk bearing capacity. During the dry periods of *rabi* and summer, insufficient sewage water is received and therefore farmers dug bore wells to supplement sewage irrigation. They grow intercrops until the trees are 5-6 years old. Fruit crops do not require many inputs, especially pesticides. In fact, sapota is relatively free of insects and pests risks, and if irrigated it yields twice in a year. Unlike some other fruits, it can be harvested when desired. Farmers have also identified the good markets apart from Hubli-Dharwad since these

villages are well connected to roads to transport their goods. They get ready cash when they sell their fruits, which are much needed by the smaller farmers.

Groundnut is a very remunerative crop during summer, which is largely grown by large land holders. The small farmers cannot afford to take the risk of investing heavily in groundnut seeds which are very costly.

The total pesticide used in Hubli – Dharwad was 1227.7 kg wherein Dharwad consumed 826.6 kg and Hubli 401.1 kg which was half of that of Dharwad. It is known that the crops grow luxuriant (especially the leafy vegetables) in case of sewage irrigation due to high load of nutrients in sewage water which makes the crops more susceptible to pests and diseases. There were nearly 32 pesticides used under sewage irrigated cropping. Among these 32 there were nearly 6 chemicals which were used between 50 kg to 422 kg. The highest used was Monocrotophos 36 EC (422 kg), followed by Dimethoate (149 kg), Methyl Parathion (81 kg), Quinalphos, Alphamethrin and Carbandizim. In Dharwad Monocrotophos, Methylparathion, Dimethoate, and Alphamethrin were sprayed maximum to leafy vegetables whereas Carbandizim was used in groundnut and Quinalphos for chickpea. In case of Hubli Monocrotophos was used more in case of oilseeds. The rate of application is quite high on crops like cauliflower, chilli, cucumber, ridge gourd, tomato, cotton in Dharwad whereas in Hubli it is ladies finger, chilli, radish, tomato and cotton. The rate of application of the pesticides was the highest in case of cauliflower (1.11kg/acre) followed by chilli (1.06 kg/acre), tomato (0.92 kg/acre), cucumber, ridge gourd (0.76-0.77 kg/acre) Since all these vegetables are almost sold in Dharwad and Hubli the pesticides would be carried in the food chain causing much dangers to human health. Apart from this the pesticides and fertilizers can also be leached and carried further with the sewage which is some times used as drinking water for the livestock. Therefore it is very essential to have more safer methods thereby reducing the environmental pollution. However we did not assess the residual toxicity of these pesticides used in sewage irrigation to know the longevity of the pesticides as well their effect on the human and animal health.

Conclusions

The cropping was much influenced by the type of soil, climate, irrigation source, labour availability and access to markets. The small land holders in the nearby peri urban villages produced leafy vegetables to a large extent while the large land holders concentrated on commercial crop production. Although fruit crops were grown mostly by large farmers but small farmers also grew that supplementing sewage irrigation with boreholes. More than 50% of the pesticides were used on the vegetables which would cause dangers to the environment and human and animal health as they are likely to enter the food chain depending on their residual toxicity.

The issues that need to be addressed are

- Safe disposal and treatment of sewage
- Control of weed and pest infestation: With each irrigation there is a flush of weeds emerging, which makes horticulture very labour intensive. Secondly the waste-water irrigated crops are very lush and susceptible to pests, resulting in intensive use of insecticides (Hunshal *et al*., 1997). This presents a health risk

for the farmers, who never use protective clothing while handling and spraying insecticides. Therefore, it is important to develop integrated pest management (IPM) systems for sewage irrigated crops and also residual toxicity for pesticides needs to studied.

- Use of sewage contaminated waste-water has significant health implications for the both farmer and consumer (Birley and Lock, 2002; Keraita *et al.,* 2003) since both men and women come in contact with sewage while irrigating, weeding etc. Proper health education is essential.
- Vegetable cultivation through sewage irrigation is a livelihood especially for the poor small holding farmers who undertake intensive cropping of vegetables. They should be encouraged and supported to adopt safer and more sustainable farming practices.
- The particular nature of the farming systems along the Dharwad and Hubli *nallas* and the complex nature of IPM suggest a village based extension approach is likely to be more suitable than the present commodity based approaches. The public health benefits of such an approach could also be enhanced through public education, aimed at raising awareness in disease prevention through better food handling, preparation and working practices.

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Table 1. Peri-urban villages along the sewage *nalla* in Dharwad and Hubli				
Name of the village		**Distance from source city centre (km)**	**Number of farmers**	**Sewage irrigated area (ac)**
Dharwad city				
1.	Madihal	2	41	131.00
2.	Hebballi Agasi	2 to 3	20	60.25
3.	Govanakop	5 to 6	57	211.00
4.	Gongadikop	9	23	223.50
5.	Maradagi	12	22	132.50
6.	Somapur	11	21	115.00
7.	Hebballi	15 to 18	42	327.00
8.	Vanahalli	18	13	91.50
9.	Talemorab	27	23	158.00
10.	Hosayallapur	2 to 4	63	200.00
	Total		325	1649.75
Hubli city				
1.	Bidnal	2	11	106.50
2.	HaleHubballi	4 to 8	52	591.00
3.	HaleGabbur	2 to 3	23	217.50
4.	Budersinghi	3 to 9	37	146.75
5.	Mavanur	7	29	214.00
6.	Katnur	8	48	302.00
7.	Giriyala	9	27	144.75
8.	Belagali	12	10	60.50
9.	Inamveerapur	12	14	110.00
10.	Karadikoppa	17	28	85.50
	Total		279	1978.50
Grand total (Dharwad + Hubli)			**604**	**3628.25**

(Note: 2.5 acres=1 ha)

Table 2. Month wise rainfall (mm) data recorded at Main Research Station, UAS, Dharwad								
Month	**1950-94**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Jan	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	62.7	0
March	7	52.9	0	0	0	0	0	0.7
April	50	93.0	0	14.7	44.1	52.1	72.9	54.4
May	90	34.0	33.2	32.8	45.4	23.1	90.0	0
June	112	104.0	222.2	71.8	50.7	32.5	22.5	32.3
July	158	100.4	82.5	113.9	125.2	33.1	17.1	15.3
August	102	202.3	51.4	19.7	50.4	58.1	46.0	8.6
September	105	6.5	214.4	8.8	132.1	53.6	6.6	16.1
October	137	99.2	98.1	161.1	88.3	17.0	103.6	48.7
November	34	36.4	40.2	0	0.0	0	7.0	1.9
December	6	20.8	0	0	3.0	0	0.0	0.0
Total	**801**	**749.5**	**742.0**	**422.8**	**539.2**	**269.6**	**428.4**	**178.0**

Table 3. Net sewage irrigated area (acres) in peri urban villages (distance) of Hubli and Dharwad

City	Distance(km)	Category of sewage irrigated land holding (acres)											Total
		0-1	1.1-2	2.1-3	3.1-4	4.1-5	5.1-6	6.1-7	7.1-8	8.1-9	9.1-10	10.1-60	
Dharwad	2	14.00	36.75	3.00	50.00		36.00	7.00	23.00		10.00		179.75
	3	5.00	18.50	22.75	24.00	13.75	18.00		32.00			12.00	146.00
	4		12.00	19.00	3.50	4.50	11.50	7.00	8.00				65.50
	5		16.00	6.00	4.00	5.00		7.00	16.00		10.00	15.00	79.00
	6	4.00	20.50	39.00	8.00	20.00	17.50	14.00		9.00			132.00
	9		2.00		16.00	10.00	23.50		24.00		30.00	118.00	223.50
	11		4.00	17.50	15.50	20.00		7.00			10.00	41.00	115.00
	12		7.50	10.50	20.00	4.50	18.00	7.00		9.00	20.00	36.00	132.50
	15		5.00	8.50	3.50	48.00	24.00	21.00	32.00	9.00	40.00	130.00	321.00
	18			3.00	15.50	15.00	6.00	14.00				44.00	97.50
	27		2.00	15.00	12.00	15.00	18.00	21.00	16.00		10.00	49.00	158.00
	Total	23.00	124.25	144.25	172.00	155.75	172.50	105.00	151.00	27.00	130.00	445.00	1649.75
Hubli	2		6.00		12.00	10.00	5.50	7.00	8.00			60.00	108.50
	3		4.00	3.00	8.00	14.50	6.00		8.00	18.00	20.00	147.00	228.50
	4	2.00	7.50	3.00	3.50						10.00	59.00	85.00
	5			3.00	8.00	9.50	6.00	7.00		9.00	10.00	210.50	263.00
	6			3.00	4.00		6.00		8.00		50.00	83.00	154.00
	7	1.00	3.50	17.00	27.00	13.50	18.00			9.00	10.00	168.50	267.50
	8	6.00	16.00	17.50	19.50	29.50	24.00	13.50	23.50	9.00	20.00	159.00	337.50
	9	5.75	30.00	26.75	27.00	49.00	35.50	27.50	8.00	9.00	10.00	50.00	278.50
	12	1.00	8.00	8.50	16.00	5.00	6.00		24.00	9.00	10.00	83.00	170.50
	17	6.00	17.00	11.25	15.00	4.25	12.00		8.00			12.00	85.50
	Total	21.75	92.00	93.00	140.00	135.25	119.00	55.00	87.50	63.00	140.00	1032.00	1978.50
Grand Total		44.75	216.25	237.25	312.00	291.00	291.50	160.00	238.50	90.00	270.00	1477.00	3628.25

Table 4. Number of sewage irrigating farmers in peri urban villages (km) with different land holdings

City	Distance (km)	Village	Category of sewage irrigated land holding(acres)											
			0-1	1.1-2	2.1-3	3.1-4	4.1-5	5.1-6	6.1-7	7.1-8	8.1-9	9.1-10	10.1-60	Total
Dharwad	2	Hebballi Agasi		1										1
		Hosayallapur	10	5	1	2		2		1				21
		Madihal	5	17		11		4	1	2		1		41
		Total	15	23	1	13		6	1	3		1		63
	3	Hebballi Agasi	2	8	5		1	2					1	19
		Hosayallapur	3	4	3	6	2	1		4				23
		Total	5	12	8	6	3	3		4			1	42
	4	Hosayallapur		6	7	1	1	2	1	1				19
	5	Govanakop		8	2	1	1		1	2		1	1	17
	6	Govanakop	4	11	13	2	4	3	2		1			40
	9	Gongadikop		1		4	2	4		3		3	6	23
	11	Somapur		2	6	4	4		1			1	3	21
	12	Maradagi		4	4	5	1	3	1		1	2	1	22
	15	Hebballi		4	3	1	10	4	3	4	1	4	7	41
	18	Hebballi						1						1
		Vanahalli			1	4	3		2				3	13
		Total			1	4	3	1	2				3	14
	27	Talemorab		1	5	3	3	3	3	2		1	2	23
	Total		24	72	50	44	32	29	15	19	3	13	24	325
Hubli	2	Bidnal		2		3	2	1	1	1			1	11
		Halegabbur		1										1
		Total		3		3	2	1	1	1			1	12
	3	Budersinghi											1	1
		Halegabbur		2	1	2	3	1		1	2	2	8	22
		Total		2	1	2	3	1		1	2	2	9	23
	4	HaleHubballi	2	4	1	1						1	3	12
	5	HaleHubballi			1	2	2	1	1		1	1	9	18
	6	HaleHubballi			1	1		1		1		5	5	14
	7	HaleHubballi			1			1				1	2	5
		Mavanur	1	2	5	7	3	2			1		8	29
		Total	1	2	6	7	3	3			1	1	10	34
	8	HaleHubballi				1			1				1	3
		Katnur	6	9	6	4	6	4	1	3	1	2	6	48
		Total	6	9	6	5	6	4	2	3	1	2	7	51
	9	Budersinghi	1	13	6	6	4	3	1		1		1	36
		Giriyala	5	2	3	1	6	3	3	1		1	2	27
		Total	6	15	9	7	10	6	4	1	1	1	3	63
	12	Belagali		1	2	2	1			2	1		1	10

		Inamveerapur	1	3	1	2		1		1		1	4	14
		Total	1	4	3	4	1	1		3	1	1	5	24
	17	Karadikoppa	6	9	4	4	1	2		1			1	28
	Total		22	48	32	36	28	20	8	11	7	14	53	279
Grand Total			46	120	82	80	60	49	23	30	10	27	77	604

Table 5. Area (acres) under different crop categories in peri urban villages of Hubli and Dharwad

City	Crop category	Season				Total
		All	***Kharif***	***Rabi***	**Summer**	
Dharwad	Annual vegetables		842.85	55.75	13.50	912.10
	Cereals		177.65	1048.30	5.90	1231.85
	Cotton		23.25			23.25
	Fodder crops	1.00	3.30	4.00	1.00	9.30
	Fruit crops	17.65				17.65
	Leafy vegetables		33.55	22.20	27.30	83.05
	Oilseeds		288.50	5.00	4.00	297.50
	Plantation crops	5.50				5.50
	Pulses		211.75	392.75		604.50
	Total	**24.15**	**1580.85**	**1528.00**	**51.70**	**3184.70**
Hubli	Annual vegetables	0.25	86.25	103.00	40.30	229.80
	Cereals		825.50	350.25		1175.75
	Cotton		5.00			5.00
	Flower crops	2.00	0.55			2.55
	Fodder crops	1.00	3.50	1.00		5.50
	Fruit crops	658.75				658.75
	Leafy vegetables		24.15	41.70	28.95	94.80
	Mulberry	59.50				59.50
	Oilseeds		267.00	463.50	191.00	921.50
	Plantation crops	22.60				22.60
	Pulses		13.00	11.00		24.00
	Sugarcane	40.00	3.00			43.00
	Total	**784.10**	**1227.95**	**970.45**	**260.25**	**3242.75**
Grand Total		**808.25**	**2808.80**	**2498.45**	**311.95**	**6427.45**
All = Perennial cropping						

Table 6a. Cropped area (acres) under various crops during different growing seasons in peri urban villages (distance, km) of Dharwad

Crop Category	Season	Distance from Dharwad (km)											Total
		2	3	4	5	6	9	11	12	15	18	27	
Annual vegetables	*Kharif*	40.85	27.00	13.00	44.50	87.50	130.00	79.00	83.25	174.75	58.00	105.00	842.85
	Rabi	21.25	11.00	4.50	9.50				9.00	0.50			55.75
	Summer	13.50											13.50
	Total	75.60	38.00	17.50	54.00	87.50	130.00	79.00	92.25	175.25	58.00	105.00	912.10
Leafy vegetables	*Kharif*	22.15	3.75	2.00	2.00	2.35	1.00		0.30				33.55
	Rabi	17.80	2.40	1.50	0.50								22.20
	Summer	27.30											27.30
	Total	67.25	6.15	3.50	2.50	2.35	1.00		0.30				83.05
Cereals	*Kharif*	17.65	40.25	14.50	9.50	8.25	5.00		10.00	51.50	1.00	20.00	177.65
	Rabi	100.55	118.00	43.00	54.50	85.25	95.00	82.00	86.50	200.50	74.00	109.00	1048.30
	Summer	5.90											5.90
	Total	124.10	158.25	57.50	64.00	93.50	100.00	82.00	96.50	252.00	75.00	129.00	1231.85
Oilseeds	*Kharif*	74.25	76.00	31.00	14.00	13.25	25.00	13.00	20.00	9.00	13.00		288.50
	Rabi			1.00			4.00						5.00
	Summer	1.00	1.00			2.00							4.00
	Total	75.25	77.00	32.00	14.00	15.25	29.00	13.00	20.00	9.00	13.00		297.50
Pulses	*Kharif*	7.75	8.00	4.00	8.00	4.50	15.50	12.00	18.50	81.50	18.00	34.00	211.75
	Rabi	17.50	25.50	9.00	8.50	16.00	76.00	26.00	27.50	119.75	17.00	50.00	392.75
	Total	25.25	33.50	13.00	16.50	20.50	91.50	38.00	46.00	201.25	35.00	84.00	604.50
Cotton	*Kharif*				4.50	7.75			5.00	4.00	2.00		23.25
Fodder crops	All		1.00										1.00
	Kharif	3.30											3.30
	Rabi	3.00								1.00			4.00
	Summer	1.00											1.00
	Total	7.30	1.00							1.00			9.30
Fruit crops	All	11.40	4.00	0.50		1.50		0.25					17.65
Plantation crops	All		1.50					1.00				3.00	5.50
Total		386.15	319.40	124.00	155.50	228.35	351.50	213.25	260.05	642.50	183.00	321.00	3184.70

All = Perennial cropping

Table 6b. Cropped area (acres) under various crops during different growing seasons in peri urban villages (distance, km) of Hubli

Crop Category	Season	Distance from Hubli (Km)										Total
		2	3	4	5	6	7	8	9	12	17	
Annual vegetables	All								0.25			0.25
	Kharif	4.00	8.00	11.50	6.50		5.50	1.00	14.75	21.00	14.00	86.25
	Rabi	10.20	13.50	8.00	8.00	3.00	4.00	5.00	19.80	30.50	1.00	103.00
	Summer	8.00	23.00		1.50				7.80			40.30
	Total	22.20	44.50	19.50	16.00	3.00	9.50	6.00	42.60	51.50	15.00	229.80
Leafy vegetables	*Kharif*	8.50	2.15	6.00	1.50		2.00		3.00	1.00		24.15
	Rabi	6.50	7.60	4.00	4.90		2.00	0.50	9.20	7.00		41.70
	Summer	8.50	8.25	2.50	1.60			0.50	7.60			28.95
	Total	23.50	18.00	12.50	8.00		4.00	1.00	19.80	8.00		94.80
Cereals	*Kharif*	29.50	180.00	42.00	142.00	97.00	101.50	30.00	123.75	52.00	27.75	825.50
	Rabi	29.00	40.00	16.50	45.50	15.00	32.00	24.50	67.00	28.00	52.75	350.25
	Total	58.50	220.00	58.50	187.50	112.00	133.50	54.50	190.75	80.00	80.50	1175.75
Oilseeds	*Kharif*	50.00	5.00	15.50	45.00	26.00	23.50	22.00	28.50	18.50	33.00	267.00
	Rabi	32.00	113.00	25.00	96.00	57.00	70.00	19.50	49.00		2.00	463.50
	Summer	31.00	19.00	13.00	43.00	31.00	24.00	7.00	8.50	7.50	7.00	191.00
	Total	113.00	137.00	53.50	184.00	114.00	117.50	48.50	86.00	26.00	42.00	921.50
Pulses	*Kharif*	3.00	6.00					1.00	3.00			13.00
	Rabi	3.00	4.00	2.00	2.00							11.00
	Total	6.00	10.00	2.00	2.00			1.00	3.00			24.00
Cotton	*Kharif*									3.00	2.00	5.00
	Total									3.00	2.00	5.00
Sugarcane	All		3.00		18.00	18.00		4.00				43.00
Mulberry	All				6.00		7.00	35.50	7.00	4.00		59.50
Fodder crops	All			1.00								1.00
	Kharif	3.50										3.50
	Rabi	1.00										1.00
	Total	4.50		1.00								5.50
Fruit crops	All	0.25	13.50	3.50	50.50	35.00	124.00	237.60	113.40	65.50	15.50	658.75
Plantation crops	All	3.00	1.00	5.00	1.00			10.00	0.60	2.00		22.60
Flower crops	All			1.00			1.00					2.00
	Kharif								0.55			0.55
	Total			1.00			1.00		0.55			2.55
Total		230.95	447.00	156.50	473.00	282.00	396.50	398.10	463.70	240.00	155.00	3242.75

All = Perennial cropping

Table 7a. Crops grown by different size of land holders in *kharif* and *rabi* seasons in peri urban villages of Hubli and Dharwad

Season	City	Crop category	Category of sewage irrigated land holding(acres)											Total
			0-1	1.1-2	2.1-3	3.1-4	4.1-5	5.1-6	6.1-7	7.1-8	8.1-9	9.1-10	10.1-60	
Kharif	Dharwad	Annual vegetables	6.00	52.05	79.00	85.90	121.00	99.90	64.50	55.00	14.00	73.00	192.50	842.85
		Leafy vegetables	3.30	15.25	2.00	3.85	1.00	3.40	2.75	2.00				33.55
		Cereals	6.40	8.00	22.00	19.25	14.00	13.50	4.00	37.50	2.00	10.00	41.00	177.65
		Oilseeds	4.75	38.25	31.25	41.25	8.50	41.00	10.00	35.00		16.00	62.50	288.50
		Pulses	1.50	9.00	6.00	15.25	31.00	10.50	14.00	12.00	8.00	25.00	79.50	211.75
		Cotton	0.75	1.00	4.00		1.00		2.00	3.50	2.00	3.00	6.00	23.25
		Fodder crops		1.30				2.00						3.30
		Total	22.70	124.85	144.25	165.50	176.50	170.30	97.25	145.00	26.00	127.00	381.50	**1580.85**
	Hubli	Annual vegetables	5.00	12.75	7.50	8.00	15.00	8.00		1.00		1.50	27.50	86.25
		Leafy vegetables	1.50	8.50		1.90	1.75	6.00					4.50	24.15
		Cereals	2.50	21.25	38.75	61.50	40.00	47.00	28.00	27.00	22.00	78.50	459.00	825.50
		Oilseeds	1.00	18.50	5.50	21.50	20.00	14.00	6.50	22.50	4.00	19.00	134.50	267.00
		Pulses					2.00		1.00		2.00		8.00	13.00
		Cotton		2.00									3.00	5.00
		Fodder crops					1.50			2.00				3.50
		Flower crops	0.25		0.30									0.55
		Total	10.25	63.00	52.05	92.90	80.25	75.00	35.50	52.50	31.00	99.00	636.50	**1224.95**
Rabi	Dharwad	Annual vegetables	0.50	9.75	0.50	10.50	1.00	7.50	4.50	8.50		4.00	9.00	55.75
		Leafy vegetables	3.00	10.05	0.90	2.00	0.25	2.00	0.50	2.50		1.00		22.20
		Cereals	13.00	85.05	117.00	138.25	120.50	115.00	64.00	90.50	17.00	74.50	213.50	1048.30
		Oilseeds			1.00			1.00		3.00				5.00
		Pulses	1.00	15.00	14.50	18.50	44.00	48.75	21.00	34.50	4.00	44.50	147.00	392.75
		Fodder crops		1.00				3.00						4.00
		Total	17.50	120.85	133.90	169.25	165.75	177.25	90.00	139.00	21.00	124.00	369.50	**1528.00**
	Hubli	Annual vegetables	1.00	10.30	6.50	14.70	11.00	5.00	1.00	6.50	3.00		44.00	103.00
		Leafy vegetables	1.50	5.20	5.50	4.60	2.50	8.50	1.50	1.50	2.00		8.90	41.70
		Cereals	7.50	21.50	21.25	42.50	36.50	23.00	14.50	29.00	8.00	20.00	126.50	350.25
		Oilseeds		7.00	10.00	16.50	20.00	23.50	13.00	4.00	7.00	45.00	317.50	463.50
		Pulses					2.00		3.00		2.00	2.00	2.00	11.00
		Fodder crops					1.00							1.00
		Total	10.00	44.00	43.25	78.30	73.00	60.00	33.00	41.00	22.00	67.00	498.90	**970.45**

Table 7b. Crops grown by different size of land holders in year round and summer seasons and in peri urban villages of Hubli and Dharwad

Season	City	Crop category	Category of sewage irrigated land holding(acres)										Total
			0-1	1.1-2	2.1-3	3.1-4	4.1-5	5.1-6	6.1-7	7.1-8	8.1-9	9.1-10	10.1-60	
Summer	Dharwad	Annual vegetables				1.50		3.00	1.00	4.00		4.00		13.50
		Leafy vegetables	2.70	13.80		2.30		2.00	2.50	2.00		2.00		27.30
		Cereals	5.40	0.50										5.90
		Oilseeds			2.00	1.00			1.00					4.00
		Fodder crops		1.00										1.00
		Total	8.10	15.30	2.00	4.80		5.00	4.50	6.00		6.00		**51.70**
	Hubli	Annual vegetables		2.30	2.00	1.00	5.00	2.50		7.00	6.00		14.50	40.30
		Leafy vegetables	1.50	9.10	2.50		3.50	6.00	1.60		2.00		2.75	28.95
		Oilseeds		6.00	3.50	11.00	3.00	7.00	9.00	6.00	6.00	16.00	123.50	191.00
		Total	1.50	17.40	8.00	12.00	11.50	15.50	10.60	13.00	14.00	16.00	140.75	**260.25**
All	Dharwad	Fodder crops	1.00											1.00
		Fruit crops	4.10	1.30		1.50	1.25	9.50						17.65
		Plantation crops					1.50	1.00	3.00					5.50
		Total	5.10	1.30		1.50	2.75	10.50	3.00					**24.15**
	Hubli	Annual vegetables	0.25											0.25
		Sugarcane									3.00		40.00	40.00
		Mulberry	3.00		10.00	4.00		2.00		1.50	2.00	4.00	33.00	59.50
		Fodder crops											1.00	1.00
		Fruit crops	13.70	41.75	43.25	51.20	47.00	33.50	14.00	32.85	29.50	61.50	290.50	658.75
		Plantation crops	0.30			0.30				3.00			19.00	22.60
		Flower crops						1.00					1.00	2.00
		Total	17.25	41.75	53.25	55.50	47.00	36.50	14.00	37.35	34.50	65.50	384.50	**787.10**

All = Perennial cropping

Table 8. Number of boreholes owned by farmers of different size of holding over distance in peri urban villages of Hubli and Dharwad

City	Distance(km)	Category of sewage irrigated land holding(acres)											Total
		0-1	1.1-2	2.1-3	3.1-4	4.1-5	5.1-6	6.1-7	7.1-8	8.1-9	9.1-10	10.1-60	
Dharwad	2	3											3
	3						1					1	2
	4			1									1
	5											3	3
	9				1								1
	12				1			1					2
	15			1		2	1					1	5
	Total	3		2	2	2	2	1				5	17
Hubli	2					1			1				2
	7				1	1	2			1		5	10
	8	1	2	3	2	2	2	1	2	1	1	16	33
	9	2	2	3	1	4	2	1	1			3	19
	12	1	3				1		2		1	8	16
	17		2		1	1			2			3	9
	Total	4	9	6	5	9	7	2	8	2	2	35	89
Grand Total		7	9	8	7	11	9	3	8	2	2	40	106

Table 9: Pesticides used on various crops under sewage irrigation (kg or l)

	Acephate 75 SP	Alphamethrin 10 EC	BHC 10 % Dust	Carbendizim 12WP + Mancozeb 63WP	Carbendizim 50 WP	Chlorpyriphos 20 EC	Cypermethrin 25 EC	Deltamethrin 2.8EC	Dimethoate 30EC	Endosulfan 35 EC	Ethion	Mancozeb 45 WP	Mancozeb 5 % Dust	Methyl Parathion 50EC	Monocrotophos 36EC	Profenophos 50 EC	Propiconazole 25 EC	Quinalphos 25 EC	Quitazin 48 EC	Spinosad 2.5EC	Triazophos 35EC + Deltamethrin 1EC	Zineb 78 SP	Grand Total
Dharwad																							
Annual vegetables	17.4	31.5		7.4	6.3	5.6	6.5	18.2	69.2	6.9	4.8	9.9		33.8	121.5	16.6	17.5	14.7	30.5	5.1	4.2		434.2
Cereals				0.2	0.2	0.8			1.2	1.3					4.8							6.6	15.4
Cotton		0.2					2.8	4.3	1.3					0.3	6.9			1.3					17.0
Leafy vegetables							0.1	2.9						1.2	4.9	0.1		0.7					12.0
Oilseeds					20.8	0.6			0.9	1.5		4.3		0.5	76.6			12.4					119.2
Pulses	13.6	14.8		0.9	11.1			0.2	6.5	4.5		5.0		23.1	112.6		2.2	33.2					228.9
Total	30.9	46.5		8.5	38.3	7.0	9.4	25.6	79.0	14.2	4.8	19.2		58.9	327.3	16.7	19.8	62.3	30.5	5.1	4.2	6.6	826.6
Hubli																							
Annual vegetables	8.1	6.2			4.6		5.5	9.6	18.5	3.4		2.2		22.2	34.3	17.6		3.6		7.0	5.5		159.1
Cereals															0.8								2.8
Cotton		1.0						1.1							1.4								3.5

Fruit crops			40.8						35.8			4.5	25.0								7.5	134.8
Leafy vegetables									0.9	0.3					1.6			0.9				3.7
Mulbery					0.9																1.3	2.1
Oilseeds					9.9	0.9			13.4	2.0					54.8			6.9				89.0
Pulses	1.0	1.6						0.3	1.2					0.1	1.8							6.0
Total	9.1	8.8	40.8		15.4	0.9	5.5	11.0	69.8	5.7		6.7	25.0	22.3	94.6	17.6		11.3		7.0	5.5	8.8	401.1
Grand Total	**40.1**	**55.2**	**40.8**	**8.5**	**53.7**	**7.9**	**14.9**	**36.6**	**148.8**	**19.8**	**4.8**	**25.9**	**25.0**	**81.2**	**421.9**	**34.3**	**19.8**	**73.6**	**30.5**	**12.1**	**9.7**	**15.3**	**1227.7**

Note: Ten of the chemicals which were used in very meager quantity have not been mentioned in Table 9

Table 10: Crops which received higher level of pesticides (kg or lit per acre) under sewage irrigation

Crops	**Dharwad**	**Hubli**
Cauliflower	1.11	0.42
Chilli	0.96	1.06
Cucumber	0.77	0.54
Ridge gourd	0.76	0.42
Tomato	0.92	0.90
Cotton	0.73	0.71
Ladies finger	0.53	1.02