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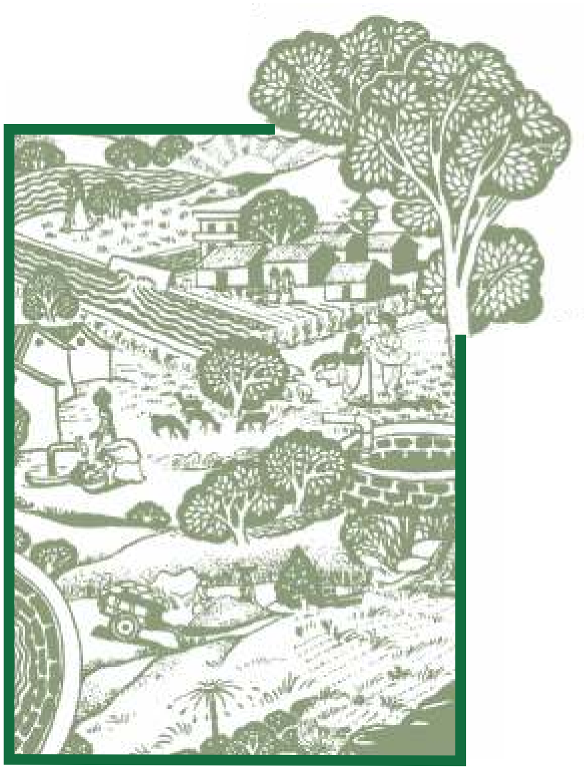

Wastewater irrigation is not new in Maharashtra and the Government of Maharashtra as well as farmers are beginning to recognize its value as a drought response. This Highlight presents a synthesis of field explorations in 11 locations in Maharashtra which cover the extent of wastewater irrigation; economics of wastewater and freshwater use; farmers' preferences and perceptions about wastewater; and how they are adapting to its use in agriculture.

IWMI-TATA
Water Policy Program

Water Policy Research
HIGHLIGHT

Wastewater Irrigation in Maharashtra

An exploration

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Wastewater Irrigation in Maharashtra*†

An exploration

Research highlight based on Ramola (2016) and Sakhare *et al.* (2016).

1. Wastewater Scenario in Maharashtra

With a population of 112 million (Chandramouli 2011), which is expected to grow to 132 million by 2025, Maharashtra is the second largest state in India, by population. It is also highly urbanized with 45.2 per cent people residing in urban areas. A large number of growing cities are located in five major river basin, taking freshwater away and discharging wastewater back into the catchments. Owing to acute fresh water scarcity, many peri-urban areas consider these urban return flows to be a valuable resource. Our field studies found that peri-urban farmers not only use the water carried downstream by streams and rivers; but also seek it specifically in times of crises.

The 23 Municipal Corporations of Maharashtra have 57 per cent sewage network coverage. Only 9 of the 23 have sewage treatment plants and their treatment capacity is only 40 per cent of the total wastewater generated. According to Central Pollution Control Board, in 2006, Maharashtra generated 9,986 MLD of wastewater in 50 class I cities. Sewage treatment capacity is reported as 4,225 MLD and nearly 58 per cent untreated wastewater is discharged into downstream water bodies. In 2010-11, a performance audit carried out by CAG noted that, "*domestic effluents in the state are inadequately treated*". Scrutiny of the State Pollution Control Board records reveals that only 8 out of 150 local bodies were provided STPs; in 18 out of 25 cities, domestic effluents were discharged without any treatment and in 7 (except Navi Mumbai) the gap between sewage generation and treatment capacity was in the range of 48 to 94 per cent (CAG 2011).

In Konkan and western Maharashtra, about 45 per cent of the local bodies have underground drains; in Marathwada and Vidarbha, the underground drain coverage is only 23 per cent. Even where such drainage systems exist, their coverage is intermittent. In Sangli-Miraj-Kupwad Municipal Corporation, for example, only 51 of the 68 wards have drainage facilities with some wards partially covered. In many cases the STPs were constructed for a much lower capacity and are now overloaded, causing untreated sewage to be directly released into rivers. 99 per cent of the sewage water generated by the Municipal Councils and over 50 per cent of sewage discharged by Municipal Corporations goes untreated. While smaller towns and rural habitations do not contribute significant amounts of sewage (due to lesser population and low per capita water supply), the problem of wastewater generation and disposal is severe in larger cities and towns.

2. Objectives and Methodology

Besides estimating the spread and scale of wastewater irrigation in and around select cities, this study also aims to assess changes in production of specific crops due to wastewater irrigation. The productivity changes are likely as bulk of wastewater being used is untreated or partially treated. Raschid-Sally (2008) states that local opportunities and constrains should guide policies and decisions about wastewater irrigation. Therefore, in addition to productivity changes public health concerns with the use of wastewater were also brought out for mainstreaming them. Hence a framework based on Sanitation Safety Manual published by WHO (2015) for assessing health risks was applied. The specific objectives of this study are to:

- estimate the spread and scale of the wastewater irrigation in select locations in Maharashtra;
- assess the contribution of wastewater and the changes in crop productivity driven by its use;
- understand the views, concerns and preferences of farmers regarding wastewater irrigation; and
- assess the perceived direct and indirect health risks associated with wastewater irrigation.

As our objective was to capture as much of wastewater use in Maharashtra as possible, selection of study locations was done through extensive discussions with experts and a review of popular media. See ANNEX for map. The cities of Aurangabad, Dhule, Ichalkaranji, Jalgaon, Kolhapur, Miraj, Nashik, Nagpur, Pune and Sangli were covered; in addition, the Purandar Lift Irrigation Scheme was also included in the exploration.

Observations about aggregation and disposal of municipal sewage were made to track wastewater flow and its usage downstream. In addition to untreated sewage flowing through open drains, STPs were identified as important sources of wastewater for downstream farmers. A transect walk along the path of sewage flow was undertaken. Land

*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.

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use classification into settlements, irrigated area and uncultivated land was done with data from NRSC Open Data Archive (NOEDA) and Bhuvan using ERDAS IMAGINE software. The satellite imagery of *Rabi* season was taken for classification of land uses. Irrigation was assumed to be a pre-requisite for *Rabi* cultivation. This was followed by ground truthing and village-wise survey of stakeholders using semi-structured interviews. The profits of farmers are estimated as *'cash profit'* and not '*net profit*' as these do not account for rent of land and the imputed cost of family labor.

3. Evidence from Field Studies

3.1 Extent of Wastewater Use

Table 1 shows the extent of wastewater irrigation along with cash profit per hectare. Among our study locations, the Purandar Lift Irrigation Scheme has highest wastewater irrigated area followed by Pune, Nagpur, Jalgaon and Aurangabad. In Aurangabad, nearly 90 per cent of wastewater generated by the city is disposed in *Kham* river, making wastewater available to farmers throughout the year. As groundwater is scarce, almost all the net irrigated area here can be attributed to wastewater use.

Purandar LI Scheme uses water from *Mutha* river (after confluence with *Mula* river and before confluence with *Bhima* river) for irrigation. The scheme has been functioning for the past five years and was the result of farmers' demand for providing wastewater in years of drought. Untreated or partially treated wastewater, which is disposed by urban areas, is widely used for irrigation in this water scarce region that includes talukas of Purandar, Daund, Haveli, and Baramati. The wastewater is pumped in a nallah/ pond and released only when a collective demand from the farmers is generated. Usually each village demands for the release of water 5-6 times in a year. Usually, groups of 3 to 25 farmers share a mobile pump to extract the wastewater. A farmer typically has to shell out ₹ 40,000 as payment to the irrigation department for drawing wastewater. Many prosperous farmers in these four talukas have constructed wells on their farms and use drip irrigation to conserve the wastewater which they acquire at a high price.

The *Sade Satra Nalli* scheme has its genesis in the 1920s when the city got an underground sewage network. Instead of disposing the sewage in the *Mula Mutha* river, the British decided to utilize the wastewater for agriculture. They designed the scheme such that one-part sewage would be mixed with three parts of freshwater before its application in agriculture. The cities of Kolhapur, Miraj, Sangli and Ichalkaranji have the least percentage of net irrigated area attributable to wastewater; this is so because they have access to freshwater from nearby rivers. Miraj and Sangli have freshwater available from *Krishna* river. The farmers here believe that using wastewater requires greater frequency of irrigation vis-à-vis freshwater; they also feel that wastewater irrigated crops are more prone to diseases and hence require higher pesticide application. Similarly, farmers in Kolhapur and Ichalkaranji have freshwater supply from *Panchaganga* river. During the summer months, there is reduction in the availability of river and groundwater; and this explains the use of wastewater. Farmers from Ichalkaranji reported that repeated use of wastewater has led to soil degradation and loss of productivity. Farmers here irrigate their fields alternately with freshwater and wastewater to overcome/minimize this perceived loss.

Table 1: Extent of wastewater use for irrigation in study locations in Maharashtra

Location	No. of Villages	Sample size	Net Irrigated Area (ha)	Net WW Irrigated Area (ha)	% Net WW Irrigated Area	Gross WW Irrigated Area (ha)	Cash Profit per ha (₹/ha.)
Kolhapur	Urban Area	8	1,172	77	7	113	₹ 2,07,792
Miraj	2	10	1,405	120	9	190	₹ 1,17,500
Sangli	3	12	1,115	130	12	220	₹ 1,21,308
Ichalkarangi	4	15	2,851	375	13	510	₹ 1,96,667
Jalgaon	2	6	5,435	1,232	23	N.A.	₹ 43,019
Nashik	8	18	2,113	925	44	1,560	₹ 45,405
Purandar LIS	4	12	49,941	25,498	51	N.A.	₹ 41,768
Nagpur	29	17	5,375	3,186	59	9,557	₹ 6,84,650
Dhule	4	12	476	350	74	868	₹ 77,143
Pune	9	2	7,223	5,579	77	N.A.	₹ 94,820
Aurangabad	15	9	1,128	1,036	92	2,072	₹ 5,82,046
TOTAL	**76+**	**121**	**76,044**	**38,507**	**51**		**₹ 1,19,970**

Data Sources: Field Study 2015; Sakhare *et al*. (2016); and Ramola (2016)
N.A.: Data not available

3.2 Economics of Wastewater and Freshwater Irrigation

A comparison of returns from wastewater irrigation shows that Nagpur and Aurangabad have the highest cash profit per hectare, as well as very high proportion of wastewater irrigated area. In Jalgaon, Nashik and Purandar, cash profits per hectare were relatively low despite significant wastewater irrigation. This might be explained by high labor and other input costs.

The comparative economics of wastewater and freshwater irrigated agriculture (Table 2) shows that despite spending more on labor and pesticide, wastewater farmers are able to secure higher cash profits as they have higher yields and spend considerably less on fertilizers. The higher crop productivity of wastewater farmers can be explained by the high nutrient content of wastewater. Drechsel *et al.* (2015) have noted several challenges in comparing wastewater and freshwater irrigated parameters. Among other things, they point to the intrinsic differences between wastewater farmers and the freshwater control group which might make the comparison of yields and productivity unduly favorable towards wastewater farmers. We interviewed 121 farmers using wastewater across all the selected cities in the state of Maharashtra. These farmers were selected by clustering to capture different crop production using wastewater. Our field surveys did not take such differences into account and not all the differences in yields and productivity can be attributed to wastewater or freshwater use alone.

3.3 Farmers' Perceptions about Wastewater Irrigation

Most farmers we interviewed noted the year-round availability of wastewater as a key driver for its growing use; they also noted that wastewater irrigation involved lower input costs (via reduction in fertilizer use) and resulted in higher crop productivity. On the flip side, farmers noted that the labor costs of wastewater irrigated crops were higher due to greater need for weeding; this also led to higher use of pesticides. Farmers in Pune reported decline in soil fertility owing to repeated wastewater application; farmers in Kundane village in Dhule reported incidence of salinity in groundwater due to wastewater use. Sangli farmers believed that wastewater has “heat content” which leads to higher irrigation water requirement, in turn leading to higher energy and labor costs. In fact, our data is inconclusive on the energy costs of wastewater irrigation; in some locations, farmers reported lower energy costs while others reported higher.

There is some epidemiological evidence that wastewater use imposes significant health risks if undertaken without effective risk-management practices. Blumenthal and Peasey (2002) argue that the greatest risk for farm workers in wastewater irrigated agriculture arises from intestinal nematode infections and for produce consumers, from bacterial disease infections. However, field studies show that farmers generally are satisfied with their wastewater use and do not perceive or associate significant health risk with wastewater irrigation. While some farmers were aware of the health risks posed by wastewater irrigation, they seemed willing to accept these risks due to unavailability of freshwater and the significant economic benefits of wastewater use. A perception-based health risk assessment was undertaken during our field visits. The framework is adapted from the Sanitation Safety Planning Manual published by WHO (2015). However, unlike in the WHO manual, the parameters in our study were decided based on the perceptions of the farmers and consumers; not on the research team's understanding of health risks (see Table 3).

We classified wastewater farmers in to two broad exposure groups:

F1: Farmers who directly handle wastewater but do not consume the produce cultivated with it;

F2: Farmers who directly handle wastewater and are also consumers of wastewater produce.

Some farmers completely rejected the possibility of any negative health consequences of handling wastewater or consuming crops grown with wastewater. F1 farmers in Ichalkaranji, Aurangabad, Nagpur and Pune perceived only moderate health risks associated with wastewater use (risk scores between 8 and 10). As the Purandar Lift Irrigation scheme in Pune is relatively new, farmers were unable to attribute any health problems to the use of wastewater. In the *Sade Satra* Scheme, dilution of untreated wastewater with treated water has reduced the health risk of farmers considerably. Further, preventive measures such as the use of long boots while entering farms could explain the absence of health problems. On the other hand, F1 farmers in Jalgaon perceived high health risks owing to skin problems associated with wastewater use (risk score R = 20).

Category F2 farmers irrigate with wastewater and also consume wastewater irrigated produce; their perceived health risks are understandably higher than F1 farmers. All sample farmers in Sangli, Miraj, Kolhapur and Aurangabad cultivated only sugarcane and Jowar as fodder crops. So they did not consume the wastewater irrigated produce and hence fall in F1 category. Farmers reported they had skin rashes due to exposure to wastewater; these farmers are classified under “medium risk”. Only one farmer from Ichalkaranji cultivated groundnut and consumed the produce. The farmer reported that there was taste difference and that he had stomach ache. F2 farmers in Dhule cultivated vegetables with wastewater (and also consumed the produce themselves) reported a risk score of 32, the highest among all study locations. Farmers here associated the occurrence of kidney stone with the use of wastewater.

3.4 Control Measures adopted by Farmers

We found farmers adapting to wastewater irrigation through various irrigation management practices and control measures. Farmers taking water from the *Sade Satra* scheme in Pune initiated the use of boots for their farm workers; this saves their feet from direct contact

Table 2: Economics of wastewater and freshwater irrigation in Maharashtra

Crop	Market Price‡ (₹ per ton)	WASTEWATER IRRIGATION								FRESHWATER IRRIGATION							
		Yield‡ (tons/ha)	Gross Revenue¥ (₹ per ha)	Cash Expenses‡ (₹ per ha)					Cash Profit¥ (₹ per ha)	Yield‡ (tons/ha)	Gross Revenue¥ (₹ per ha)	Cash Expenses‡ (per ha)					Cash Profit¥ (₹ per ha)
				Labor	Energy	Fertilizer	Pesticide	TOTAL				Labor	Energy	Fertilizer	Pesticide	TOTAL	
Radish	5,000	10.00	50,000	15,000	3,500	1,750	5,000	31,250	18,750	7.50	37,500	10,500	5,000	2,150	4,250	27,900	9,600
Marigold	12,000	19.50	234,000	25,000	6,800	13,750	11,250	159,800	74,200	17.40	208,800	19,750	8,000	17,500	8,250	156,500	52,300
Jowar	16,200	1.00	16,200	N.A.	N.A.	N.A.	N.A.	8,200	8,000	0.80	12,960	N.A.	N.A.	N.A.	N.A.	8,400	4,560
Green Gram (Moong)	42,000	0.75	31,500	N.A.	N.A.	N.A.	N.A.	15,100	16,400	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Ground Nut	45,000	1.40	63,000	N.A.	N.A.	N.A.	N.A.	27,000	36,000	1.20	54,000	N.A.	N.A.	N.A.	N.A.	26,500	27,500
Cotton	112,500	1.80	197,438	N.A.	N.A.	N.A.	N.A.	92,600	104,838	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Bengal Gram (Chana)	75,000	1.30	93,750	N.A.	N.A.	N.A.	N.A.	16,500	77,250	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Spinach	10,000	8.00	80,000	12,500	4,000	1,750	9,750	32,250	47,750	4.00	40,000	8,750	5,000	3,200	7,500	28,700	11,300
Wheat	22,000	2.00	44,000	8,750	1,750	7,000	3,400	28,100	15,900	1.60	35,200	7,300	2,500	10,000	2,500	29,500	5,700
Sugarcane (Fodder)	2,000	52.50	105,000	3,600	18,000	3,000	32,500	65,500	39,500	46.50	93,000	30,000	4,500	25,600	2,000	70,500	22,500
Corn / Jowar (Fodder)	10,000	10.00	100,000	11,450	3,950	1,000	3,300	26,500	73,500	6.00	60,000	12,000	2,700	3,600	2,700	27,800	32,200
Sugarcane	2,000	125.00	250,000	32,500	3,000	18,000	30,500	93,300	156,700	112.00	224,000	30,000	4,500	26,600	2,000	72,400	151,600
Tomato	6,000	24.80	148,800	N.A.	N.A.	N.A.	N.A.	104,400	44,400	24.00	144,000	N.A.	N.A.	N.A.	N.A.	109,900	34,100
Onion	12,000	15.00	180,000	N.A.	N.A.	N.A.	N.A.	112,600	67,400	12.00	144,000	N.A.	N.A.	N.A.	N.A.	97,700	46,300
Cauliflower	9,000	30.00	270,000	25,000	3,800	1,500	21,000	63,800	206,200	18.00	162,000	22,000	8,000	9,000	15,000	66,500	95,500

Data Sources: Field Study 2015; Sakhare *et al.* (2016); and Ramola (2016)
N.D.: No data (these crops were not grown by freshwater farmers); N.A.: Data not available
Notes: ‡: Values represent average numbers for the crop in the study area;
¥: Values represent summations of the crop in the study area.

Table 3: Perception based Health Risk Assessment*

Location	Exposure group (Sample size)	Exposure route	Event	Farmers and consumers perception of health risk			Score	Risk Category	Total Risk Score
				Health issues perceived	Occurrence of disease	Level of treatment required			
Ichalkaranji	F1 (5)	Skin penetration	Skin exposure	Skin rashes	None; unlikely in future	Minor health effects; no medication required	4 x 2 = 8	Medium	R = 8 [MEDIUM RISK]
	F2 (10)	Skin penetration	Skin exposure	Skin rashes	Yes; may occur in future	Minor health effects; no medication required	4 x 2 = 8	Medium	R = 8+3 = 11 [MEDIUM RISK]
		Ingestion	Consumption of contaminated produce	None reported	None; may occur in future	None or negligible health effects	3 x 1 = 3	Low	
Aurangabad	F1 (9)	Skin penetration	Skin exposure	Skin rashes	Yes; may occur in future	Minor health effects; no medication required	4 x 2 = 8	Medium	R = 8 [MEDIUM RISK]
Dhule	F2 (12)	Ingestion	Consumption of contaminated produce	Occurrence of kidney stone	Yes; may occur in future	Acute disease; long-term medication reqd.	4 x 8 = 32	High	R = 32 [HIGH RISK]
Nagpur	F1 (17)	Skin penetration	Skin exposure	Skin rashes	Yes; may occur in future	Minor health effects; no medication required	4 x 2 = 8	Medium	R = 8 [MEDIUM RISK]
Pune/ Purandar LIS	F1 (7)	Skin penetration	Skin exposure	Burning on palms and soles	Yes; certain to re-occur in future	Temporary symptom; no medication required	5 x 2= 10	Medium	R = 10 [MEDIUM RISK]
	F2 (7)	Skin penetration	Skin exposure	Burning on palms and soles	Yes; almost certain to re-occur in future	Temporary symptom; no medication required	5 x 2 = 10	Medium	R = 10+2 = 12 [HIGH RISK]
		Ingestion	Consumption of contaminated produce	None reported	None; unlikely in future	None or negligible health effects	2 x 1 = 2	Low	
Jalgaon	F1 (3)	Skin penetration	Skin exposure	Skin irritation	Yes; certain to re-occur in future	Short-term ailment; some medication reqd.	5 x 4 = 20	High	R = 20 [HIGH RISK]
	F2 (3)	Skin penetration	Skin exposure	Skin irritation	Yes; certain to re-occur in future	Short-term ailment; some medication reqd.	5 x 4 = 20	High	R = 20+2 = 22 [HIGH RISK]
		Ingestion	Consumption of contaminated produce	None reported	None; may occur in future	None or negligible health effects	2 x 1 = 2	Low	

Data Source: Field Study 2015; Sakhare *et al.* (2016); and Ramola (2016)
* The semi-quantitative framework for Health Risk Assessment is an adaptation of the one used in WHO (2015)

with wastewater and none of the farmers in the area reported any skin irritation / itching problem. Some farmers in the same system reported that vegetables grown with wastewater tend to rot faster and therefore they decided not to use wastewater for irrigating vegetable crops. Diluting one-part wastewater with three parts freshwater was another common practice in the *Sade Satra* scheme as well as among cotton farmers in Jalgaon. In Purandar LI scheme, drip irrigation is extensively used with wastewater; this is done to conserve the expensive wastewater but also to minimize direct contact. Further, water is stored in a farm well before it is applied to the crops. This serves two purposes: one, the well serves as a storage tank to ensure sufficient supply; two, it allows the sludge to settle down. Some enterprising farmers also breed fish and turtle in their wells to reduce the scum in the wastewater. Farmers also believe that the quality of wastewater improves as it travels over long distances through natural cleansing by the soil.

4. Conclusion

The key findings from this study can be summarized as below:

1. The key drivers for expansion of wastewater irrigated area across our study locations were: [a] round-the-year availability of wastewater; [b] nutrient content of wastewater; and [c] lower pumping cost of wastewater vis-à-vis groundwater.
2. While farmers in cities like Sangli and Dhule used 100 per cent untreated wastewater, others used a mix of treated and untreated wastewater. We did not find any direct correlation between extent of treatment and the extent of use of wastewater in agriculture. The non-availability of freshwater was the primary driver.
3. The cropping pattern in all study villages exhibits the farmers' tendency to maximize cropping intensity with year-round availability of wastewater.
4. In several villages, wastewater is used to irrigate vegetables, especially green leafy vegetables. In Sangli, Miraj, Ichalkaranji, Aurangabad, Kolhapur, Nashik and Dhule, fodder crops and sugarcane were cultivated using wastewater. Fruit, bulb and vegetable seeds like tomato, onion and chillies are wastewater irrigated only in Pune.
5. Wastewater irrigated vegetables were routinely consumed by farmers in Dhule and Pune. Farmers in Dhule perceived higher health risks as they use 100 per cent untreated wastewater while up to 70 per cent of the wastewater used in Pune was treated.
6. No protection measures were adopted by farmers in the study location except in Pune where wastewater irrigating farmers used long boots to prevent direct skin contact.
7. Farmers using wastewater are either not aware of the health risks associated with wastewater use or did not perceive them to be significant. According to farmers, they have never received complaints about the quality of produce from consumers. Direct exposure-linked health risks were perceived more commonly then consumption-linked health risks.
8. Decline in soil fertility was attributed to repeated wastewater use by farmers in peri-urban Jalgaon and Pune.

The biggest challenge in wastewater reuse in agriculture may arise due to its potential health impacts. These can be mitigated if enough attention is paid to basic, cost-effective wastewater treatment, education of farmers and adoption of simple safety measures at the farm. Productive use of wastewater in agriculture can be sustainable if key economic actors – municipal authorities and farmers – work together to fulfil each other's needs. This would strengthen wastewater dependent agriculture and prevent the degradation of land and water resources attributable to incessant disposal of untreated wastewater.

In Maharashtra, wastewater irrigation has been practiced for many years. It seems to be the most cost-effective way for cities to dispose-off their ever growing wastewater. It can also become a source of revenue for the ULBs as is being done in some parts of Gujarat.; while farm level control measures being practiced in Maharashtra may be emulated by Gujarat. For farmers, especially in water-scarce areas, adoption of basic wastewater treatment and simple safety measures can insure year-round, risk-free irrigation access with the added opportunity of harvesting its rich nutrient content. This would require careful co-management of nutrient and water cycles.

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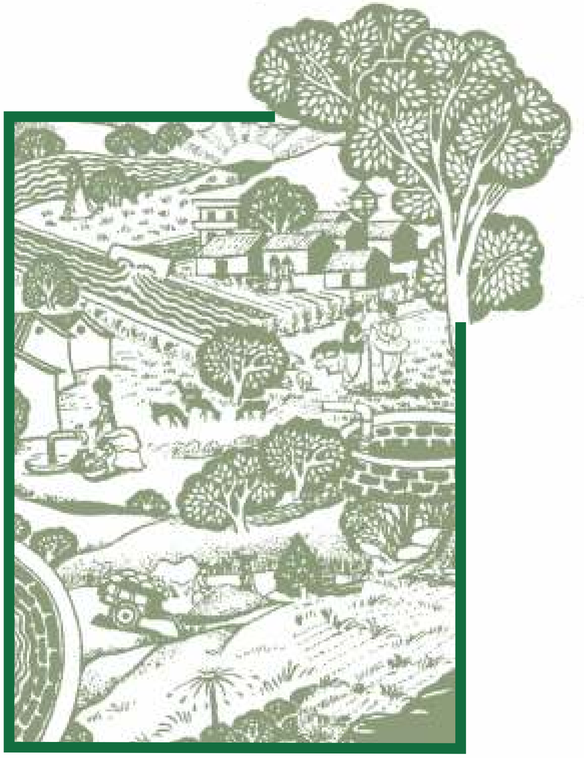

About the IWMI-Tata Program and Water Policy Highlights

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.

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