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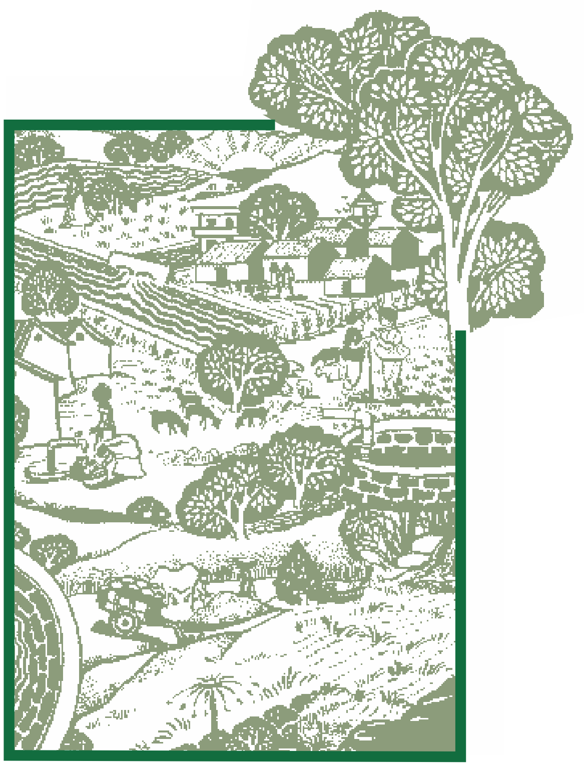
2016



The availability of reliable and permanent supply of wastewater from urban areas like Hubli–Dharwad and Vijayapura in Karnataka has enabled peri-urban farmers to sustain their farming livelihoods. Proximity to cities has helped farmers adopt year-round, intensive vegetable cultivation. Apart from the increase in crop yield due to high nutrients available in the wastewater, it also makes cultivation a profitable venture during the summer season. However, there are adverse health impacts of irrigating with untreated wastewater and intensive application of pesticides to fight the pests that infest these crops. Through a case study approach, this highlight attempts to analyze the current status of wastewater generation, its uses and benefits along with farmers' perceptions about its negative health impacts.

IWMI-TATA
Water Policy Program

Water Policy Research
HIGHLIGHT

Wastewater Irrigation in Karnataka

An exploration

Mahima Gupta
Vandana Ravindra
Alka Palrecha

WASTEWATER IRRIGATION IN KARNATAKA
*An exploration**

Research highlight based on Gupta (2015); Ravindra and Karande (2015).

1. URBAN WASTEWATER SCENARIO IN KARNATAKA

With a population of 62.5 million, Karnataka is one of the most urbanized states of India. The urban population of Karnataka is 38 per cent (2011 census), up 5 per centage points from 2001.. The state has 213 urban local bodies (ULBs) which are responsible for providing water and sanitation services in urban Karnataka. The growing urban population has meant increased sewage generation and while there are proposals to set up sewage treatment plants along with conventional sewage systems in most towns and municipal corporations, the current treatment capacity remains far below the requirement.

The Karnataka State of Environment Report (EMPRI 2011) states that "*only 36 out of 213 ULBs (except Bangalore and City Municipal Councils around Bangalore) have been covered with underground drainage (UGD) facilities. Even in those towns where the UGD is being provided, the percentage coverage of households is relatively less. In the 36 ULBs where UGD is present, 9 urban local bodies do not have treatment plants. Even among other urban bodies where sewage treatment plants are provided, they are either oxidation plants (in 16 towns) or primary treatment plant (in 6 towns). In none of the towns secondary and tertiary treatment plants are established*".

According to the Central Pollution Control Board, Karnataka generated 3,777 MLD (million liters per day) of wastewater in 2015. However, sewage treatment capacity of the state is only 1,304 MLD and nearly 65 per cent wastewater is discharged untreated into water bodies, deteriorating water quality.

Many farmers use this untreated wastewater for irrigation because it is the only source of water available to them. Farmers obtain irrigation water from streams/*nallas* that are polluted with effluent from a nearby city or housing development. In a sense, farmers using untreated wastewater provide a public service by removing effluent from polluted streams and applying it to soil, thus reducing the pollutant load downstream. Thus, application of wastewater for agricultural purpose assumes a higher significance in the current scenario.

2. OBJECTIVES AND METHODOLOGY

The study was undertaken with the following objectives:

[a] Quantify area irrigated with wastewater in Karnataka and specifically in the periphery of the chosen cities to arrive at total size of the wastewater irrigation economy.

[b] Investigate the preferred crops, farmers' views about wastewater irrigation and their rationale for wastewater use.

[c] Undertake risk assessment for wastewater irrigation.

Published reports and documents were reviewed to identify cities where wastewater irrigation is practiced. Hubli-Dharwad Municipal Corporation and Vijayapura Town Municipal Corporation (TMC) were selected since wastewater use in their periphery was known to some extent.

In Vijayapura, 7 out of 23 wards were selected as only in these wards farmers had access to wastewater. In Hubli-Dharwad, 7 villages were selected through which storm water drain passes that carries wastewater. Since Hubli-Dharwad region is relatively bigger than Vijayapura and it was difficult to cover the entire region within given time frame, for locating the places to be studied, Geographic Information Systems (GIS) and Remote Sensing (RS) technologies were used. Wastewater *nallas* (open drains) which flow into the city's hinterland were identified and the villages through which these drains pass were selected for study. Finally, Madihal, Govankoppa, Gongadikoppa and Maradagi villages in Dharwad and Bidnal, Gabbur and Budarsinghi villages in Hubli were selected. The relevance of these places was further verified through literature.

During the reconnaissance visits in these cities, it was observed that untreated sewage eventually gathers in open drains (*nallahs*) and flows into the city's hinterland. The sewage passing through these *nallahs* within the city limits was not taken into account as no agriculture is being practiced within the city. However, the sewage used for irrigation in the periphery of the city was taken into consideration and tracked.

A transect walk along the path of sewage flow (untreated sewage passing through *nallahs*) was undertaken and the villages were marked on the map. Subsequently, using RS and GIS, land use classification was done to compute the cropped area in the *rabi* season.

The field visits comprised of Participatory Rural Appraisals (PRAs), which were conducted in all the selected villages.

*This Highlight is based on research carried out under the IWMI-Tata Program (ITP) with additional support from the CGIAR Research Program on Water, Land and Ecosystems (WLE). It is not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or its funding partners.

Cropping calendar, major cropping pattern, cost of cultivation of those crops and the farmers' perceptions about the use of wastewater were gathered through Focus Group Discussions (FGDs).

3. Key Findings

[i] There are no sewage treatment facilities in the selected cities and the untreated sewage is disposed into the natural storm water drains towards the periphery of the cities. In the absence of freshwater, farmers in peri-urban villages use untreated wastewater for irrigation.

[ii] The reliability of its supply, its nutrient value and almost no cost to access it make wastewater irrigation an appealing proposition for the farmers.

[iii] Both large and small farmers were observed to be using wastewater. Wastewater is generally used during *rabi* and *dry* seasons when there is no rain. Large farmers use both bore well and wastewater, but small and marginal farmers mainly depend on wastewater for irrigation.

[iv] The cropping pattern in the study villages indicates that with assured supply of wastewater, land use is maximized for cropping throughout the year. The farms are kept fallow for only one or two months in a year.

[v] Vegetable production is concentrated more in villages close to Hubli-Dharwad while fruit crops are preferred in farther-off villages. In Vijayapura, on the other hand, most farmers prefer growing vegetables, flowers and fodder with wastewater. Vegetables like knol-khol, beetroot, carrot and flowers are mainly grown due to the accessible urban market of Bangalore. Fodder cultivation is common among small and marginal farmers. Vijayapura is famous for its grape cultivation but these are grown using freshwater only.

[vi] Farmers using wastewater for the last 20 years in Hubli-Dharwad did not observe any deterioration in soil quality; rather they reported that the productivity of land has improved over time.

[vii] It was found that the yield in wastewater irrigated vegetables like cauliflower and ridge gourd in Hubli-Dharwad and beetroot in Vijayapura is nearly 20 per cent more than freshwater irrigated vegetables. Also, the input cost is much lower in wastewater irrigated fields as compared to freshwater irrigation systems. On an average, freshwater farmers spend 3 times more in fertilizers than wastewater farmers in both Hubli-Dharwad and Vijayapura. Few wastewater farmers reported that for wheat and ragi, they do not use any chemical fertilizers.

[viii] It was observed that the amount of chemical fertiliser needed is lower with wastewater irrigation, though the amount of pesticide needed increases in some cases on account of prolific weed growth and pest attacks. The increase in number of weeds may be due to the fertile nature of sewage water, but may also simply be due to the increased availability of water in areas that were traditionally rainfed.

[ix] In both the study locations, it was found that ease of access to local urban markets and high urban demand ensured a secure market for vegetable produce, particularly during the summer season when vegetable market prices increase.

[x] A very small proportion of farmers in both locations have adopted on-farm measures like use of settling tanks and filters before letting wastewater into the farms to reduce solid particulates or suspended solids from wastewater especially to prevent clogging.

[xi] Farmers using wastewater, in general, do not rank the health risks highly. Also according to farmers, they have never received complaints about the quality of vegetables and other crops they produce.

4. Extent of Wastewater Use in Agriculture

As part of the study, the use of wastewater, yields of crops irrigated with wastewater, expenses and profits were computed. In Hubli-Dharwad there is large extent of wastewater use which can be attributed to factors like year-round free availability of wastewater. Whereas in Vijayapura, only 8 per cent of area is wastewater irrigated owing to unavailability of sewage in larger volumes (Table 1).

In order to assess the costs and benefits of wastewater irrigation, a representative sample of 43 farms was studied in detail. Twenty six of the sample farms used wastewater while the remaining 16 used groundwater. It was not possible to compare wastewater-irrigated fields with freshwater-irrigated fields that had a similar cropping pattern, because almost all wastewater farmers took advantage of reliable supplies by growing vegetables that could not easily be grown by the groundwater irrigators. However, a comparison was made for wheat, cotton and beetroot, which were grown by both groups of farmers.

The cost of irrigation was higher for the groundwater irrigators than for the wastewater irrigators. This was mainly due to the high cost of pumping groundwater (table 2). However, there is no significant difference in total cash costs of farm inputs between wastewater farms and groundwater farm. Wastewater farmers spent more on labour and

Table 1: Extent of wastewater use for irrigation in peripheral villages of study cities

S.N.	Cities Whose Surrounding Villages Use Wastewater for Irrigation	No. of Villages Using Wastewater	Net Irrigated Area (in Ha)	Net Wastewater Irrigated Area (in Ha)	% of Wastewater Irrigated Area
1	Dharwad	4	1,178	210	17
2	Hubli	3	390	186	48
3	Vijayapura	1	499	35	8
Total		**8**	**2,067**	**429**	**24 (average)**

Table 2: Comparison of financial costs of inputs and value of products for wastewater and freshwater-irrigated farms

Description of variable (Rs/Ha)	Wheat		Cotton		Beetroot	
	Wastewater	Freshwater	Wastewater	Freshwater	Wastewater	Freshwater
Seed	1,485	1,485	4,950	4,950	46,505	49,505
Labour	25,270	22,277	14,851	13,614	37,129	32,227
Fertilizer	0	2,475	1,238	4,950	2,475	5,693
Pesticide	500	0	4,950	3,713	4,950	4,000
Energy Cost	580	2,000	800	1,850	350	1,300
Total Input Cost	27,835	28,238	26,790	29,078	91,409	92,725
Yield (quintal per ha)	27	20	40	35	136	108
Market Price per quintal	2,000	2,000	4,000	4,000	1,800	18,00
Gross Returns per Ha	54,000	40,000	1,60,000	1,40,000	2,44,800	1,94,400
Net Returns per Ha	26,165	11,762	1,33, 210	1,10,922	1,53,391	1,01,675
Returns per Rupee Invested	0.94	0.42	4.97	3.81	1.68	1.10
% increase in returns per rupee invested with wastewater use	126		30		53	

pesticides but applied significantly lower doses of fertilizers and no farmyard manure at all. The groundwater farmers spend almost thrice on fertilizers.

The crop yields are higher for wastewater farmers. Thus, the gross value of product and the net profit at the wastewater farms were significantly higher than those for the freshwater-irrigated farms.

5. Perception-Based Health Risk Assessment

There is a lot of epidemiological evidence that wastewater use imposes significant health risks if undertaken without effective risk-management practices. Several studies show that the greatest risk for farm workers in wastewater irrigated agriculture derives from intestinal nematode infections and for produce consumers, from bacterial disease infections (Blumenthal and Peasey 2002). However, perception studies show that farmers generally are satisfied with their wastewater sources and do not perceive that wastewater irrigation poses a significant health risk. Those farmers who are aware of the potential health risks appear to perceive such risks to be low and seem willing to accept these risks because of the economic benefits derived from wastewater use and the scarcity of other water sources (Gbewonyo 2007).

Against this backdrop, a health risk assessment has been undertaken based on the results of farmers' perceptions survey. The framework for health risk assessment is adapted from Sanitation Safety Planning (SSP) manual for safe use and disposal of wastewater, greywater and excreta published by WHO (2015). The parameters were decided based on the perceptions of the farmers and consumers and not based on the research team's understanding of health risks as suggested by SSP.

Broadly, there are two exposure groups: (i) F1 = Farmers handling wastewater but do not consume their cultivated produce; and (ii) F2 = Farmers as consumers of their wastewater cultivated produce.

F1 category of farmers in Hubli-Dharwad who only use wastewater to irrigate crops and do not consume the produce have a risk score of **R = 20** and are categorized as high risk based on the matrix (see Table 3). Whereas in Vijayapura, this category of farmers are at medium risk based on their perceptions.

Category F2 farmers who along with wastewater irrigation, also consume the produce grown by them have a total risk score of **R= 22** (as they are at the risk of both skin as well as food borne infection) in Hubli-Dharwad and thus categorized as high risk. Whereas, in Vijayapura, the risk score is R = 12 and categorized as medium risk.

6. Control Measures Adopted by Farmers

During the field visits, farmers were found to be developing methods to adapt to deteriorating water quality in order to maintain or increase yields and minimize negative outcomes including health problems.

[a] Use of a settling tank: 7 out of 26 farmers interviewed in study villages use a settling tank. This innovative method was also observed in Vijayapura, Bidnal and Maradagi villages. In this method, wastewater is first collected and made to stand in a tank (generally dug in the field). This serves two purposes, one, it acts as a sewage storage tank to ensure a sufficient irrigation supply when the sewage flow is low; two, it allows the sludge to settle down. The water is then

Table 3: Health risk assessment based on perceptions of farmers

Location	Exposure Group	Exposure Route	Hazardous Event	Farmers and Consumers Perception of Health Risk			Score (A x B)	Risk	Total Score of Risk (R)
				Health Issues Perceived	Occurrence of Disease (A)	Level of Treatment Required (B)			
Hubli-Dharwad	F1	Skin Penetration	Exposure to sewage during farming activities	Worm infestation[1] along with dermatitis was observed and reported by farmers	Farmers perceive that such skin infection and other health issues would almost certainly happen again in future while working with wastewater	Moderate Level of treatment (described as short-term ailment that required treatment and medicines)	5x4=20	High	R = 20 High Risk
	F2	Skin Penetration	Exposure to sewage during farming activities	Dermatitis was observed and reported by farmers	Farmers perceive that such skin infection would almost certainly happen again in future while working with wastewater	Moderate Level of treatment (described as short-term ailment that required treatment and medicines)	5x4=20	High	20 + 2 = 22 High Risk
		Ingestion	Consumption of contaminated produce	HHs did not report any health impact	HHs reported that it has not happened in the past and is unlikely to happen in the future	Insignificant (No/negligible health impact)	2x1=2	Low	
Vijayapura	F1	Skin Penetration	Exposure to sewage during farming activities	Farmers related skin irritation to wastewater use	Skin infection is certain to happen again in future	Temporary symptom that does not require treatment	5x2=10	Medium	R = 10 Medium Risk
	F2	Skin Penetration	Exposure to sewage during farming activities	Dermatitis was observed and reported by farmers	Farmers expect that skin infection will definitely happen again	Temporary symptom that does not require treatment	5x2=10	Medium	10 + 2 = 12 Medium Risk
		Ingestion	Consumption of contaminated produce	HHs did not report any health impact	HHs did not report any skin infection and did not expect it in the future	Insignificant (No/negligible health impact)	2x1=2	Low	

pumped out using either electric or fuel operated motors. According to farmers, this method has its own problem as these tanks become mosquito breeding sites. To overcome this problem farmers are using mosquito nets to cover the tanks.

[b] Use of filter as sewage is pumped: Few farmers have adopted a method of filtering the wastewater as it is pumped from the *nalla* before letting the wastewater into the field. The filtration serves two purposes: it prevents debris from entering the pump thereby reducing wear and tear, and it prevents the fouling of soil with any debris and solid wastes present in the sewage. However, remaining wastewater users directly pump out the raw sewage and let it into the fields without any filter. The pumped water often contains solid wastes like plastics, used syringes and other debris. After tilling operations, the waste becomes half buried, resulting in potentially hazardous conditions for farmers.

7. Conclusion

In Karnataka, a significant quantity of untreated or partially treated wastewater is disposed directly into the environment. Our study found that a large part of this wastewater is reused by peri-urban farmers for irrigation. In Hubli-Dharwad and in Vijayapur, we found that more than 400 ha. of net

[1]Based on an earlier study conducted in the same villages (Bradford *et al.* 2003).

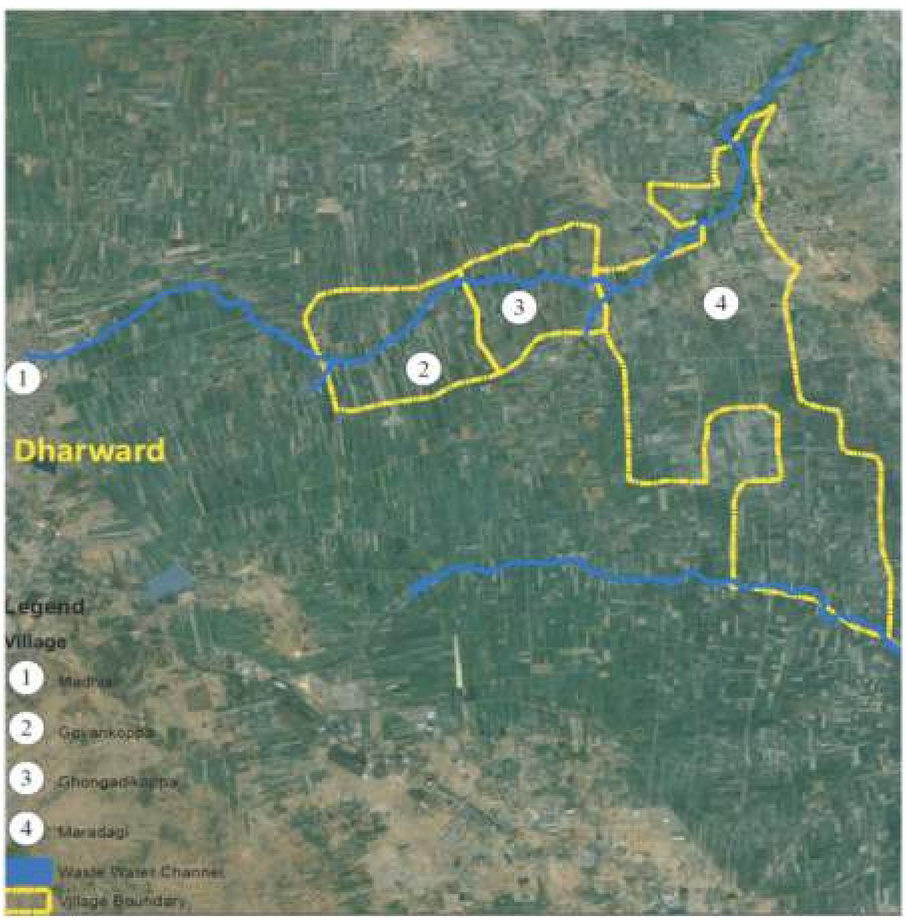
Constructed tank for storage and settling of waste-water in Vijayapura

Shallow pit used as settling tank in Vijayapura

cropped area is irrigated with wastewater. Wastewater is an appealing irrigation source for farmers since it is available year-round and is high in nutrient content. We found that wastewater irrigators get higher yields and enjoy significant savings in fertilizer and irrigation costs.

The key challenge in managing wastewater irrigation is the negative health impacts. These may be mitigated if enough attention is paid for making wastewater irrigation safe through simple practices of safe handling. Productive use of wastewater in agriculture can be sustainable if key economic actors like municipalities work with farmers to meet their needs. Doing so would strengthen wastewater dependent agri–livelihoods as well as protect degradation of land and water resources taking place due to incessant disposal of untreated wastewater.

Map 1: Extent of wastewater irrigation in Dharwad



Map 2: Extent of wastewater irrigation in Hubli

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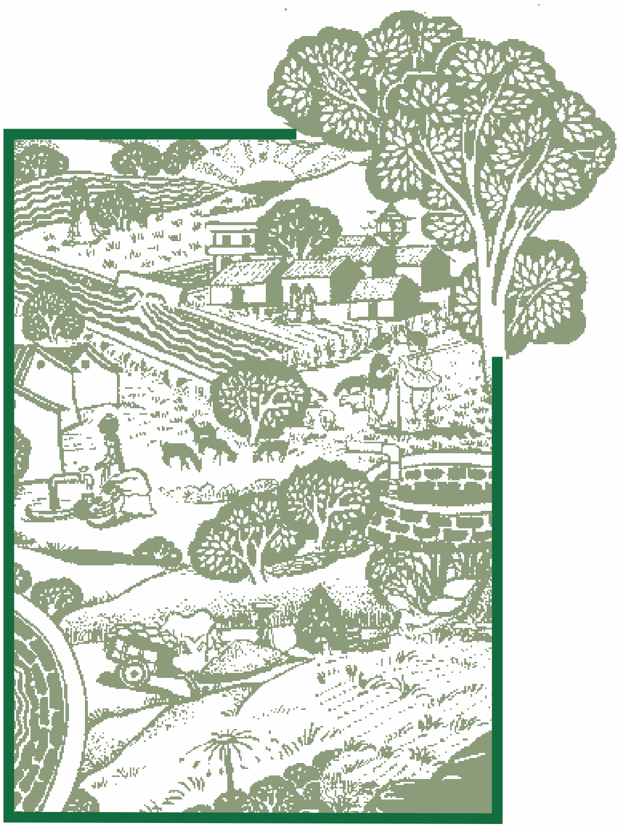

About the IWMI-Tata Program and Water Policy Highlights

The IWMI-Tata Water Policy Program (ITP) was launched in 2000 as a co-equal partnership between the International Water Management Institute (IWMI), Colombo and Sir Ratan Tata Trust (SRTT), Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations. Through this program, IWMI collaborates with a range of partners across India to identify, analyze and document relevant water management approaches and current practices. These practices are assessed and synthesized for maximum policy impact in the series on Water Policy Highlights and IWMI-Tata Comments.

Water Policy Highlights are pre-publication discussion papers developed primarily as the basis for discussion during ITP's Annual Partners' Meet. The research underlying these Highlights was funded with support from International Water Management Institute (IWMI), Tata Trusts, CGIAR Research Program on Water, Land and Ecosystems (WLE) and CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). However, the Highlights are not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or any of its funding partners.

IWMI Headquarters
127 Sunil Mawatha
Pelawatte, Battaramulla
Colombo, Sri Lanka
Mailing Address
P. O. Box 2075, Colombo, Sri Lanka
Tel: +94 11 2880000, 2784080 **Fax:** +94 11 2786854
Email: iwmi@cgiar.org **Website:** www.iwmi.org

IWMI-Tata Water Policy Program
"Jal Tarang"
Near Smruti Apartments, Behind IRMA Gate
Mangalpura, Anand 388001, Gujarat, India
Tel: +91 2692 263816, 263817
Email: iwmi-tata@cgiar.org

IWMI International Water Management Institute

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