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For long, the rights over canal water have been determined by topography. Lower areas on one side of a contour canal become natural command areas, while up-lying areas on the other side end up as 'non-command'. Over time, however, the so called 'non-command' farmers have increasingly asserted their rights over canal water using siphons, pumps and pipes. This puts paid to original design parameters and a few years after their commissioning, canal commands get reconfigured. This raises many questions about the design and management of canal irrigation systems. The most important question it raises, however, is 'whose water is it anyway'?

This Highlight explores this dynamic of rivalry between command and 'non-command' irrigators in the context of Guhai irrigation system of North Gujarat. The rise of lift irrigation may violate original design assumptions and infringe on the water rights of command area farmers, but it may lead to higher water productivity and bigger Gross Canal Product. The Highlight also shows Guhai to be an excellent example of conjunctive use of surface and groundwater, but by default more than by design.

IWMI-TATA
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HIGHLIGHT

Whose Water Is It Anyway?

Evolving Rights Over Canal Water - The Case of Guhai Irrigation System in Gujarat

Meghna Brahmachari and Seema Dave

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Whose Water Is It Anyway?

Evolving Rights Over Canal Water - The Case of Guhai Irrigation System In Gujarat[1]

Research highlight based on a paper with the same title[2]

Introduction

In irrigation systems across the country, canal water is being lifted by pumps and transported via pipelines to irrigate land inside and outside the designed command area of irrigation systems (INPIM 2007). While considered theft in most areas, the phenomenon has been helped by the lowering cost of diesel pump sets (Shah et al. 2011). In some cases, the lifting of water from canal systems has been legalised and facilitated by the state (Fawaz and Rai 2010)[3]. However, recent media reports suggest that lifting is increasingly becoming an area of concern - since water meant for drinking is being diverted by lift irrigators - leading to the deployment of mounted police along the canal.

The use of water from gravity flow irrigation systems to irrigate land outside canal command area is a sensitive issue. Some experts argue that farmers whose land falls within the command area have first right over canal water and lifting by non command farmers is unacceptable. Arguments in favour of water lifting by non command farmers contend that in contrast to gravity flow irrigators, lifters make a substantial amount of investment in pumps and pipelines to transport water and diesel in order to obtain canal water which motivates these farmers to maximize productivity and minimise wastage.

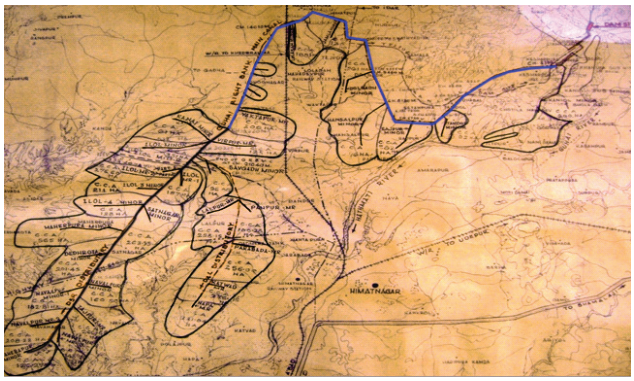
The Guhai system is interesting not just because of a significant presence of lift irrigators, but also since these lifters exist alongside flow irrigators organised into active water users' associations (WUAs). This study attempts to understand the impact of the presence of lift irrigators on water use patterns of different groups within the irrigation system and investments in irrigation by flow irrigators.

The Guhai irrigation system

The Guhai Irrigation system is located in Himmatnagar Block of Sabarkantha district in Gujarat. Currently, there exist 29 flow irrigator WUAs in the system covering the entire Irrigable Command Area of 7111 ha (DSC Records). The 29 WUAs have also come together to form a Federation. However, the Gujarat Participatory Irrigation Management Act 2007 does not recognise a Federation of WUAs. As a result, the role of the Federation is primarily to provide a platform for interaction between the different WUAs. The Development Support Centre, an NGO based in Ahmedabad, has been actively involved in the formation of WUAs in the Guhai Irrigation system - starting with the first one in the Parabda minor of the distributary D4L in 1997.

The structure of the Guhai irrigation system (Figure 1) is such that along the main canal, gravity flow irrigation can only be provided on the left bank. This implies that, in certain areas a farmer on the right bank is outside the command area even though his/ her land might be adjacent to the main canal. It is largely these right-bank

Figure 1 Spread of Guhai irrigation system



[1]This IWMI-Tata Highlight is based on research carried out with support from the International Water Management Institute (IWMI), Colombo and Development Support Centre, Ahmedabad. It is not externally peer-reviewed and the views expressed are of the authors alone and not of IWMI or its funding partners.

[2]This paper is available on request from p.reghu@cgiar.org

[3]Surendranagar district of Gujarat - Saurashtra Branch canal

Table 1 Area irrigated by gravity-flow and lift irrigation

Year	Water released into main canal (mcft)[4]	Flow Irrigated Area (ha)	Lift Irrigated Area (ha)	Total Irrigated Area (ha)	Lift irrigated area as a percent of total irrigated area (percent)
2005-06	548.36	3436	632	4068	16
2006-07	862	3192	527	3719	14
2007-08	721.03	3024	623	3647	17
2008-09	440	2299	670	2969	23
2009-10	459	2638	894	3532	25

Source: Irrigation Department, Himmatnagar.

farmers that have taken to lifting water mostly using diesel pumps. There are 296 licensed lift irrigators operating in the system (Irrigation Department Records). However, flow irrigators believe that the actual number might be closer to 400.

From the Irrigation Department, data was obtained for the area irrigated through flow and lift irrigation in the last five years (Table 1). Although the area irrigated via lift is much less than the area irrigated through gravity flow, over time the lift irrigated area has not only been increasing in absolute terms but also as a percentage of total area irrigated.

Methodology

To understand the functioning of a canal system with a significant presence of lift irrigators, a survey of lift and flow irrigators was conducted. The canal system was divided into ten segments on the basis of data on the command area and number of within-command farmers in the main canal and two distributaries. Approximately 10 within-command flow irrigators were surveyed from each segment to obtain a perspective on the head, middle and tail reaches of the system. A higher proportion of lift irrigators were sampled from the main canal than the two distributaries given their larger presence in these areas arising due to the structure of the system. The total number of farmers sampled in different categories is provided in Table 2.

Table 2 Sampling plan

	Number of farmers sampled			
	Main canal	Distributary D5R	Distributary D4L	Total
Flow irrigators	30	45	24	99
Lift irrigators	20	5	3	28

In addition to the survey, discussions were held with the Chairman of the Federation of flow irrigator WUAs and Committee Members of WUAs. Discussions were also held with the Chairman of the Vaktapur Lift Irrigation Cooperative.

Key results from the survey

The purpose of the survey was to understand the water use patterns of lift and flow irrigators and any divergence that would arise in this respect due to differences in how the two groups access canal water.

1. Cropping pattern

Castor, cotton and wheat are the main crops grown in the Guhai system and cover a substantial proportion of total area irrigated for both the lift and flow irrigators. While the percentage of area under cotton and wheat is similar for both groups, the percentage of area under castor is 62 percent higher for lift irrigators (Table 3). Castor requires more water and a higher rate of cultivation could be indicative of lift irrigators having a greater physical access to canal water. Most lift irrigators' pumps are situated on the main canal and they can irrigate whenever there is water in the main canal. On the other hand, flow irrigators have to wait until the water reaches the minor. Lift irrigation licences stipulate that the pumps can operate only 12 hours at night on designated days. However, the lifters surveyed admitted to operating pumps far longer than permitted. According to flow irrigator WUAs, in the time taken for tail end minors to receive three waterings,

[4]Water released in Rabi season of every year.

Table 3 Comparison of lift irrigators with head, middle and tail end gravity flow irrigators: cropping pattern

	Lift	Flow	Flow head	Flow middle	Flow tail
Total area covered (acres)	339.98	792.5	230.4	247.1	315
Total number of farmers	28.00	99	30	30	39
Total area under: acres (percentage of total)					
Castor	133.60 (39 percent)	191.1 (24 percent)	74.6 (32 percent)	73.3 (30 percent)	43.2 (14 percent)
Cotton	134.525 (40 percent)	350.6 (44 percent)	95 (41 percent)	111.5 (45 percent)	144.1 (46 percent)
Wheat	132.60 (39 percent)	325 (41 percent)	117.6 (51 percent)	122.5 (50 percent)	84.9 (27 percent)

lifters can irrigate their land five times.

Among the flow irrigators the percentage of total land under different crops changes from the head to the tail end of the system. For instance, among flow irrigators castor was cultivated on 32 percent of net irrigated area in the head end and only on 14 percent of net irrigated area in the tail end. Wheat covers 51 percent of net irrigated area by gravity flow in the head end and only 27 percent in the tail end of the system. For flow irrigators, the percentage of area under cotton increases slightly as we move from the head to the tail reaches of the system. Head end flow irrigators are *a priori* expected to receive more canal water than those in the tail end. The higher proportion of castor, a crop with high water requirement, in the head end supports this expectation. In the choice between cotton and wheat, both of which have lower water requirement than castor, flow irrigators in the tail end, with uncertain canal water supply, prefer to cultivate more cotton than wheat - possibly due to higher returns per quintal produced or due to the different sowing seasons of the two crops.

2. Proportion of canal water used in irrigation

Lift and flow irrigators were also compared in terms of the proportion of canal water used in total irrigation. Figure 2 provides data on the percentage of canal water used in total irrigation across different categories of farmers - lift irrigators, all flow irrigators, and head, middle and tail end flow irrigators. A 100 percent stacked column has been used to represent the data. The blue area represents the proportion of farmers using canal water to meet 0-25 percent of their irrigation requirement. The purple area represents the proportion of farmers meeting 75-100 percent of their irrigation requirements through canal water.

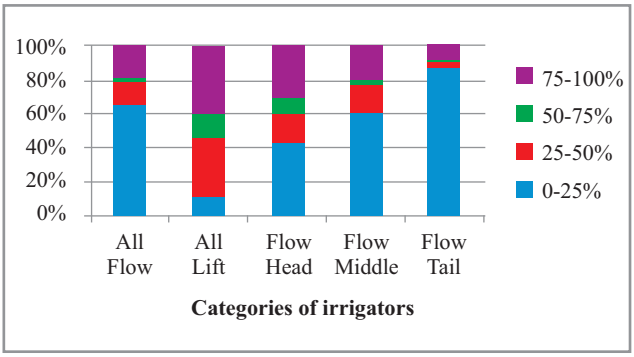
For flow irrigators as a whole, 66 percent farmers meet less than 25 percent of their irrigation needs through canal water. From the head to the tail end of the system, the percentage of flow irrigators sampled meeting less than 25 percent of their total irrigation through canal water increases and the percentage of those using canal water to meet more than 75 percent of total irrigation decreases.

[5]The calculation of percentage of canal water used in irrigation is illustrated below:

Farmer A	Total Land: 5 acres	Source: No. of irrigations		Percentage of canal water use	Calculation
Castor	2 acres	Well: 3	Canal: 3	50 percent	{(2 x 50 percent)+ (1 x 0 percent)+ (0 x 0 percent) +(5 x 100 percent)}/ (2+1+5)
Cotton	1 acre	Well: 5		0 percent	
Jowar	2 acres	Rainfed		0 percent	
Wheat	5 acres		Canal: 5	100 percent	
		Percentage of canal water used by farmer A			75 percent

The above calculation was done for each farmer and used in the graph in figure 1.

Figure 2 Percentage of canal water used in irrigation across different categories of farmers.



Further, 7 percent of the head end and 23 percent of middle flow irrigators meet their irrigation requirements entirely through groundwater. In the tail end of the system, while about 38 percent of command area flow irrigators use only groundwater, as much as 20 percent are solely rainfed resulting in only 42 percent of tail end farmers using canal water to any extent[6].

It is important to note that, in the case of lift irrigators, the sampling method itself eliminated the possibility of having lift irrigators who did not access canal water. Nevertheless, some interesting results emerged with respect to the patterns of water use. Among lift irrigators only 10 percent meet less than a quarter of their irrigation needs through canal water. As much as 39 percent of the lift irrigators sampled use canal water to meet more than 75 percent of their irrigation requirement. However, it is interesting to note that for 46 percent of the lift irrigators sampled, canal water constitutes less than half of total irrigation water use. This could be due to the distance from the canal to the field. The average distance from the canal to the field for all lift irrigators sampled is 2746 feet. However, among the lifters using canal water to meet less than half of their irrigation requirement, the average distance increases to 3637 feet. The lower use of canal water in irrigation for these farmers could be due to the large distances over which water has to be transported.

In the system as a whole, canal water comprises a smaller part of total irrigation for flow irrigators than for lifters and moving from head to tail, more and more groundwater is used in irrigation. While deprivation of tail end irrigators due to the presence of lifters could be expected, head end flow irrigators are expected to have as much access to canal water as lift irrigators. However, this does not seem to be the case. When compared to the lift irrigators, canal water forms a smaller part of the total irrigation even among head end flow irrigators. A contributing factor to this could be that flow irrigators are organised into WUAs which together constitute a system wide federation. WUA members must abide by the rotation schedules agreed upon by the federation while independent lift irrigators have no such institutional restrictions imposed upon their use of canal water.

3. Expenditure on irrigation

Differences in the nature of access to canal water by farmers across categories manifests in the data on irrigation expenditure. While lift irrigators might have higher physical access to canal water than flow irrigators, their investment in canal irrigation is also much higher. The only investment that gravity flow irrigators need to make is to pay the irrigation fees levied by the WUAs[7]. On the other hand, in order to irrigate with canal water lifters pay the water charges of the Irrigation Department and also invest in pumps, diesel and pipelines to transport water from the canal to the fields. As seen in Table 4, per acre expenditure on canal irrigation is Rs. 2275 for the lift irrigators surveyed, more than ten times higher than that

Table 4 Comparison of lift irrigators with head, middle and tail end gravity flow irrigators: expenditure on irrigation

	Lift	Flow	Flow head	Flow middle	Flow tail
Per acre expenditure: (Rs./acre)					
Canal irrigation	2274.24	203.85	357.06	220.76	78.53
Canal + purchased	2278.66	424.46	693.68	405.27	242.59
Groundwater	1061.74	2010.17	1149.74	1177.74	3292.50
Total expenditure	3340.40	2434.62	1843.42	1583.01	3535.09

[6]The criterion for sampling flow irrigators was their inclusion in the command area of the system. Thus, farmers who were in the command area but did not receive any canal water were also interviewed.

[7]This fee is levied in terms of Rs./ha/watering.

Table 5 Yield (q/acre) of castor, cotton and wheat across farmer categories

	Lift	Flow	Flow head	Flow middle	Flow tail
Castor	9.83	9.46	9.60	9.56	9.06
Cotton	6.28	7.70	8.41	8.90	6.32
Wheat	13.79	11.34	8.27	12.87	13.40

of flow irrigators[8]. On the other hand, the expenditure on groundwater of the lifters is only half that of the flow irrigators. Flow irrigators were found to spend an average of Rs. 2010 on ground water, ten times their expenditure on canal water.

While the total per acre expenditure on irrigation is much higher for lift irrigators than it is for flow irrigators as a whole, tail end flow irrigators on average spend slightly more on irrigation per acre than the lifters. While head end farmers' demand for canal water is usually met, flow irrigators in the tail reaches have a lower access to canal water which has led to increased groundwater use. Part of this deprivation is that which is endemic to the tail end of any irrigation system and part of it is due to the presence of almost 300 registered lift irrigators on the main canal and two distributaries. The heavy dependence on groundwater has led to a lower water table in the tail end compared to the rest of the system, in turn making groundwater irrigation more expensive.

4. Agricultural productivity

Lift irrigators invest a lot more to access canal water than flow irrigators. Moreover, it isn't only a one time fixed investment. Through their expenditure on diesel, lift irrigators undertake a significant investment per cubic meter of canal water used. Thus lifters have strong incentives to ensure minimum wastage of canal water which could in turn lead to a higher level of water productivity. It would be very interesting to observe the effects that the magnitude and nature of investment in irrigation would have on water productivity (yield per unit of water used) across different categories of farmers.

However, it is outside the scope of this paper to obtain any robust estimate of water productivity of lift and flow irrigators. The yield (q/acre) for castor, cotton and wheat for flow and lift irrigators has been provided in Table 5. Other than availability of canal water, a variety of factors such as quality of land, agricultural methods and access to groundwater, contribute to the determination of yield. Yield per acre cannot be used as a proxy for yield per unit water. The survey results indicate that the yield per acre of lift irrigators is found to be marginally higher than that of flow irrigators for castor and wheat, and lower in the case of cotton. Thus while *a priori* it can be expected that lift irrigators will have a higher yield per unit water, given their incentives, the same does not apply for yield per acre as several different factors could be affecting this.

The yield per acre for wheat of tail end flow irrigators is 62 percent higher than that of head end flow irrigators. This is an interesting phenomenon as it is typically expected that the yield per acre would decline on moving from the head to the tail end of the system. A possible explanation for this result could be that tail end flow irrigators invest in and use more groundwater than canal water to meet their irrigation requirements. This higher usage of groundwater due to deprivation of canal water has increased the cost of irrigation it might have also resulted in greater water control for tail end farmers, possibly contributing to productivity. However, in order to be able to draw decisive conclusions on the basis of yield data, it is necessary to undertake a more comprehensive survey of agricultural practices. Drawing conclusions from a survey that primarily focuses on water use patterns

The Vaktapur Lift Irrigation Cooperative

While a majority of lift irrigators in the Guhai system operate independently, 115 of the registered lift irrigators are members of the Vaktapur Lift Irrigation Cooperative which covers 243 ha of land and accounts for 54 machines on the canal system. The cooperative was formed in 2008 in order to protect the rights of lift irrigators to operate their pumps as permitted by the Irrigation Department. The members of the cooperative are subject to restrictions to ensure compliance with official lifting regulations. According to the Chairman, none of the members have an underground pipeline longer than 5000 feet and they do not engage in the illegal sale of canal water. While this cooperative constitutes a significant proportion of the lift irrigators in the Guhai system, it is not an easily replicable achievement. It is difficult to control canal water use by individual lift irrigators as there are no clear incentives for them to restrict use in the current scenario.

[8]In calculating the per acre expenditure on canal irrigation for lifters, the operations and maintenance cost of the pumps and pipelines and the fees levied by the irrigation department were taken into account. Many of the lifters interviewed were unable to provide details of the total expenditure on diesel for running the pumps. Wherever this information was obtained, it has been included in the estimate. Thus, if diesel expenditure information were to be obtained for all lift irrigators, the per acre expenditure on canal water would be far higher than the current figure.

would be misleading as yield results would be interpreted solely on the basis of irrigation input.

5. Water markets

The presence of lift irrigators in the canal system has significantly contributed to the emergence of water markets in the command area of the Guhai system. While the nature of groundwater markets alter from the head to the tail end of the system, the rate charged for purchased water remains more or less the same, around Rs. 50-60 per hour of pumping from mostly electric pump sets.[9] The average depth to water increases as we move from the head to the tail end of the system - from about 70 feet in the head end to 315 feet in the tail end of the system.

Although the sample size of the survey is not adequate to draw conclusions about the scale of groundwater markets in the system, learnings from the survey provide an insight into how the contribution of purchased water to overall water use in irrigation varies from head to tail of the system.

In moving from the head to the tail end of the irrigation system, the groundwater market evolves from one that provides supplementary irrigation to one in which farmers meet a majority of their irrigation requirements through purchased groundwater.

The data on irrigation expenditure provided above clearly indicates that canal water use through lift is much more expensive than flow irrigation. However, this does not imply that only well off farmers engage in lifting. Several instances were found where farmers devised innovative arrangements for lift irrigation. While survey results indicate that groundwater markets are not widespread among lifters, 21 percent of the lift irrigators sampled engaged in the sale and purchase of canal water. Purchased canal water is transported to buyers' fields via the underground pipelines owned by the sellers. However, the hesitance of lift irrigators surveyed to provide details of the amount of canal water sold and discussions with flow irrigator WUAs indicate that lift irrigators might be pumping more canal water than permitted. In fact, flow irrigator WUAs believe that lifters steadily extend the underground pipelines causing far more non command area to be irrigated by canal water than is currently estimated by the irrigation department. Such claims are hard to verify. However, discussions with both lift and flow irrigators brought to light some of the arrangements that exist among lifters with regard to canal water use:

1. **Joint ownership:** Six to ten farmers would split the initial costs and the operation and management costs of the pump and pipeline. The expenditure on diesel is borne by farmers according to their individual usage.
2. **Sharecropping:** Cases were observed where a lift irrigator would take over the production responsibilities of the land under which his pipeline would pass and the land owner is paid with either a share of the produce or given monetary compensation.
3. **Water sellers:** Lifters sell water to those farmers under whose fields their pipelines would pass. In some cases sellers submit demand for water to the irrigation department taking into account the water that they sell to others and accordingly pay the irrigation department for the same. In other cases, farmers sell canal water to others without submitting demands or paying the irrigation department for the water that is sold.

CONCLUSION

The case of the Guhai system is interesting because on the one hand there exist actively functioning gravity flow irrigator WUAs and on the other hand, there is an increasing presence of lift irrigators. As a result, conflicts between flow irrigators and lifters over canal water use have escalated. As illustrated by the data provided above, it is evident that at a system level, canal water forms a larger part of total irrigation for lifters than for flow irrigators albeit at a higher cost.

An interesting point that emerged from the discussions with flow and lift irrigators was the manner in which different groups determined rights over canal water. According to flow irrigators only those whose land falls within the designed command area of the project, where water can reach through gravity flow, have a right over canal water. Within this definition, lift irrigators outside of the command area have been illegally accessing canal water. Discussions with the chairperson of the lift irrigation co-operative revealed an even more nuanced definition of rights over canal water - in villages where only some farmers' lands fall within the command area, residents whose land is outside the command areas have a right to lift water. Lift irrigators whose villages are entirely outside the designed command should not be given permission to lift water.

These varied definitions lead to an important question that the paper attempts to raise. All the stakeholders involved recognise that there are limits to how much land can be

[9]In two cases in the tail end of the system, the rates charged were Rs. 100 per hour of pumping. The seller's pumps were 30 HP and 20 HP.

served by the canal system. However, strict definitions of command and non command are not only difficult to enforce but also envision. It is unreasonable to expect that a farmer outside of the command area but adjacent to the canal system will refrain from trying to access canal water.

In light of the inevitable presence of lift irrigators, it is important to critically re-evaluate the manner in which rights over a canal system are defined. Expanding the criteria of those eligible to access canal water to include farmers outside the command area also raises the question of what limits to set on this expanded definition.

In defining rights over canal water, an objective that can be kept in mind is to spread canal water over as large an area as is efficient while simultaneously promoting effective conjunctive use of surface and ground water wherever feasible. The survey results show that as we move from the head to the tail end of the system, flow irrigators use more and more groundwater to meet their irrigation requirements. Further, in the course of the survey, a few cases of water logging were found in the head end of the system. Promoting groundwater use in the head end would help to spread the same amount of canal water over a larger surface area.

The survey results also indicate that the dependence of lift irrigators on canal water decreases as distance from the canal increases. Additionally, flow irrigators' per acre expenditure on irrigation increases as we move towards the tail end of the system. In fact, the results of the survey show that per acre expenditure on irrigation is higher for tail end flow irrigators than that of lift irrigators. Thus the system has naturally evolved towards an equalisation of the kind of expenditure made by different categories of farmers.

In the case of Guhai, the implementation of Participatory Irrigation Management has been very successful among flow irrigators. However, it operates on the concept that command area flow irrigators have first right over canal water. Changing and expanding the definition of rights over canal water use will in turn lead to an alteration in the kind of institutional arrangements that are considered desirable.

Even though it is not officially recognised by the PIM Act of Gujarat, among the flow irrigators, the Federation has played a very important role in coordinating between WUAs and fixing rotation schedules. However, its functions are restricted to managing the distribution of canal water among flow irrigators. If the objective of the Federation is to spread canal water over as large an area as possible, then it is important to focus on the integrated management of surface and ground water. Of course, it is very difficult to regulate the use of groundwater by individual farmers. If the Federation were able to formally gather information regarding groundwater use in different parts of the system, then this would be an extremely valuable input to the planning of canal water distribution.

An important component of Participatory Irrigation Management, whether or not it includes non-command farmers, is successful coordination among the various stakeholders in the irrigation system. It is in the interest of flow irrigator WUAs to recognise the rights of lifters on canal water and work with them towards a distribution of water that is mutually acceptable. However, in the current scenario, independent lift irrigators have a strong incentive to resist coordination efforts. The independent lift irrigators submit their demands to the Irrigation Department and are able to access water from the main canal. It is very difficult to monitor their water use. It is thus essential to devise mechanisms to motivate lift and flow irrigators to cooperate with each other. The informal but active Federation of WUAs functioning in the Guhai system can play a pivotal role in these efforts.

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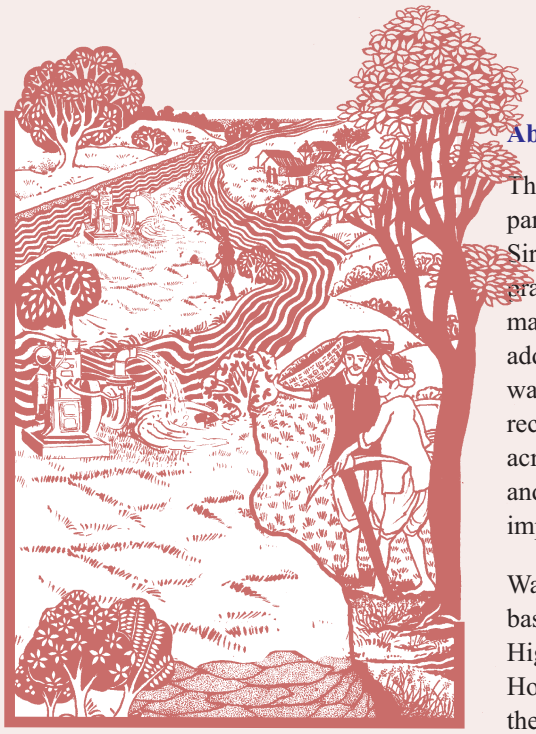

About the IWMI-Tata Program and Water Policy Highlights

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 IWMI, Colombo and SRTT, Mumbai. However, the Highlights are not externally peer-reviewed and the views expressed are of the author/s alone and not of ITP or either of its funding partners.

IWMI OFFICES

IWMI Headquarters and Regional Office for Asia
127 Sunil Mawatha, Pelawatte
Battaramulla, Sri Lanka
Tel: +94 11 2880000, 2784080
Fax: +94 11 2786854
Email: iwmi@cgiar.org
Website: www.iwmi.org

IWMI Offices

SOUTH ASIA
Hyderabad Office, India
C/o International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
401/5, Patancheru 502324, Andhra Pradesh, India
Tel: +91 40 30713735/36/39
Fax: +91 40 30713074/30713075
Email: p.amerasinghe@cgiar.org

New Delhi Office, India
2nd Floor, CG Block C, NASC Complex
DPS Marg, Pusa, New Delhi 110 012, India
Tel: +91 11 25840811/2, 65976151
Fax: +91 11 25842075
Email: iwmi-delhi@cgiar.org

Lahore Office, Pakistan
12KM Multan Road, Chowk Thokar Niaz Baig
Lahore 53700, Pakistan
Tel: +92 42 35299504-6
Fax: +92 42 35299508
Email: iwmi-pak@cgiar.org

SOUTHEAST ASIA
Southeast Asia Office
C/o National Agriculture and Forestry Research Institute (NAFRI)
Ban Nongviengkham,
Xaythany District,
Vientiane, Lao PDR
Tel: + 856 21 740928/771520/771438/740632-33
Fax: + 856 21 770076
Email: m.mccartney@cgiar.org

CENTRAL ASIA
Central Asia Office
C/o PFU CGIAR/ICARDA-CAC
Apartment No. 123, Building No. 6, Osiyo Street
Tashkent 100000, Uzbekistan
Tel: +998 71 237 04 45
Fax: +998 71 237 03 17
Email: m.junna@cgiar.org

AFRICA
Regional Office for Africa and West Africa Office
C/o CSIR Campus, Martin Odei Block,
Airport Residential Area
(Opposite Chinese Embassy), Accra, Ghana
Tel: +233 302 784753/4
Fax: +233 302 784752
Email: iwmi-ghana@cgiar.org

East Africa & Nile Basin Office
C/o ILRI-Ethiopia Campus
Bole Sub City, Kebele 12/13
Addis Ababa, Ethiopia
Tel: +251 11 6457222/3 or 6172000
Fax: +251 11 6464645
Email: iwmi-ethiopia@cgiar.org

Southern Africa Office
141 Cresswell Street, Weavind Park
Pretoria, South Africa
Tel: +27 12 845 9100
Fax: +27 86 512 4563
Email: iwmi-southern_africa@cgiar.org

IWMI SATELLITE OFFICES
Kathmandu Office, Nepal
Jhamsikhel 3, Lalitpur, Nepal
Tel: +977-1-5542306/5535252
Fax: +977 1 5535743
Email: l.bharati@cgiar.org

Ouagadougou Office, Burkina Faso
S/c Université de Ouagadougou Foundation
2iE 01 BP 594 Ouagadougou, Burkina Faso
Tel: +226 50 492 800
Email: b.barry@cgiar.org

IWMI-Tata Water Policy Program
c/o INREM Foundation
Near Smruti Apartment, Behind IRMA
Mangalpura, Anand 388001, Gujarat, India
Tel/Fax: +91 2692 263816/817
Email: iwmi-tata@cgiar.org

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