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Note from the Editor

Dear Reader,

This is the first volume of South Asian Water Studies (SAWAS) since I took over the charge of the journal in November 2014. I was one of the fortunate members of the team when SAWAS was conceptualized at a tiny office in southern Indian city of Hyderabad in 2009. Since then, Prof Vishwa Ballabh of Xaviour Labour Relations Institute (XLRI), Jamshedpur, India has been the chief editor of this open access journal. After the term of Prof Ballabh expired, I had taken over as the chief editor and this is the first volume we are presenting to our readers. With this note, I want to thank Dr. Ballabh for his able leadership in editing this journal for first five years.

The present volume has three interesting papers on three different topics – micro irrigation systems, water privatization issues in India and food security issues in coastal Bangladesh. The paper by P.K. Viswanathan and Chandrasekhar Bahinipati titled - Exploring the Socio-Economic Impacts of Micro-Irrigation System (MIS): A Case Study of Public Tube wells in Gujarat, Western India, presents the results of a techno-economic analysis of the performance of 122 tube wells installed with pressure-induced irrigation network and micro-irrigation systems in nine sub-districts of Banaskantha district in western Indian state of Gujarat. The analysis demonstrates that farmers who had adopted the MIS under the state subsidy programme had been compensated for the investments they had made. By and large, farmers reported growing a range of crops especially during the kharif and rabi seasons. Most of these crops had been brought under the MIS. Even so, while their adoption of MIS has been quite impressive during these two seasons, the use of MIS for growing summer crops was found to be much lower and highly restricted to a few crops. This was reported mainly due to the shortage of groundwater. The paper highlights that the limited adoption of MIS among farmers belonging to socially backward communities is a matter of concern that needs to be addressed by implementing specifically targeted MIS programmes for communities lower in socio-economic hierarchies.

Gregory Pierce's paper - The Late Embrace of Urban Water-Service Privatization in India: A Political Economy Explanation, explores the Political and economic reforms in India that made private sector participation (PSP) in urban water delivery a viable strategy for state and city policymakers. This move has been against the expectations of many scholars. The paper provides a comprehensive analysis of the development of temporal, geographic, and stakeholder variations in urban water PSP in India. Regression models are used to explore state-level correlates of PSP as well as variations in city-level contract features. Findings emphasize the role of political party ideology in implementation and the decreasing cost and length of initiatives. They also suggest the prospects for future private sector participation in India. The paper by Kibria Gulam et al titled - Achieving Food Security in Storm Surge-prone Coastal Polders of South-West Bangladesh documents the issue of food security from the south-west coastal region of Bangladesh which is highly vulnerable to various natural disasters. The area had experienced numerous cyclonic storms in the past. During the cyclone Aila in 2009, the embankments were breached and overtopped at many places, causing inundation and saline water intrusion, damaging agricultural land, and subsequently resulting in food insecurity. This paper is based on a study that was conducted to assess the impacts of Aila and the measures to achieve food security in Dacope upazila, Khulna district. Data were collected in 2014 from three visits to the study area and relevant organizations. The results showed that agriculture was the most affected sector along with distinct changes in land use pattern. The farmers found that cultivation of rice as well as non-rice crops such as sunflower, sesame, and watermelon was more profitable than single rice crop cultivation, previously practised. The FAO AquaCrop model simulation resulted also in an increased yield of dry-season crops in the future. This indicates that integrating the practice of cultivating both staple food and cash crops with improved water management will increase income, provide better accessibility to food, and serve as the way to attain food security in the long run.

At the end, an interesting perspective comes from Paula Hanasz titled Water into whine: Why deliberative governance of South Asia's rivers is little more than a talk shop? In a rather provocative commentary, Paula talks of deliberative governance of South Asia's transboundary waters. The region with its long history of political participation of citizen in governance and commitment to pluralistic democracy, consensus building on transboundary water governance is not proving right due to lack of institutional and multi-lateral governance structures. She calls for addressing power asymmetry and political will for solving the issue of transboundary water governance in South Asia. Lastly, the review of the book - Diverting the Flow: Gender Equity and Water in South Asia edited by Margreet Zwarteveen, Sara Ahmed, Suman Rimal Gautam is done by Vishal Narain. I am sure you would enjoy this volume. We look forward to your views on this.

Warm regards,

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Articles

Commentary

Book Review

Exploring the Socio-Economic Impacts of Micro-Irrigation System (MIS): A Case Study of Public Tube wells in Gujarat, Western India

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P.K. Viswanathan and Chandrasekhar Bahinipati

Abstract

This paper presents the results of a techno-economic analysis of the performance of 122 tube wells installed with pressure-induced irrigation network and micro-irrigation systems in nine talukas of Banaskantha district in Gujarat, western India. The results bring out significant economic and social benefits reported by the beneficiary farmers such as increase in crop yields during kharif, rabi, and summer seasons, considerable savings in energy consumption, reduction in – the use of chemical fertilizers and pesticides, the cost of weeding, groundwater over-extraction and water-scarcity induced labour migration. The analysis demonstrates that farmers who adopted the MIS under the state subsidy programme were compensated for the investments they had made in the MIS. Even so, while their adoption of MIS has been quite impressive during the two seasons, the use of MIS for growing summer crops was found to be much lower and highly restricted to a few crops. This was reported due to shortage of groundwater mainly.

Keywords: micro-irrigation systems, groundwater, MIS, Gujarat, India

Introduction

The trajectory of growth of India's irrigated agriculture demonstrates a major contradiction: on the one hand, there is over-development of groundwater resources stimulated by the proliferation of private tube wells, on the other, public investments by the states have vigorously favoured the development of surface (canal) irrigation systems.

It may be argued that the over-development of groundwater by agriculturally prosperous states such as Andhra Pradesh, Gujarat, Haryana, Punjab, and Maharashtra, has been triggered by a host of factors. These include ineffective surface-irrigation systems as much as populist state policies and financial incentives promulgating groundwater development. The result has been that the extent of groundwater use for agricultural purposes has far exceeded the net annual groundwater availability (NAGWA) in some states (like Haryana, Punjab and Rajasthan). Meanwhile, the stage of groundwater development (SGWD) has begun fast approaching critical limits (SGWD > 68%) in many regions and states, especially Gujarat, Karnataka, and Uttar Pradesh, as emerges from the estimates by the Central Ground water Board (CGWB) [GOI 2005].

According to the latest available data, the SGWD, computed as the ratio of groundwater draft to annual, utilizable groundwater resources, comes to about 58% for the country as a whole. This varies from below 5% in the north-eastern states to over 100% in Punjab (167%), Haryana, and Rajasthan (119% each).

The national report on groundwater resource assessment and irrigation potential in India clearly shows that Gujarat along with other states like Andhra Pradesh, Karnataka, Maharashtra, and Tamil Nadu is facing problems of groundwater over-exploitation (GOI 2005). For instance in Gujarat, the overall SGWD is around 76% with considerable inter-district variations. While three districts show groundwater over-exploitation (above 100% utilization of recharge), two districts fall in the dark category (85-100%), and six districts are in grey or semi-critical (65-85%) conditions.

Not only is the groundwater development scenario a matter of great concern, it is also critical to consider that the over-exploitation of groundwater resources has been contingent on the energisation of pump sets. These have caused a sharp rise in agricultural power consumption in states like Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, and Tamil Nadu.

In this grim scenario of groundwater development the potential of water saving technologies (WSTs) such as micro-irrigation systems (MIS) assume importance, especially in the groundwater over-exploited regions/states of India. Since water availability in river basins as well as groundwater aquifers is increasingly influenced by rainfall, it is important that demand-side management and not supply management should hold the key to future water management strategies in India. Realising the long-term potential of the WSTs, the Central Government as well as states have been promoting the adoption of micro-irrigation systems in the form of sprinkler and drip irrigation systems. These come under the National Mission on Micro-Irrigation (NMMI) and various other development plans and programmes such as the National Technology Mission on horticulture, the cotton development programme, and the oil palm development programme.

Taking a cue from international experiences, the strategies for promoting the MIS in India are built on the expectation, that WSTs, like sprinklers and drips, are enhancing the productivity of crops as also result in water saving. Thereby they are ensuring water-use efficiency (WUE) and an optimal allocation and use of scarce water resources. Results in this regard show that drip systems help achieve an on-farm irrigation efficiency of 90%, while sprinkler systems offer on-farm water efficiency of about 70% against just about 40% through conventional (flood/surface) irrigation methods (INCID 1994; Sivanappan 1994; Postal et al. 2001).

Specific studies on the impact of MIS undertaken by scholars broadly looked at:

- The physical impact of water-saving technologies on irrigation water use (Narayanamoorthy 2004)
- The impact of water-saving technologies and water-efficient crops on crop water productivity in physical terms (kg/m3) (Kumar 2007; Kumar & van Dam 2013; Singh 2013)
- The benefit-cost analysis of micro-irrigation systems such as drips and sprinklers (Palanisami et al. 2002; Kumar et al. 2004; Narayanamoorthy 2004)
- The comparative economics of the cultivation of water-efficient and high-valued crops; and (e) an analysis of the economic and social costs and benefits of micro-irrigation systems (Suresh Kumar & Palanisami 2011).

To a large extent, the majority of these analyses have been based on farm/plot-level assessments of the physical, economic, environmental or social benefits/outcomes of the MIS across major states, viz. Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Rajasthan, and Tamil Nadu.

Based on the MIS adoption status across farms covering the three seasons of kharif, rabi, and summer in Gujarat, it has been observed by some that the micro-irrigation systems can also bring about dynamic changes in the entire farming system in terms of crop diversification in favour of high valued cash/ horticultural crops (Kumar et al. 2008; Kumar 2009) as well as an increase in milk production. This is due mostly to the increase in area covered under fodder crops, such as alfalfa [Singh & Kumar (2013) in Kumar et al. (2013)].

Nevertheless, despite the beneficial outcomes reported in the vast empirical literature, the progress in the adoption of MIS has been very slow. For instance, the total area covered under MIS in India was about 4.94 million ha during 2010, which is a little less than 5% of the total irrigated area. Interestingly, six states: Maharashtra (18.2%), Rajasthan (18.1%), Andhra Pradesh (15.4%), Karnataka (12%), Haryana (11%), and Gujarat (8.2%), together account for about 83% of the total area under MIS in India. This lukewarm state of adoption of MIS in India is a matter of concern. It also posits an irony that the low rate of adoption persists in spite of the fact that many states have been promoting MIS through the provision of subsidies, especially to small and marginal farmers, to the extent of 50-75%.

By and large, the poor state of adoption of MIS in India has been attributed to several factors and constraints, including physical, socio-economic, financial, institutional - pricing, subsidies, extension service - and policy-related ones (Narayanamoorthy 1997; Kumar 2002; Kumar et al. 2008).

More importantly one may observe that the economic analyses do not seem to be adequately contextualized with respect to the socio-economic, institutional, and environmental situations in which these water saving technologies have been adopted. Invariably, the socio-economic and institutional environments determine the extent to which the MIS can offer efficient and alternative solutions.

Against this backdrop, the broad objective of this paper is to present a case study of the adoption of MIS and its socio-economic impacts on agriculture/farming as well as the water sector in Gujarat. The analytical focus of the paper is the most recent policy intervention made by the Government of Gujarat to promote the adoption of MIS among small and marginal farmers in the state.

In this promotion effort, the Gujarat Water Resources Development Corporation (GWRDC) has been implementing a scheme called, the 'pressurized irrigation network system (PINS) & micro irrigation system (MIS)' since 2009. Under the scheme, the PINS & MIS have been established for public tube wells located in the water-scarce districts of North Gujarat[1] , viz., Banaskantha, Mehsana, Patan, Sabarkantha, and Gandhinagar. Individual farmers coming under the jurisdiction of public tube wells were also provided with financial incentives (50-75%) to install drip and sprinkler systems on their farms/ plots.

The prime objective of the programme is to provide multiple benefits: (a) water saving; (b) increase in production; (c) savings in power consumption, along with improvements in the socio-economic status of the farmers. So far, MIS have been implemented in about 250 tube wells, and these tube wells are mostly operated by a tube well users' association (TUA), locally known as Mandali.

Objectives, Data, and Methods

The specific objectives of the paper are:

- To examine the socio-economic benefits of adopting MIS, specifically measured in terms of yield, area coverage, and cropping patterns, and
- To understand the farmers' perception of the social, economic, and environmental benefits of the MIS.

The analysis contained in the paper covers 122 public tube wells that had been installed with MIS in the Banaskantha district of North-Gujarat under the PINS & MIS [2]. MIS adoption in this district had been selected for the case study, because the programme had been launched from there. The district also has the largest share (57%) in the total number of public tube wells installed with MIS as well as the number of farmers benefiting and the area brought under the MIS (see Table 1). Further, the tube wells in Banaskantha also fulfil the evaluation criterion that they must have completed a minimum of two agricultural seasons, so that observable impacts comparable across seasons and crops would show up.

1. North-Gujarat is one of the intensively groundwater exploited regions of the state (Kumar 2007).

2. Although the total number of public tube wells installed with MIS in Banaskantha is 143, 21 tube wells were excluded from the survey, because they were either reported to be non-functional at the time of survey, and/ or the head of the Mandali was not available during the field visit.

The survey for assessing the techno-economic performance of the tube wells was undertaken from December 2013 to January 2014. Information about their techno-economic performance was gathered from the main tube well operator, locally known as 'Prayojak', who also heads the Mandali and is located in the village itself.

To make a comparative assessment of this performance, the paper uses standard methodological approaches, i.e., 'before and after MIS adoption' and 'with and without MIS'; 'without MIS' refers to the conventional method of flood irrigation.

Since the GWRDC had launched the MIS in 2009, 2007-08 was selected as the reference year for 'before MIS' and 2012-13 for 'after MIS'. For a comparative analysis of changes in area and yield of crops, we used the three agricultural seasons for pre- and post-MIS as well as with and without MIS periods. To reflect on the overall impact of the MIS-installed tube wells, perceptions of key respondents were gathered in a binary variable (1= Yes; 0 = No) against various social and economic benefits and/or performance indicators, which is common in various studies on MIS in an Indian context.

1. Implementation of Micro-Irrigation System in Gujarat

In the state of Gujarat, situated in western India, major parts of agricultural land are in arid and semi-arid regions, where about half of the agricultural land is covered under irrigation. In 2007-2008, around 43% of the total net sown area (NSA) was irrigated through surface and ground water (GoG 2008).

But the state's water sector is beset with a major crisis characterized by under-performance of surface irrigation systems [in terms of area coverage, as surface irrigation covered only about 22% of the net irrigated area in 2007-08 (GoG 2008)] along with over-extraction of groundwater. In particular, there has been an extensive use of tube wells and open wells in the state. For example, during 1970-71, around 10,830 thousand ha (79% of the total net irrigated area) were irrigated through tube wells and other wells. This had increased to 33,027 thousand ha (78% of total net irrigated area) during 2007-08. The compounded annual growth rate (CAGR) was around 3%, which was higher than that of the other sources of irrigation (GoG 2008).

The groundwater draft has far exceeded the natural recharge levels[3] (IRMA/UNICEF 2001; Ranade & Kumar 2004). This may have serious implications for the performance of the agriculture sector of the state in the future, especially in those arid and semi-arid regions. Such a scenario gets much worse, when we consider the potential impacts of climate change on the water sector. This might cause unprecedented scarcities in the water sector, and could have a significant negative impact on agriculture, resulting in food insecurity in the state.

3. Over-exploitation of groundwater had caused drying up of open wells and dug-cum-bored wells in alluvial parts of Gujarat. The falling groundwater table had not only resulted in an increase in the capital cost of tube well construction but also added to variable costs of energy used for lifting water and well maintenance. The costs of irrigation in Gujarat amount to about 36% of total input costs, with the result that the net return per unit land for crops such as wheat and cotton remains the lowest in those parts of Gujarat that are mostly hit by water crisis (IRMA/UNICEF 2001).

Agriculture and allied activities are the single largest source of water use[4] (as high as 80-90% in most parts of western India including Gujarat). Gujarat has shown an impressive growth rate of around 10 per cent in the last decade (Kumar et al. 2010). The impending water crisis along with potential challenges of adverse environmental and climatic uncertainties underscore the imperative of adopting prudent strategies for saving the water resources from being depleted further. These also help sustaining and/or enhancing the agricultural growth rate. That is why MIS has been promoted by both national and state governments in India. The main objective is to save water and energy, besides increasing agricultural production and productivity that can reduce poverty and enhance the food as well as nutritional security of rural households (Namara et al. 2005). In Gujarat, the Gujarat Green Revolution Company Limited (GGRC) has been acting as the nodal agency for promoting MIS in the state, by providing financial incentives (subsidy) of 50% of the MIS cost or Rs. 60,000 per ha for farmers in general, and 75 % to tribal farmers (75% of the MIS cost or Rs. 90,000 per ha) [GGRC 2013].

Given the water scarcity scenario in the state, MIS could be a vital option for effectively managing and utilizing existing resources, and sustaining the irrigation systems in a viable manner (Government of India 2013). Micro-irrigation and the introduction of water-efficient crops are reported to save water in water-scarce regions, with no social costs (Kumar & Palanisami 2011). Most of the recent work which has analyzed the impact of MIS in India brings out the positive benefits of the MIS in terms of water and energy savings, increase in area under high value crops, and the resultant income benefits[5].

To a greater extent, as data indicate, the state interventions to promote MIS had resulted in a remarkable change in the way groundwater is used in agriculture in many parts of Gujarat. For instance, hundreds of thousands of farmers from North Gujarat today use micro-irrigation systems, particularly drip and sprinkler systems, to irrigate their crops and some low-water consuming high value crops (Kumar et al. 2008). But hardly 10 per cent of the total potential area was covered under MIS in Gujarat by 2010, which is observed as low among the other major states that have adopted MIS (Palanisami et al. 2011).

1.1.Pressurized Irrigation Network Systems and Micro-Irrigation Systems in Gujarat

It is observed that the water management scenario in Gujarat has undergone major changes in recent years in terms of promotion of MIS as well as well as artificial groundwater recharge programmes. While adoption of MIS was promoted through the provision of subsidy to prospective farmers, artificial recharge programmes were put into effect through groundwater recharge, watershed development, and village and farm pond renovation schemes (Viswanathan et al. 2012). For instance, the GWRDC had implemented MIS in about 250 tube wells in the districts of North Gujarat, covering 1500 farmers and 1271 ha of agricultural land (Data collected from GWRDC).

4. As water becomes scarce, demand management becomes the key to the overall strategy for managing water (Molden et al. 2001). Since agriculture is the major user of diverted water in India, demand management in agriculture would be central to reducing the aggregate demand for water to match available future supplies, thereby reducing the extent of water stress the country is likely to face (Kumar 2003a and 2003b).
5. Evidence shows that 40-80% water can be saved and water use efficiency (WUE) can be enhanced up to 100% in a properly designed and managed MIS, compared to 30-40% under conventional practice (INCID 1994; Sivanappan 1994).

Under this programme, small and marginal farmers as well as tribal farmers can avail subsidies in the range of 50-75% of the total MIS cost respectively, whereas it is only 50% for large farmers.

Table 1 presents the details and status of the MIS being implemented by the GWRDC in the five districts of Gujarat. Banaskantha district turns out to have the largest share (57%) of public tube wells installed with MIS, the number of farmers (47.6%) adopting MIS, and total area covered under the MIS (642.55 ha, i.e. 50.6%). Patan and Mehsana are the districts with the next highest number of tube wells and farmers who benefited from the implementation of the scheme.

Table 1. Distribution of public tube wells with MIS in Gujarat districts, 2012-13

District	Tube wells (No)	(%) share	Farmers (No)	(%) share	Total Area (ha)	Avg. no of farmers per tube well	Area (ha) per tube well	Avg. farm size (ha)
Banaskantha	143	57.2	650	47.6	642.55	4.55	4.49	1.28
Gandhinagar	24	9.6	131	9.6	122.99	5.46	5.12	1.19
Mehsana	32	12.8	244	17.9	214.43	7.63	6.70	1.11
Patan	42	16.8	285	20.9	204.02	6.79	4.86	0.91
Sabarkantha	9	3.6	55	4.0	87.15	6.11	9.68	1.76
Total	250	100	1365	100.0	1271.14	5.46	5.08	1.20

Source: Compiled from GWRDC database

On an average, a tube well benefits about 6 farm households across districts with an exception in the case of Banaskantha (close to 5 farmers). The average area irrigated by a tube well under the scheme is about 5 ha with a farmer holding an average farm size of 1.2 ha across districts. Sabarkantha and Banaskantha report a relatively higher size of operational holdings, i.e. 1.76 ha and 1.28 ha respectively. Overall, it is found that Banaskantha accounts for the highest percentage of MIS installed tube wells. That is why it was taken as the study area for the present analysis.

Table 2 shows the taluka-wise distribution of number of farmers and area brought under MIS in the Banaskantha district. Notably two talukas, Deesa and Palanpur, show the highest concentration of farmers and area benefited under the scheme (39% and 29% respectively), followed by Vadgam (11%) and Dhanera (8%) talukas. The average farm size reportedly benefited under the scheme is slightly above 1 ha in most talukas with only Amirgadh taluka with a single farmer reporting a higher farm size of 4.4 ha.

Table 2. Distribution of number of farmers and area covered under MIS across Talukas in Banaskantha district

Taluka	Farmers (No.)	Area (ha)	Average size (ha)
Amirgadh	1	4.4 (0.7)	4.40
Bhabhar	6	7.05 (1.1)	1.18
Dantiwada	12	13.22 (2.1)	1.10
Deesa	227	248.41 (38.7)	1.09
Deodar	25	22.92 (3.6)	0.92
Dhanera	44	49.7 (7.7)	1.13
Kankrej	35	37.32 (5.8)	1.07
Palanpur	201	188.6 (29.4)	0.94
Tharad	3	3.39 (0.5)	1.13
Vadgam	96	67.54 (10.5)	0.70
Total	650	642.55 (100.0)	0.99

Note: Figures in brackets indicate the respective share in total area
Source: Viswanathan & Bahinipati 2014

Table 3 presents the taluka-wise distribution of 143 MIS installed public tube wells and the number of 122 sample tube wells (85%) covered in the study in Banaskantha. The sample tube wells selected from the talukas was proportional to the total distribution as shown in the Table. It may also be seen that excepting Kankrej taluka, the sample tube wells surveyed have a larger proportion of installation and adoption of MIS.

Table 3. Number of surveyed tube wells in Banaskantha District

Taluka	No. of tube wells installed with MIS	No. of tube wells surveyed	Percentage of sample to total no. of MIS installed tube wells
1. Amirgadh	1 (0.7)	0 (0.00)	0.0
2. Bhabhar	4 (2.8)	4 (3.3)	100.0
3. Dantiwada	4 (2.8)	3 (2.5)	75.0
4. Deesa	54 (37.8)	47 (38.5)	87.4
5. Deodar	6 (4.2)	6 (4.9)	100.0
6. Dhanera	16 (11.2)	14 (11.5)	87.5
7. Kankrej	10 (7.0)	5 (4.1)	50.0
8. Palanpur	31 (21.7)	29 (23.8)	93.6
9. Tharad	1 (0.7)	1 (0.8)	100.0
10. Vadgam	16 (11.2)	13 (10.7)	81.3
Total	143 (100.0)	122 (100.0)	85.3

Note: Figures in brackets indicate percentage
Source: Viswanathan & Bahinipati 2014

The tube well questionnaire was designed to elicit specific information on:
(i) details of socio-economic characteristics of the head of the Mandali, (ii) operational land holding and caste characteristics of the farmers adopting MIS, (iii) technical and economic performance of the MIS, and (iv) farmers' perception of the overall socio-economic and environmental benefits of the MIS.

While the information for the kharif season was collected for the year 2013, the data for rabi and summer seasons were gathered for the previous agricultural season of the year 2012. Further, Focused Group Discussions (FGDs) were conducted to get more insights into the performance of the MIS and its overall economic, social, and environmental benefits.

1.2.Profile of MIS installed tube wells in Banaskantha

By and large, farmers are mostly dependent on MIS during the rabi and summer seasons, as the amount of rainfall is less during these seasons. Table 4 shows the status of adoption of MIS across the study talukas in Banaskantha. It emerges that almost half of the total command area under the tube wells are covered by MIS (47.9%) with notable variation across talukas. For instance, Dantiwada taluka reports the highest coverage (72%), though the total tube well command area is not significant. In Deesa taluka, around 67% of farm land with tube wells is irrigated through MIS. In contrast, a relatively lower amount of agricultural land is covered in the three talukas of Bhabhar, Kankrej, and Tharad. Irrigation dependency during the rabi season is found to be higher (87%) compared to the kharif (43%) and summer seasons (51%).

Table 4. Distribution of tube-well irrigated area adopting MIS in Banaskantha talukas

Taluka	Total area under PINS/ MIS (in ha)	% of total command area	MIS area as % of total irrigated area	(%) Area irrigated during 3 seasons		
				Kharif	Rabi	Summer
Bhabhar	6.71	12.5	13.7	44.8	82.8	0.0
Dantiwada	11.22	72.1	72.1	21.7	62.9	62.9
Deesa	213.50	66.5	70.2	64.8	90.3	56.9
Deodar	22.90	41.4	41.4	0.0	93.9	61.6
Dhanera	50.67	57.0	58.7	38.4	79.9	40.6
Kankrej	21.05	22.7	37.8	39.6	83.5	19.8
Palanpur	167.94	41.2	67.3	31.4	84.6	49.3
Tharad	3.47	26.0	26.0	0.0	33.3	33.3
Vadgam	60.97	51.9	68.8	28.8	98.2	57.2
Total	558.43	47.9	60.9	43.3	87.4	51.3

Source: Viswanathan & Bahinipati 2014

1.2.1. Status of adoption of MIS among farmers

It is useful to understand the status of public tube wells in terms of number of farmers depending on them, and the extent as well as type of MIS adopted. In this regard, Table 5 provides details about adoption of MIS, including the adoption of a specific MIS system (sprinkler and drip) along with the prevalence of the flood method of irrigation across talukas in Banaskantha.

Almost 76% of all farmers appear to have adopted MIS. This suggests that farmers depending on tube wells have shown greater interest in switching over to the new system of irrigation by allocating a major part of their farm lands to the MIS. The adoption of MIS seems to be quite significant especially in the talukas of Palanpur (71%), Deesa (85%), and Vadgam (90%). Interestingly, these three talukas together accounted for 78% of the total number of farmers adopting MIS in Banaskantha.

While the overall percentage of farmers still following the flood irrigation method under the tube wells was 24% at district level, a majority of farmers in two talukas, viz., Bhabhar (81%) and Kankrej (64%), was found to follow this method. The question 'why a large number of farmers still continue to follow the flood irrigation method, when there is scope for adopting MIS' is beyond the scope of this paper.

Table 5. Number of farmers adopting MIS and methods of irrigation across talukas

Taluka	Total no. of farmers	Percentage of farmers		(%) of farmers adopting	
		Adopting MIS	Flood irrigation method	Sprinkler irrigation	Drip irrigation
Bhabhar	31 (4.1)	19.4	80.2	16.7	83.3
Dantiwada	9 (1.2)	100.0	0.0	100.0	0.0
Deesa	228 (30.5)	84.7	15.3	100.0	0.0
Deodar	29 (3.9)	86.2	13.8	92.0	8.0
Dhanera	46 (6.1)	91.3	8.7	95.2	4.8
Kankrej	45 (6.0)	35.6	64.4	0.0	100.0
Palanpur	261 (34.9)	71.3	28.7	87.1	12.9
Tharad	3 (0.4)	100.0	0.0	100.0	0.0
Vadgam	96 (12.8)	89.6	10.4	100.0	0.0
Total	748 (100.0)	75.7	24.3	91.3	8.7

Note: Figures in brackets indicate column percentage.
Source: Viswanathan & Bahinipati 2014

With respect to the specific micro-irrigation system adopted by the farmers, it is observed that around 91% had opted for sprinkler irrigation. Even more, five out of the nine talukas reported 95-100% adoption of sprinkler systems. In contrast, a large percentage of farmers in two talukas, Kankrej (100%) and Bhabhar (83%), showed a strong preference for the drip irrigation system.

1.2.2. Socio-economic profile of farmers adopting MIS

The socio-economic profile of farmers adopting MIS is examined to understand if this water saving technology (WST) has a wide acceptance among all socio-economic groups. In this regard, Table 6 presents the distribution of MIS adopted farmers by land-size class. The overall picture suggests that the majority of these farmers belong to semi-medium (37%) and medium (41%) size classes. While the proportion of marginal farmers was a little higher in Dantiwada and Palanpur talukas (11% and 7.5% respectively), the proportion of small farmers adopting MIS was higher in Vadgam (24%) and Palanpur (12%) talukas.

Table 6. Distribution of farmers adopting MIS by land holding classes

Taluka	Percentage of farmers across land size classes				
	Marginal	Small	Semi-Medium	Medium	Large
Bhabhar	0.0	0.0	0.0	100.0	0.0
Dantiwada	11.1	0.0	11.1	77.8	0.0
Deesa	0.5	3.7	32.5	50.3	13.1
Deodar	0.0	0.0	60.0	36.0	4.0
Dhanera	0.0	7.1	35.7	47.6	9.5
Kankrej	0.0	0.0	6.3	81.3	12.5
Palanpur	7.5	11.8	38.7	36.0	5.9
Tharad	0.0	0.0	0.0	0.0	100.0
Vadgam	3.5	24.4	50.0	17.4	4.7
Total	3.4	9.4	37.1	41.3	8.9

Note: Marginal: below 1 ha; Small: 1to 1.99 ha; Semi-Medium: 2 to 3.99 ha; Medium: 4 to 9.9 ha; Large: >10 ha
Source: Viswanathan & Bahinipati 2014

This implies that relatively fewer marginal and small farmers are adopting the MIS. This was also reported in a study by Palanisami et al. (2011) with respect to Tamil Nadu, South- India.
This could be because of several reasons including: (i) lack of knowledge about the scheme, (ii) MIS being expensive for them even after the government subsidy provided, and (iii) due to an interplay of local dynamics, in which the caste, political as well as kinship related factors work in sharing the benefits. It may also be an outcome of natural exclusion caused by the location of the holdings around the MIS installed tube wells under study. This point needs further empirical validation, but it is beyond the scope of the present analysis.

Table 7 presents the details of MIS adoption by socio-economic groups. It reveals that majority of the farmers adopting MIS belong to other backward class (OBC) with a major share of 76 per cent at the aggregate level, followed by general (12%) and scheduled caste (11.5%). Notably, the presence of farmers belonging to general and scheduled caste (SC) categories also differs across talukas. For instance, while four talukas, viz., Vadgam, Deodar, Bhabhar, and Palanpur report larger share of farmers belonging to general category, other four talukas, viz., Dantiwada, Dhanera, Kankrej and Deesa show larger number of farmers belonging to SC category.
Apparently, there was no farmer belonging to the ST category except the Deesa taluka, and this

dynamics may have nothing to do with the implementation of the system. Perhaps, it may be due to the specific settlement pattern that prevails in the study villages.

Table 7. Distribution of farmers adopting MIS by caste categories

Taluka	Percentage of farmers across caste categories			
	General	OBC	SC	ST
Bhabhar	16.7	83.3	0.0	0.0
Dantiwada	0.0	66.7	33.3	0.0
Deesa	2.1	80.1	17.3	0.5
Deodar	20.0	80.0	0.0	0.0
Dhanera	11.9	66.7	21.4	0.0
Kankrej	0.0	81.3	18.8	0.0
Palanpur	17.2	75.8	7.0	0.0
Tharad	0.0	100.0	0.0	0.0
Vadgam	25.6	69.8	4.7	0.0
Total	12.2	76.1	11.5	0.2

Note: OBC- Other Backward Class, SC- Schedule Caste, and ST- Schedule Tribe.
Source: Viswanathan & Bahinipati 2014

1.2.3.Impact of MIS adoption on agricultural practices and household income

A large number of the previous studies on the water saving technologies (WSTs) in India as discussed above, highlight that the MIS has positive impact on agricultural production, and in turn, on income of the agricultural households. In this backdrop, the present section makes a comparative assessment of the impact of adoption of MIS on agriculture (i.e. particularly on cropping patterns and yield) and income of the households in Banaskantha. This analysis is done based on the information on the changes in the crops/ farming practices 'before and after adoption of MIS' as well as with 'MIS and without MIS (Non-MIS)' across the study talukas.

1.2.3.1.Season wise use of MIS

The use of MIS for irrigating kharif crops shows a mixed scenario across the talukas (see Table 8). For instance, some talukas, such as Vadgam, Palanpur, Deesa and Dhanera report greater use of MIS for irrigating kharif crops, while others, such as Bhabhar, Kankrej and Dantiwada mostly prefer flood irrigation method for irrigating kharif crops. The overall adoption of MIS during the kharif season was reported to be 63 percent while rest of the farmers (37%) followed flood irrigation method. Nevertheless, the average area irrigated under MIS during kharif was notably higher at 1.98 ha when compared to the average area (1.15 ha) irrigated using flood irrigation method.

Table 8 also shows that the average reported kharif irrigated area before and after MIS had declined in five of the eight talukas. This could probably be due to: (i) a shift in cropping pattern towards less (or no) irrigated crops during the kharif season; and (ii) non-use of any irrigation sources for growing kharif crops due to favourable monsoon.

Table 8. Kharif irrigated area before and after adoption of MIS in Banaskantha

Taluka	Average kharif irrigated area (in ha)		Kharif irrigated area under MIS		Kharif irrigated area under flood irrigation	
	Before MIS1	After MIS2	Area (in ha)2	As (%) of total Kharif irrigated area	Area (in ha)2	As % of total Kharif irrigated area
Bhabhar	5.81	3.53	0.75	21.3	2.78	78.7
Dantiwada	2.35	1.48	0.81	54.6	0.67	45.4
Deesa	4.99	4.39	2.94	67.1	1.44	32.9
Deodar	0.50	0.50	0.00	0.0	0.50	100.0
Dhanera	3.11	2.16	1.39	64.1	0.78	35.9
Kankrej	2.78	5.64	1.67	29.5	3.98	70.49
Palanpur	2.70	2.68	1.82	67.7	0.87	32.3
Vadgam	4.87	1.35	1.35	100.0	0.00	0.0
Total	3.83	3.13	1.98	63.3	1.15	36.7

Note: 1- reference period 2007-08; 2- reference period 2013-14
Source: Viswanathan & Bahinipati 2014

The extent of adoption of MIS during the rabi season was 55 percent while the rest (i.e. 45%) followed the conventional flood irrigation method at the aggregate level (Table 9). The average rabi irrigated area has shown slight increase at the aggregate level from 7.1 ha before MIS to 7.3 ha after MIS adoption. Further, five talukas, viz., Palanpur, Vadgam, Bhabhar, Tharad and Deodar are also showing notable increase in average rabi area under MIS. The proportion of rabi irrigated area under MIS was quite high in the talukas of Dantiwada (78%), Vadgam (69%), Deesa (65%) and Palanpur (59%).

On the other hand, large parts of irrigated areas in talukas, such as Tharad, Bhabhar, Kankrej and Deodar have continued to grow rabi crops using flood irrigation. These differences in the adoption and use of MIS during rabi season may be explained in terms of the adoption of particular cropping pattern by the farmers in these talukas, which may be economically less feasible to be brought under the MIS.

Table 9. Rabi irrigated area before and after adoption of MIS in Banaskantha

Taluka	Average rabi irrigated area (in ha)		Rabi irrigated area under MIS		Rabi irrigated area under flood irrigation	
	Before MIS[1]	After MIS[3]	Area (in ha)[3]	As (%) of total rabi irrigated area	Area (in ha)[3]	As % of total rabi irrigated area
Bhabhar	11.8	12.2	1.4	11.4	10.8	88.7
Dantiwada	4.5	3.0	2.4	77.7	0.7	22.3
Deesa	6.4	6.4	4.1	64.5	2.3	35.5
Deodar	8.9	9.2	3.6	38.9	5.6	61.1
Dhanera	5.9	5.7	2.9	50.7	2.8	49.3
Kankrej	12.1	10.8	3.5	32.5	7.3	67.5
Palanpur	7.6	8.3	4.9	58.8	3.4	41.2
Tharad	13.0	13.4	1.2	8.6	12.3	91.4
Vadgam	6.3	6.6	4.6	69.3	2.0	30.7
Total	7.1	7.3	4.0	55.0	3.3	45.0

Note: 1- reference period 2007-08; 3- reference period 2012-13
Source: Viswanathan and Bahinipati 2014

As Table 10 indicates, the area irrigated through MIS was higher during summer with a proportion of 59 per cent at the aggregate level. Five of the nine talukas have reported higher percentage of irrigated area under MIS during summer. Further, the average MIS irrigated area was higher (2.4 ha) than the average flood irrigated area (1.6 ha) during the summer season.

Table 10. Summer irrigated area before and after adoption of MIS in Banaskantha

Taluka	Average summer irrigated area (in ha)		Summer irrigated area under MIS		Summer irrigated area under flood irrigation	
	Before MIS[1]	After MIS[3]	Area (in ha)[3]	As (%) of total summer irrigated area	Area (in ha)[3]	As % of total summer irrigated area
Bhabhar	6.1	3.8	0.0	0.0	3.8	100.0
Dantiwada	3.5	3.0	2.4	77.7	0.7	22.3
Deesa	4.4	4.4	2.6	58.3	1.8	41.7
Deodar	5.2	4.9	2.4	48.0	2.5	52.0
Dhanera	3.2	2.2	1.5	68.5	0.7	31.5
Kankrej	3.2	3.2	0.8	26.5	2.3	73.5
Palanpur	3.7	4.3	2.9	66.9	1.4	33.1
Tharad	4.9	4.9	1.2	23.8	3.7	76.2
Vadgam	3.8	3.6	2.7	74.4	0.9	25.7
Total	4.1	4.0	2.4	59.3	1.6	40.8

Note: 1- reference period 2007-08; 3- reference period 2012-13
Source: Viswanathan & Bahinipati 2014

From the foregoing analysis it may be observed that the adoption of MIS has been quite significant during the three seasons, though a significant portion of tube well command areas has still continued with flood irrigation. There are also notable differences in the season-wise adoption of the MIS across the study talukas. For instance, while two talukas, namely, Vadgam and Dantiwada report an overall adoption rate of 81 per cent and 70 per cent for the three seasons, three of the other talukas (Palanpur, Deesa and Dhanera) report an overall adoption rate of 61-64% and rest of the four talukas (Kankrej, Deodar, Bhabhar and Tarad) show a relatively lower adoption rate of 11-30 per cent. Further, in case of talukas with the lowest level of MIS adoption (say Deodar and Tharad) the use of the technology is mostly confined to the summer season, while in Bhabhar, MIS is not being adopted during summer season at all. Such differences could be due to the specific cropping pattern followed by the farmers in those talukas, where flood irrigation practices are widely prevalent. Therefore, it is imperative to look into the use of irrigation methods based on cropping patterns, which is examined in the next section.

1.2.3.2.Cropping pattern before and after MIS over seasons

As emerge from the available literature on the farmer preferences in using the MIS, it may be expected that farmers could have moved towards bringing high valued crops under the MIS, where such possibilities exist. As may be seen from Table 11, there was not a perceptible change in the overall cropping pattern in the kharif season following the adoption of MIS. Yet a notable change was that area under groundnut had increased more than two times from 56.22 ha before MIS (2007-08) to 124.26 ha after MIS (2013-14), and as high as 89 percent of the area under groundnut was irrigated through MIS.

Table 11. Major kharif crops grown by farmers before and after MIS

Kharif crops	Total area (ha) Before MIS (2007-08)	Total area (in ha) After MIS (2013-14)	Total area (in ha) under MIS (2013-14)	(%) of total area	Total area (in ha) under Non-MIS (2013-14)	(%) of total area
Bajra	144.74 (15.0)	108.45 (13.1)	38.59	35.6	69.87	64.4
Castor	256.24 (26.6)	129.73 (15.7)	43.78	33.7	85.95	66.3
Guvar	251.15 (26.1)	225.49 (27.3)	83.82	37.2	141.67	62.8
Cotton	57.95 (6.0)	69.07 (8.4)	28.78	41.7	40.29	58.3
Fodder	106.94 (11.1)	87.85 (10.6)	37.65	42.9	50.2	57.1
Groundnut	56.22 (5.8)	124.26 (15.0)	110.44	88.9	13.82	11.1
Isabgul	2.31 (0.2)	3.24 (0.4)	0.00	0.0	3.24	100.0
Jowar	48.18 (5.0)	46.5 (5.6)	19.78	42.5	26.72	57.5
Sesame	17.93 (1.9)	14.57 (1.8)	12.15	83.4	2.43	16.7
Others*	20.42 (2.1)	17.87 (2.2)	10.58	59.2	7.29	40.8
Total	962.08 (100.0)	827.04 (100.0)	385.57	46.6	441.47	53.4

*Note: *- Others include fennel, green gram, pomegranate, pulses, tur dal, black gram; Figures in brackets indicate the column-wise percentages*
Source: Viswanathan & Bahinipati 2014

Another major crop brought under the MIS was sesame, and almost 83 percent of the area was irrigated through MIS. Horticultural and other crops were the other major crops that have been brought under the MIS during the kharif season (59%). In case of other major crops, there was a perceptible shift in the use of irrigation sources as a significant proportion of the area under these crops has been brought under MIS, though flood irrigation remained as the dominant mode of irrigation. Cotton is an example, where, a larger proportion of the area under cotton (58.3 percent) is still irrigated using flood irrigation. Probably, the sufficient availability of water during the kharif season may pre-empt the cotton farmers not to bring the crop under the MIS especially during the kharif and thus stick to the flood irrigation method.

But, as Table 12 shows, the scenario looks different during the rabi season when the area under cotton brought under the MIS was 65 per cent. As may be seen, the relative share of three major rabi crops, viz., mustard, castor and wheat remained more or less the same before and after adoption of MIS. A notable change was observed in the case of potato, which reported a more than two fold increase in its area post MIS and almost 89 percent of the area under potato was irrigated through MIS. In case of other crops, such as fodder crops, fennel and rajgaro, higher proportion of area was irrigated under the MIS. Only in case of three major rabi crops, viz., cumin, castor and mustard that flood irrigation was used as a dominant method. It also emerges from this table that about 53 percent of the area under wheat was brought under the MIS.

Table 12. Major rabi crops grown by farmers before and after MIS

Rabi crops	Total Area (in ha) Before MIS (2007-08)	Total Area (in ha) after MIS (2012-13)	Total area (in ha) under MIS (2012-13)	(%) of total area	Total area (in ha) under Non-MIS (2012-13)	(%) of total area
Mustard	296.12 (37.7)	273.06 (32.5)	131.65	48.2	141.41	51.8
Castor	239.52 (30.5)	211.96 (25.2)	81.21	38.3	130.75	61.7
Wheat	100.6 (12.8)	115.68 (13.8)	60.94	52.7	54.74	47.3
Potato	65.47 (8.3)	148.81 (17.7)	133.02	89.4	15.79	10.6
Cumin	30.54 (3.9)	22.44 (2.7)	3.24	14.4	19.2	85.6
Fodder	13.82 (1.8)	12.8 (1.5)	7.25	56.6	5.55	43.4
Rajgaro	10.58 (1.4)	8.99 (1.1)	6.71	74.6	2.28	25.4
Cotton	9.09 (1.2)	15.79 (1.9)	10.35	65.5	5.44	34.5
Fennel	5.78 (0.7)	3.47 (0.4)	2.31	66.6	1.16	33.4
Others*	14.75 (1.9)	27.08 (3.2)	24.64	91.0	2.44	9.0
Total	786.27 (100.0)	840.08 (100.0)	461.32	54.9	378.76	45.1

*Note: * Others include Barley (Jau), Cauliflower, Cluster Fenugreek (Methi), Groundnut, Jowar, Cabbage, Papaya, Pomegranate, Tobacco, Tomato and Other Vegetables. Figures in brackets indicate the column-wise percentages.*
Source: Viswanathan & Bahinipati 2014

Table 13 reports the major crops grown by the farmers during summer, and it is noted that the cropping patterns before and after MIS remain the same with respect to most of the crops. But in case of most crops, the proportion of area irrigated under the MIS was very high (i.e. 56-100%), except two crops, namely, jowar and castor; in which, the proportion of area irrigated using flood irrigation was 87 percent and 57 percent respectively. This could be because of shortage of water during summer season. In terms of relative share in total area, two major crops, bajra and fodder crops, have occupied the larger share of area under MIS, i.e. 80 percent and 15 percent respectively.

Table 13. Major Summer crops grown by farmers before and after MIS

Summer crops	Total Area (in ha) Before MIS (2007-08)	Total Area (in ha) after MIS (2012-13)	Total area (in ha) under MIS (2012-13)	(%) of total area	Total area (in ha) under Non-MIS (2012-13)	(%) of total area
Bajra	382.15 (80.5)	371.92 (77.9)	219.04	58.89	152.88	41.11
Castor	10.27 (2.2)	8.16 (1.7)	3.47	42.55	4.68	57.45
Fodder	63.94 (13.5)	70.91 (14.9)	44.94	63.38	25.97	36.62
Groundnut	0.00 (0.0)	1.74 (0.4)	1.74	100.00	0.00	0.00
Guvar	3.38 (0.7)	6.85 (1.4)	3.85	56.12	3.01	43.88
Jowar	7.87 (1.7)	7.40 (1.6)	0.93	12.50	6.48	87.50
Papaya	0.00 (0.0)	2.02 (0.4)	2.02	100.00	0.00	0.00
Pomegranate	1.16 (0.2)	3.99 (0.8)	3.99	100.00	0.00	0.00
Other Veg.	6.25 (1.3)	4.51 (0.9)	4.05	89.74	0.46	10.26
Total	475.01 (100.0)	477.50 (100.0)	284.02	59.48	193.48	40.52

Note: Figures in brackets indicate the column-wise percentages
Source: Viswanathan & Bahinipati 2014

1.2.3.3.Impact of MIS on yield of crops

The impact of MIS on the performance of crops is examined in this section. The overall changes in crop yield following the adoption of MIS is presented in terms of responses, such as: (a) no difference in yield; (b) yield increase below 20 percent; (c) yield increase of 20-40 percent; and (d) yield increase of 40-60 percent.

As evident from the Table 14, about half of the tube well operator farmers (48%) opine that there was no palpable difference in yield of crops under the MIS during the kharif season. At the same time, the largest proportion of the farmers (52%) report an increase in yield of kharif crops following the MIS adoption. But majority (45%) who are reporting a yield increase felt that yield increase was below 20 percent in case of most of the kharif crops, especially, groundnut, sesame, Bajra, Guava and Jowar. In the case of groundnut, about 19 percent of the responses indicated a yield increase in the range of 20-40 percent, and about 12 percent reported a yield improvement of 40-60 percent. In case of cotton also, there was some notable increase in its yield in the range of 20-40 percent (reported by 6.2% of respondents) and 40-60 percent (observed by 6.3% of farmers).

Compared to the kharif crops, yield increase from the adoption of MIS is higher for rabi crops, as more than three fourth of the responses (i.e. 77%) reported an increase in yield of rabi crops. In this case, while 58 percent of the farmers indicated a yield increase below 20 percent, about 14 percent reported an incremental yield of 20-40 percent and another 9 percent experienced an improvement of 40-60 percent in yield, following the adoption of MIS. Higher extent of yield increase (more than 20%) is observed in case of rabi crops, such as potato and mustard. In case of major food crops, like wheat, the yield increase was below 20 percent as indicated by almost 70 percent of the respondents. This might be because of the reason that conventionally farmers grow wheat following the flood irrigation method.

Two major summer crops benefited from MIS are bajra and fodder, where almost 69 per cent of the respondents indicated an increase in yield, though yield increase reported by majority (54%) was below 20 percent. While about 11 percent observed a yield increase in the range of 20-40 percent, hardly 5 percent reported a yield increase of 40-60 percent. Thus, the analysis of the impact of MIS on crop yield brings out quite impressive outcomes of increase in yield of majority of the crops grown during the rabi, kharif and summer seasons in the Banaskantha district.

Table 14. Impact of MIS on crop yield in Banaskantha District

Season/ Crops	No difference in yield	Increase in crop yield (% responses)		
		Below 20%	20-40%	40-60%
Major kharif crops				
Bajra	50.0	46.7	3.3	0.0
Castor	62.4	31.4	6.2	0.0
Guava	50.0	44.8	3.4	1.8
Cotton	50.0	37.5	6.2	6.3
Fodder	54.8	38.7	6.5	0.0
Groundnut	9.3	60.5	18.6	11.6
Jowar	57.1	42.9	0.0	0.0
Sesame	44.4	55.6	0.0	0.0
Average	47.3	44.8	7.4	6.6
Major rabi crops				
Castor	28.9	60.9	10.2	0.0
Fodder	45.4	45.4	9.2	0.0
Mustard	18.9	69.6	7.6	3.9
Potato	2.8	38.9	38.8	19.5
Rajgaro	21.4	64.3	14.3	0.0
Wheat	21.7	69.6	6.5	2.2
Average	23.2	58.1	14.4	8.5
Major summer crops				
1. Bajra	23.5	63.3	7.1	6.1
2. Fodder	38.2	44.1	14.7	3.0
Average	30.9	53.7	10.9	4.6

Source: Viswanathan & Bahinipati 2014

On the other hand, Table 15 presents the results of the comparative season-wise yield performance of crops before and after the adoption of MIS as well as the crop yield under MIS as compared to the flood irrigation method. It is important to note here that the average yield of kharif crops under the MIS was more than 18 percent as compared to the yield before adoption of MIS. Similarly, the yield increase under MIS is higher by 23 percent as compared to the average yield of kharif crops irrigated under the flood irrigation method. There were notable differences in average crop yield before and after adoption of MIS in case of all the kharif crops as well as crops irrigated using flood irrigation (non-MIS). In the kharif season, a positive growth rate is observed for almost all the crops under MIS as compared to the flood irrigation method except bajra and fodder.

Table 15. Comparative assessment of impact of MIS on yield of cops

Season/ crops	Average Yield before MIS1 (kg/ha)	Average yield After MIS2 (kg/ha)	Average yield under Non-MIS (kg/ha)	(%) difference in yield under MIS compared to	
				Before MIS	Non-MIS (flood irrigation)
Kharif season					
Cotton	3577.50	3456.25	3318.75	-3.4	4.1
Groundnut	3137.50	4013.75	3088.75	27.9	29.9
Bajra	3131.25	3250.00	3328.75	3.8	-2.4
Jowar	1982.50	2075.00	1610	4.7	28.9
Castor	3043.75	3507.50	3270	15.2	7.3
Guvar	1832.50	1992.50	1597.5	8.7	24.7
Fodder	3170.00	4062.50	4687.5	28.2	-13.3
Sesame	1166.25	1478.75	868.75	26.8	70.2
Green Gram	1200.00	937.50	625	-21.9	50
Vegetables	3593.75	5833.75	NA	62.3	NA
Average	2583.50	3060.75	2488.33	18.5	23
Rabi season					
Castor	2957.50	3411.25	3295	15.3	3.5
Mustard	2537.50	2935.00	3151.25	15.7	-6.9
Wheat	3808.75	4976.25	4196.25	30.7	18.6
Fodder	2812.50	2500.00	4375	-11.1	-42.9
Rajgaro	2348.75	2466.25	2911.25	5	-15.3
Fenugreek	3958.75	4166.25	3228.75	5.2	29
Potato	14548.75	21283.75	15000	46.3	41.9
Cumin	1031.25	1625.00	1812.5	57.6	-10.3
Average	4250.47	5420.47	4746.25	27.5	14.2
C. Summer season					
Bajra	3333.75	4103.75	3655	23.1	12.3
Fodder	2250.00	2571.25	2375	14.3	8.3
Guar	1625.00	1771.25	1312.5	9	35
Average	2402.92	2815.42	2447.5	17.2	15

Note: NA- not available (none of the farmers cultivated vegetables), 1- reference year 2007-08, 2– reference year 2013-14 for kharif season and reference year 2012-13 for rabi and summer seasons.
Source: Viswanathan & Bahinipati 2014

In case of rabi crops, the average yield of crops gained under the MIS was higher by 28 percent as compared to the situation before MIS adoption. Compared to the yield of crops under flood irrigation, the yield of crops with MIS adoption was higher than 14 percent in case of rabi crops. But, a higher negative growth rate is observed for Fodder crop (e.g. -42.9%), followed by rajgaro (-15.3%), cumin (-10.3%) and mustard (-6.9%) during rabi season. Similarly, in case of summer crops, the average crop yield realised from farms adopting MIS has been higher by 17 percent (before MIS) and 15 percent higher than the average yield realised from flood irrigated farms. Among the crops grown during summer season, a higher positive growth rate is observed in the case of guar (i.e. 35%) cultivated under MIS as compared to the flood irrigation method. Based on the above discussion, it may be observed that farmers are getting adequately compensated for the investments that they make to adopt the MIS and many of the crops grown during the kharif and rabi seasons are already yielding higher than those grown with flood irrigation method. But compared to kharif and rabi seasons, the adoption of MIS is found to be highly restricted to only few crops during the summer and this is an important point emerging from the analysis.

1.2.4.Farmers' perceptions about economic and social benefits of MIS

An assessment of the economic and social benefits of the MIS is presented here based on the perceptions of the farmers as regards some of the visible benefits that emerge from adopting the MIS. In this respect, it was found that majority of the responses are highly appreciative of the overall benefits accrued from adopting MIS for irrigation purposes.

The responses as regards the economic, environmental and social benefits reported by the farmers across the study talukas are presented in Table 16, as well as Figure 1 through Figure 3. More than 87 percent of the responses indicated that there was notable increase in yield of crops and savings in water use following MIS adoption. Reductions in over extraction of ground water (61%) as well as reduction in use of pesticides and fertilizers (55% each) were reported to be the other major economic and environmental benefits accrued by large number of farmers. Further, majority of responses also indicated that the adoption of MIS also resulted in a reduction in the pests and diseases (70%) as well as savings in weeding costs (70%).

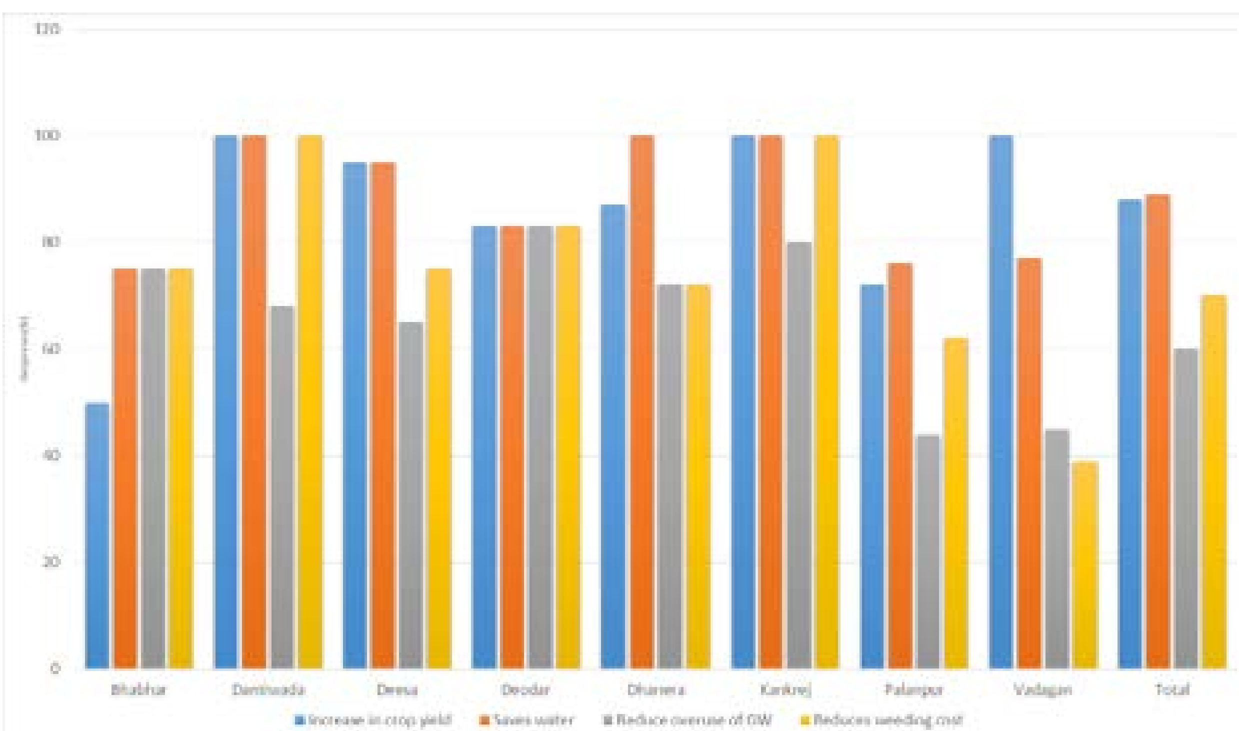
In terms of social benefits, majority of the responses reported that the adoption of MIS has resulted in savings in energy consumption (66%) and efficient allocation of scarce water among the farmers (93%). From a social angle, this has significant importance, as the new irrigation system augurs well in terms of equitable allocation and distribution of water among the farmers. Though smaller in proportion, it was also revealed from the responses that the new system of irrigation has also benefited in terms of reducing the water scarcity induced migration of labour in the talukas of Banaskantha.

Table 16. Economic, environmental, and social benefits of

Economic, environmental, and social benefits	Total responses (No.)	(%) of positive response
Economic and environmental benefits		
Increase in yield of crops	107	87.7
Saving of water use	108	88.5
Reduces over-extraction of ground water	74	60.7
4. Reduces use of pesticides	67	54.9
5. Reduction in fertilizer use	67	54.9
6. Reduction in pest and diseases	85	69.7
7. Reduces weeding cost	85	69.7
Social benefits		
Saving of energy consumption	81	66.4
Efficient allocation of water among farmers	114	93.4
Reduced water scarcity induced labour migration	43	35.3

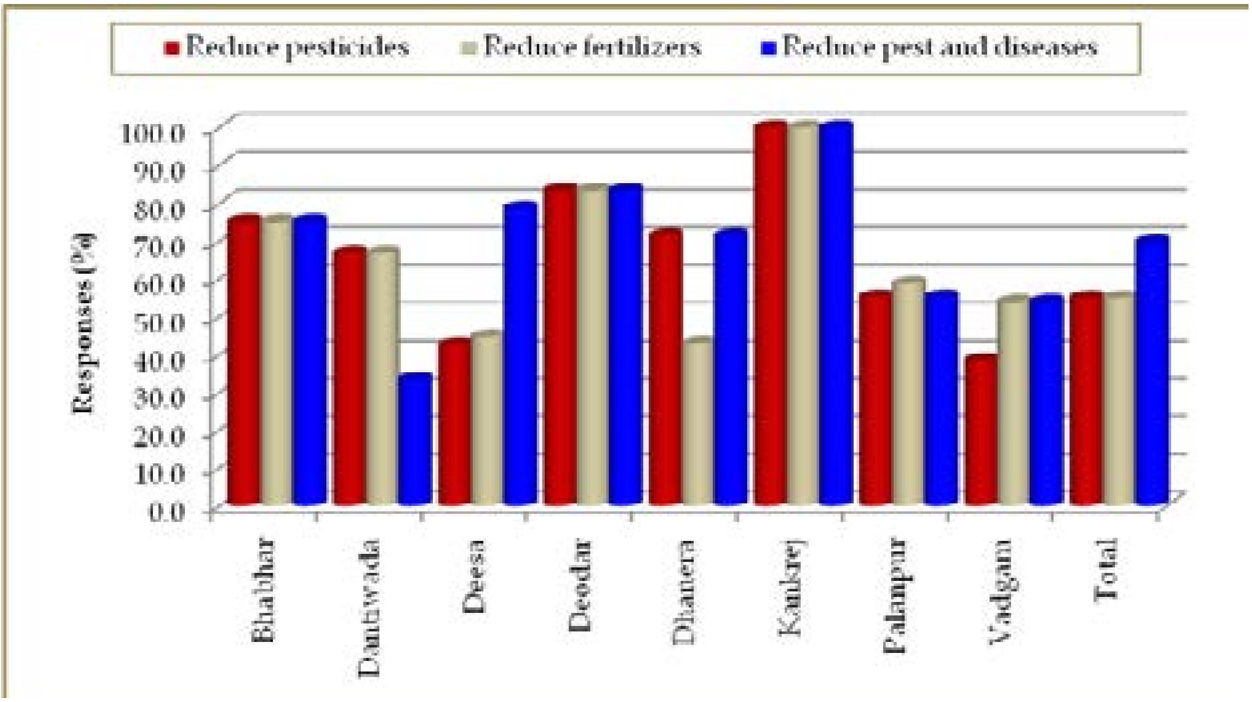
Note: The figures are multiple responses about the benefits of PINS/ MIS, based on first three responses
Source: Viswanathan & Bahinipati 2014

Figure 1. Economic benefits of adoption of MIS across talukas



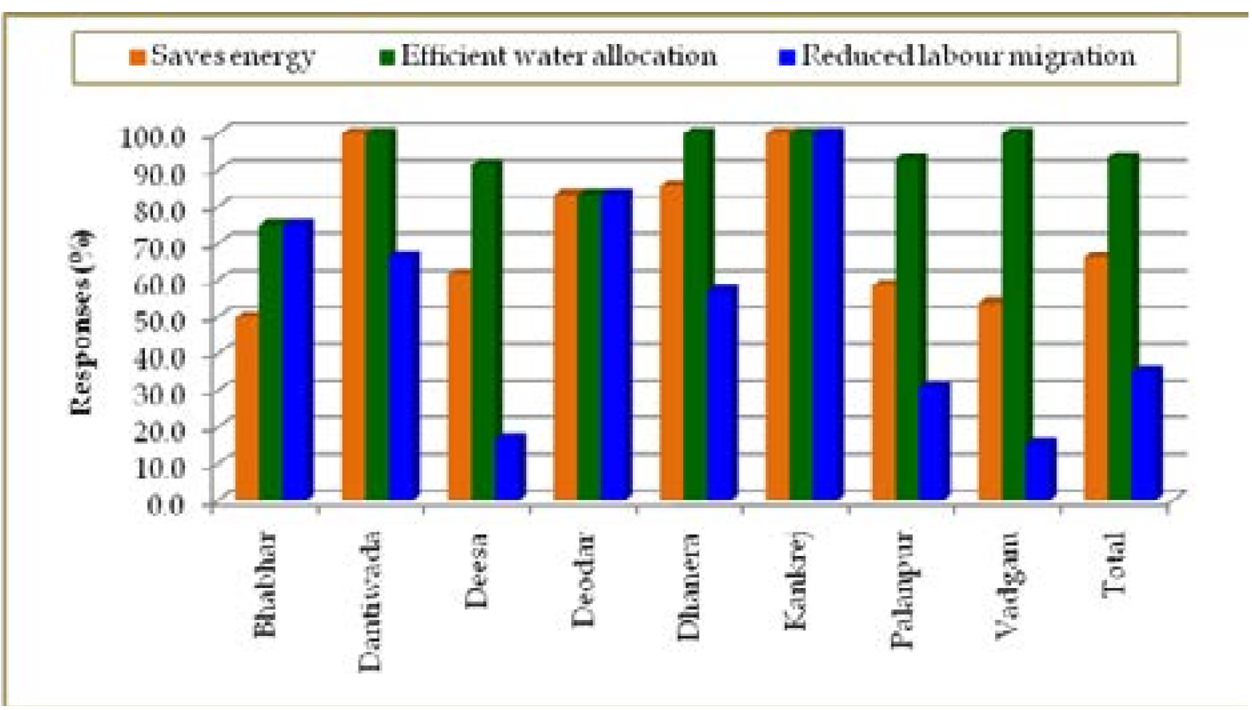
Source: Viswanathan & Bahinipati 2014

Figure 2: Environmental benefits of adoption of MIS across talukas



Source: Viswanathan & Bahinipati 2014

Figure 3: Social benefits of adoption of MIS across talukas



Source: Viswanathan & Bahinipati 2014

1.5. Concluding Observations

This study presents the results of the techno-economic analysis of the performance of 122 tube wells installed with pressure induced irrigation network and micro irrigation systems in nine talukas of Banaskantha district. While there are a large number of studies examining the multiple benefits of MIS adoption in the Indian context, this paper is an important addition to this stream of literature. This study is distinct in terms of its focus on exploring the impacts of the specific state intervention on MIS installation on Public tube wells in Gujarat. The results bring forth significant economic and social benefits to the beneficiary farmers in terms of: (a) increase in crop yields during kharif, rabi and summer seasons; (b) considerable savings in energy consumption; (c) reduction in the use of chemical fertilizers and pesticides; (d) reduction in cost of weeding; (f) reduction in groundwater over-extraction; and (f) reduction in water scarcity induced labour migration, etc to mention a few.

The analysis demonstrates that the farmers who have adopted the MIS as offered under a subsidy programme by the state government have been compensated for the investments that they made to adopt the MIS. By and large, farmers have reported to grow a range of crops especially during the kharif and rabi seasons and most of these crops have been brought under the MIS. While the adoption of MIS by the farmers has been quite impressive during the kharif and rabi seasons, the use of MIS for growing summer crops has been found to be much lower and very much restricted to few crops. This lack of a greater adoption of the MIS during the summer season could be attributed to a host of factors, including the persistent scarcity of ground water in the drier months, which in turn pre-empt the farmers from growing irrigated crops during the summer. This raises an important constraint that comes up in the way of scaling up of the MIS in the specific context of Gujarat, where the farmers are heavily promoted to adopt new agricultural practices, especially such innovative water saving technologies. While the study brings forth the significant positive economic, social and environmental outcomes of the MIS, efforts in terms of extension support and institutional interventions for facilitating wider adoption of the MIS through bringing more crops under the ambit of the scheme. More efforts are needed to rejuvenate the local water harvesting structures through artificial groundwater recharge programmes wherever such potentials exist and this in turn may help increase the adoption of MIS during the summer. The limited adoption of MIS among farmers belonging to socially backward communities is matter of concern and this need to be addressed in terms of implementing specifically targeted MIS programme for such communities.

Acknowledgements

This paper forms part of a major study undertaken by the authors on the status of adoption of MIS in Gujarat. The authors thank the Gujarat Water Resources Development Corporation Ltd., for supporting this study. Thanks are also due to Dr. M. Dinesh Kumar, Institute for Resource Analysis and Policy (IRAP), Hyderabad, for his useful inputs and comments on the larger study Report. A shorter version of the paper was also presented at the 8th Asian Society of Agricultural Economists International Conference held at Dhaka during October 14-17, 2014. We thank the participants at the Conference and the anonymous referee of the Journal for the very useful comments on the paper. The usual disclaimers apply.

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References

GoG (2008): Socio-Economic Review 2007-08: Gujarat State, Directorate of Economics and Statistics, Government of Gujarat, Gandhinagar.

GOI (2005): Dynamic Groundwater Resources of India, Central Groundwater Board, Ministry of Water Resources, Government of India, August.

GOI (2013): State of Indian Agriculture 2012-13, Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation, New Delhi, 247p.

INCID (1994): Drip Irrigation in India, Indian National Committee on Irrigation and Drainage, New Delhi.

Kumar, M. Dinesh (2002): Integrated Water Management in the Face of Growing Scarcity and Threatened Groundwater Ecology: Constraints and Opportunities, discussion paper, IWMI-TATA Water Policy Research programme.

Kumar, M. Dinesh (2003a): "Food Security and Sustainable Agriculture in India: The Water Management Challenge," paper presented at the 2nd Annual Partners' meet of IWMI-TATA Water Policy research programme, January 27-29.

Kumar, M. Dinesh (2003b): "Micro Management of Groundwater in North Gujarat, Water Policy Research Highlight # 5: IWMI-Tata Water Policy Programme, Anand.

Kumar, M. Dinesh (2007): Groundwater management in India: Physical, institutional and policy alternatives, New Delhi, India: Sage Publications.

Kumar, M. Dinesh, Ankit Patel, R. Ravindranath, OP Singh (2008): Chasing a Mirage: Water Harvesting and Artificial Recharge in Naturally Water-scarce Regions, Economic and Political Weekly, 43 (35), August 30-September 05, 2008.

Kumar, M. Dinesh (2009): Water Management India: What Works and What Doesn't, Gyan Books, New Delhi.

Kumar, M. Dinesh (2010): Managing Water in River Basins: Hydrology, Economics and Institutions, Oxford University Press, New Delhi.

Kumar, M. Dinesh, Hugh Turral, Bharat Sharma, Upali Amarasinghe and O. P. Singh (2008): "Water Saving and Yield Enhancing Micro Irrigation Technologies in India: When and where can they become best bet technologies?" paper presented at the 7th Annual Partners' Meet of IWMI Tata Water Policy Research program, ICRISAT, Hyderabad.

Kumar, Suresh (2008): Promoting Drip Irrigation: Where and Why? Managing Water in the Face of Growing Scarcity, Inequity and Declining Returns: Exploring Fresh Approaches, IWMI TATA 7th Annual Partner Meet, Vol. 1, pp 108-20.

Kumar, Suresh D and K. Palanisami (2011): 'Can Drip Irrigation Technology be Socially Beneficial?: Evidence from Southern India', Water Policy, 13: 571-587.

Kumar, M. Dinesh (2013): 'Water Saving and Yield Enhancing Micro Irrigation Technologies in India: Theory and Practice', Background Paper submitted to GIDR for developing the joint proposal for submission to the ICSSR, New Delhi.

Kumar, M. Dinesh and Jos C. van Dam (2013): 'Drivers of Change in Agricultural Water Productivity and its Improvement at Basin Scale in Developing Economies', Water International, 38(3): 312-325 (May).

IRMA/UNICEF (2001): White Paper on Water in Gujarat, Report submitted to the Department of Narmada, Water Resources and Water Supplies, Government of Gujarat, Gandhinagar.

Molden, David, R. Sakthivadivel and Zaigham Habib (2001): Basin-Level Use and Productivity of Water: Examples from South Asia, IWMI Research Report 49, Colombo: International Water Management Institute.

Narayanamoorthy, A. (1997): 'Economic Viability of Drip Irrigation: An Empirical Analysis from Maharashtra', Indian Journal of Agricultural Economics, October-December, 52 (4), pp. 728-739.

Narayanamoorthy, A. (2004): 'Drip irrigation in India: Can it salve water scarcity?', Water Policy, 6 (2): 117-130.
NCPAH (2009): Evaluation Study of Centrally Sponsored Scheme on Micro-irrigation, National Committee on Plasticulture Application in Horticulture (NCPAH), Ministry of Agriculture, Department of Agriculture and Cooperation, New Delhi.

Palanisami, K., C.R. Ranganathan, S. Senthilnathan and C. Umetsu (2009): "Diversification of agriculture in coastal districts of Tamil Nadu – a spatio-temporal analysis" Inter-University Research Institute Corporation, National Institute for the Humanities. Research Institute for Humanity and Nature, Japan, pages: 130-137.

Palanisami, K., Kadiri Mohan, K.R Kakumanu and S. Raman (2011): 'Spread and Economics of Micro-irrigation in India: Evidence from Nine States', Economic and Political Weekly, 46 (26 & 27): 81-86 (June 25).

Postal, S., Polak, P., Gonzales, F., and Keller, J. (2001), Drip Irrigation for Small Farmers: A New Initiative to Alleviate Hunger and Poverty, Water International, Vol. 26, No. 1.

Raman, S (2010): "State-wise Micro-Irrigation Potential in India-An Assessment", unpublished paper, Natural Resources Management Institute, Mumbai.

Ranade, Rahul and M Dinesh Kumar (2004): 'Narmada Water for Groundwater Recharge in North Gujarat: Conjunctive Management in Large Irrigation Projects', Economic and Political Weekly, 39 (31): 3510-3513 (July 31 - August 06).

Singh, O.P. (2013): 'Hydrological and Farming System Impacts of Agricultural Water Management Interventions in North', Indian Journal of Agricultural Economics, 68 (3): 292-312 (Jul-Sep.).

Singh, O.P. and M. Dinesh Kumar (2013): 'The hydrological and farming system impacts of agricultural water management interventions in north Gujarat, India', in M. Dinesh Kumar, M. V. K. Sivamohan and Nitin Bassi (Eds.), Water Management, Food Security and Sustainable Agriculture in Developing Economies, London: Routledge, pages: 116-137.

Sivanappan, R.K. 1994. Prospects of micro irrigation in India, Irrigation and Drainage System, 8 (1): 49-58.

Suresh Kumar, D, and Palanisami, K. (2011): "Can drip irrigation technology be socially beneficial? Evidence from southern India", Water Policy, 13 (4):571–587.

Viswanathan, P.K., Amit Mandal and Ila Mehta (2012): 'An Economic Evaluation of Revitalisation of Village Tanks in Gujarat', Report Submitted to the Gujarat Land Development Corporation Ltd., Gandhinagar, 16 July 2012, pages: v+146.

Viswanathan, P. K. and Chandrasekhar Bahinipati (2014): 'Techno-economic and Social Impacts of Water Saving Technologies in Agriculture: A Case Study of PINS & MIS in Gujarat', draft report submitted to the Gujarat Water Resources Development Corporation, Gandhinagar, March 2014, 79p.

Achieving Food Security in Storm Surge-prone Coastal Polders of South-West Bangladesh

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Abstract

The south-west coastal region of Bangladesh is highly vulnerable to various natural disasters and has experienced numerous cyclonic storms. During the cyclone Aila in 2009, the embankments were breached and overtopped at many places, causing inundation and saline water intrusion, damaging agricultural land, and subsequently resulting in food insecurity. This study was conducted to assess the impacts of Aila and the measures to achieve food security in Dacope upazila, Khulna district. Data were collected in 2014 from three visits to the study area and relevant organizations. ERDAS Imagine 9.2, FAO AquaCrop, and participatory tools including Focus Group Discussions and Key Informant Interviews were used for the detailed study. The results showed that agriculture was the most affected sector along with distinct changes in land use pattern. The farmers found that cultivation of rice as well as non-rice crops such as sunflower, sesame, and watermelon was more profitable than single rice crop cultivation, previously practised. The FAO AquaCrop model simulation resulted also in an increased yield of dry-season crops in the future. This indicates that integrating the practice of cultivating both staple food and cash crops with improved water management will increase income, provide better accessibility to food, and serve as the way to attain food security in the long run.

Keywords: Storm surge, coastal region, livelihood, food security, water management

Introduction

The coastal region of Bangladesh consists of 19 districts and has a total area of 47,203 square kilometres. Its population of 35 million is 28% of the country's total population (Khan & Awal 2009). Since long, people have been gathering in this coastal belt, although they are constantly in the precarious situation of becoming hit by a natural disaster any time. But, depending on their fate, they have been taking risks to live here, as it has vast natural resources and opportunities.

Life has not always been a blessing for those poor and marginal people, for they have experienced frequent cyclones associated with storm surges in the last few decades. Bangladesh experiences 40% of global storm surges (Murty & El-Sabh 1992). The low-lying and relatively flat terrain, geographical setting at the tip of the funnel shaped Bay of Bengal, shallow continental shelf, high tidal range, high density of population, and fragile coastal protection system are attributed as the major reasons for a disproportionally large impact of storm surges on the coast of Bangladesh (World Bank 2010). Since 1970, the country has experienced 36 cyclonic storms resulting in over 450,000 deaths and a huge economic loss (UNDP 2010). The most disastrous cyclones among these, Sidr in 2007 and Aila in 2009, had hit the south-western coast, the most vulnerable region. This had resulted in the loss of scores of lives and severe damage to properties, rendering millions of people homeless.

Aila, the deadliest cyclone, hit the Bangladesh coast on 25 May 2009. It severely affected at least 12 out of 19 districts. These included Satkhira, Khulna, Bagerhat, Pirojpur, Barisal, Patuakhali, Bhola, Laksmipur, Noakhali, Feni, Chittagong, and Cox's Bazar (Roy et al 2009). At the time of landfall at the Bangladesh coast, the sustained wind pressure of Aila was 120.7 km/hr ranking it as a category-1 cyclone (Kumar et al 2010). Though, by definition, it would still fall into a 'weak cyclone' category, due to its economic cost and long-term sufferings, the impacts of Aila outweigh those of any cyclone in the past. About 2.3 million people were affected by this event and many coastal inhabitants were stranded in the affected area, as they had no safe alternatives to survive (Kumar et al 2010). At many points the surge had risen almost three to four meters, which caused overtopping of embankments, breaching at some points, and inundation of households and croplands (Kumar et al 2010).

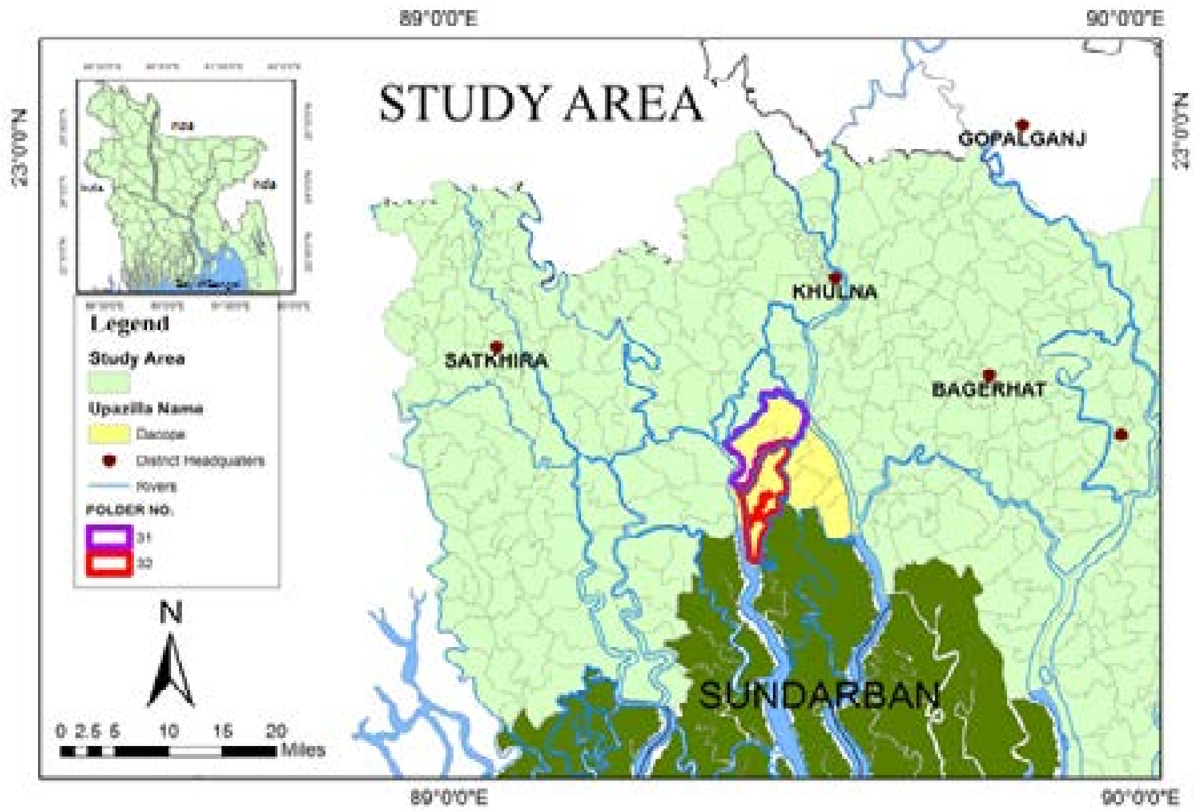
The food cycle throughout the coastal region was paralysed after Aila due to salinity ingression into cropland (both rice field and homestead garden), the poor communication system in the affected areas, a rise in market prices, and loss of livestock. Even five years after Aila, some people in the area had not managed to cope up with its long-term impacts. Also, the negative impacts of Aila had not allowed the coastal system to stay the same. The lifestyle and livelihoods of the coastal people changed depending on their exposure. People brought in changes to their traditional agricultural systems like the introduction of short-period cash crops such as sunflower, sesame, and watermelon, and an aman (monsoon rice)-rabi-fallow cropping pattern instead of an aman-fallow-fallow one. These changes were expected to ensure increased food accessibility, economic improvement, and eventually food security to the local people, where food security can be understood as: "All people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (Wheeler 2013).

This study aimed at assessing the impacts of Aila on agriculture, livelihood, and land use. It also looked at the associated measures undertaken like agricultural diversification and better water management to lessen the potential damages caused by any such event in the future and to achieve food security in the south-west coastal region of Bangladesh.

1. The Study Area

There are 139 polders in the coastal areas of Bangladesh (Khan 2014). In Dacope upazila, located at 22.5722°N latitude and 89.5111°E longitude in Khulna district, are three polders, named polder 31, 32, and 33. The losses and damages in polders 31 and 32 had been very significant after Alia. So, for this study, these two polders were selected (Figure 1).

Figure 1. Study Area



An extensive study was conducted from January - November 2014 in Pankhali, Chalna, and Tildanga unions of polder 31, and Kamarkhola and Sutarkhali unions of polder 32. Here union is the lowest administrative tier. The area had a population of 91,493 covering 143.37 square kilometres (BBS 2001). Most of the lands were medium-high (inundation depth 0.30-0.90 m) (BARC 1999). The occupation pattern consisted of shrimp farming, crop production, and wage labour. Common agricultural crops in this area were aman, boro (dry season rice), sunflower, sesame, watermelon, and some homestead vegetables.

2. Methodology and Data Collection

For this study, the damages and losses caused by Aila were assessed from primary and secondary information. These damages include agricultural damages and losses of livelihoods. Changes in land use pattern were detected through Landsat image analysis. Coping strategies adopted by the local people to counteract the impacts of the damages caused by the cyclone were analysed, based on their information. The role of strategies to attain food security was evaluated using indicators like availability, access, and stability of food provision (Ecker 2010; FAO 2013). Also, livelihood security by ensuring crop cultivation throughout the year was considered an indicator for the reduction of food insecurity.

The information on damages in the study area was collected using Participatory Rural Appraisal (PRA) tools such as Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), individual interviews, and resource mapping. Remote sensing software, ERDAS Imagine 9.2, was used for land use classification of the collected Landsat images (ERDAS 1999). First, all bands of each Landsat image were layer-stacked, then the study area was clipped from the large layer-stacked images. Next, all images were classified using a maximum likelihood classifier method (supervised classification) with pixel training data sets, resulting in land-cover maps of six different classes (Tsarouchi et al 2014).
Land types were classified as water, bare land, agricultural land, shrimp cultivation area, forest, and inundated area. ArcGIS 10 was used to calculate each land type's area percentage.

On the basis of the collected field information and local farmers' perceptions, a decision model was developed. Such models have been developed in the past to understand how farmers make decisions in the real world and the steps they go through in the process (Intal & Valera 1990; Lampayan et al 1994; Saleh et al 2002). For the development of a framework of the model, the production of monsoon rice, level of soil salinity and amount of fresh irrigation water were considered.

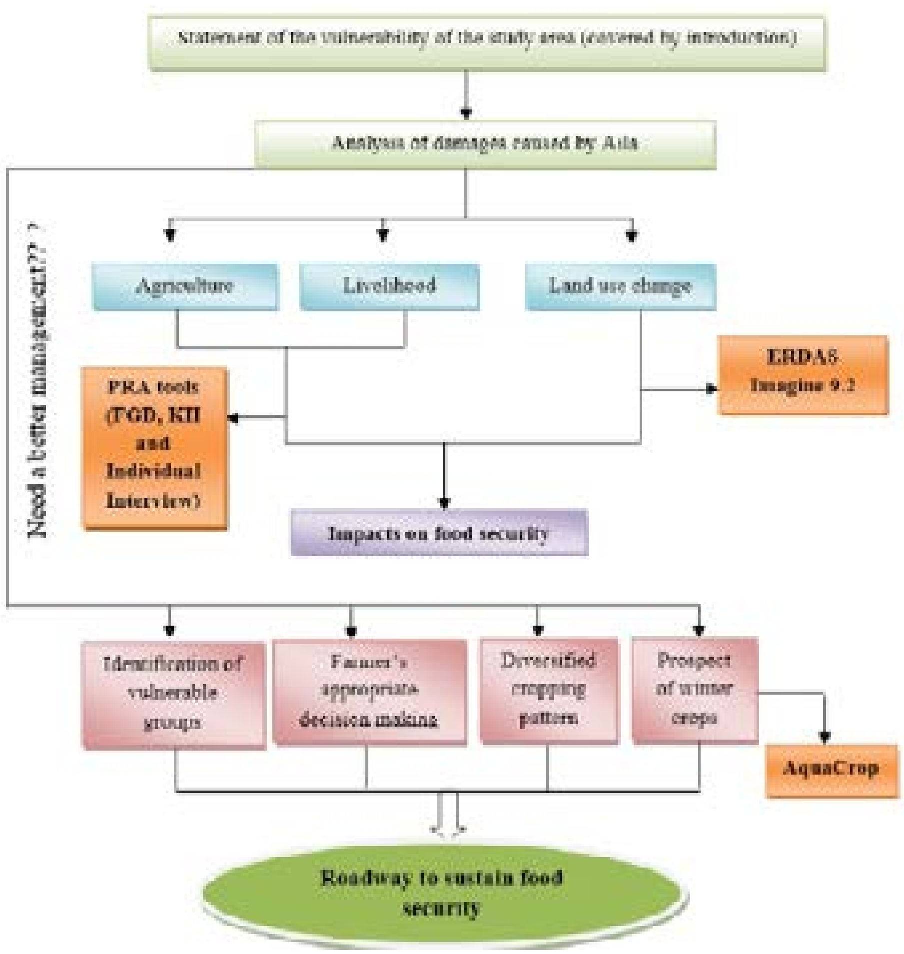
A crop model, "FAO AquaCrop" was used to simulate the yield of dry-season crops (Hsiao et al 2009; Raes et al 2009; Steduto et al 2009). Primarily, reference crop evapotranspiration was calculated using an ET0 calculator (Allen et al 1998) and used as an input of climate data. Relevant conservative data available in the crop library of AquaCrop and in its Reference Manual (Raes et al 2012) were used, and the other climatic and crop parameters were collected from the field to simulate present yield (Stricevic et al 2011; Bhattacharya & Panda 2013). Future crop yield was predicted using the climate data of future years for the IPCC climate change scenario A1B (IPCC 2007) mostly used in Bangladesh.

Finally, some qualitative and semi-quantitative information regarding changes over the indicators of food security was collected through FGDs with different groups. Relevant data were collected from three field visits to the two polders and to relevant governmental and non-governmental organizations. 15 FGDs were conducted with farmers, fishermen, and wage labourers. These groups comprised both men and women.

Landsat 5 TM and Landsat 8 images of path number 138 and row number 44 (3 in total) for dry periods in 2009 (23 March 2009), 2010 (22 February 2010), and 2014 (22 April 2014), were obtained from the US Geological Survey and Global Visualization Viewer for the analysis of land use changes. For simulation of crop yield, necessary primary information including water and soil salinity, phenological characteristics of crops, observed yield, etc., were collected from rice and sunflower fields throughout the crop growth period. Six soil samples collected from rice and sunflower fields were also tested in a laboratory to determine soil salinity. Climate data for the year under study were obtained from the Bangladesh Meteorological Department (BMD). For future years, data were obtained from the PRECIS model results. These results were collected from the ESPA-Delta Project of IWFM, BUET, through simulation of the PRECIS model in the Met Office, Hadley Centre, UK.

Figure 2 illustrates the overall methodology of the study comprising the analyses of the damages caused by Aila on agriculture, livelihood, and land use. The negative impacts of the damages in terms of reduced income and limited food availability and accessibility on food security were then assessed. Finally, the current cropping practices and management strategies followed in the study area were evaluated to determine their roles in the sustenance of local food security.

Figure 2. Conceptual framework of methodology



3. Results and Discussion

3.1 Impacts of Aila in Dacope Upazila: A Broader Picture

Seven out of nine unions of Dacope Upazila had been severely affected by Alia (Kumar et al 2010). Thousands of people of Kamarkhola and Sutarkhali unions, enclosed by polder 32, were the worst victims. Pankhali, Chalna, and Tildanga unions of polder 31 experienced comparatively less damages, as surge water had entered into this polder only through breaching at some points. Respondents of polder 31 reported that water had been stagnant inside the polder for 17 days. Thanks to the immediate response of the local people and some NGOs, only one cropping season was missed.

On the other hand, people of polder 32 informed that the area had been under water for more than two years and they had been deprived of agricultural production for three years. Although many had been relocated immediately to a nearby cyclone shelter as well as elevated roads and embankments, many others had been stranded in the affected areas finding no other alternatives. Almost all agricultural lands had been submerged by surge water for different durations of time, depending on the land type. A previous study showed 1080 hectares (ha) of crop land had been initially damaged in the upazila (Kumar et al 2010), but almost all agricultural lands in polder 32 proved unsuitable for production even two years after Aila. Table 1 illustrates a summary of damages in the upazila.

Table 1. Summary of damages in Dacope upazila caused by cyclone Aila

Affected union	Affected villages	Affected people	Displaced people	Destroyed household	Crop damage (ha)	Dead or missing livestock	Damaged shrimp gher
Tildanga	All	26,000	10,000	2,000	200	400	300
Dacope	All	25,000	9,000	1,500	160	300	200
Bajua	All	25,000	9,000	1,800	180	400	250
Sutarkhali	All	21,000	8,000	2,000	200	400	300
Banishanta	All	15,000	6,000	1,300	140	300	300
Pankhali	All	15,000	6,000	1,200	120	250	150
Kamarkhola	All	10,000	4,000	950	80	200	150
Total		1,37,000	52,000	10,750	1,080	2,250	1,650

Source: USS 2009

3.1.1 Impacts on Agriculture

Though short-term impacts on agricultural crops had not been severe in the study area, the long-term residual impacts had been far-reaching and caused profound negative results on local crop production. For instance, rice yield significantly decreased in consecutive years following cyclone Alia, due to a sudden and drastic increase in soil salinity (Table 2) that resulted from in-land storm surges.

Table 2. Soil salinity (dS/m) before and after Aila in the study area

Union	Soil salinity before Aila (2001)	Soil salinity after Aila (2011)
Kamarkhola	14-30	21-49
Sutarkhali	14-30	17-34
Chalna	8-22	12-29
Tildanga	8-22	10-25
Pankhali	2.5-8	8-14

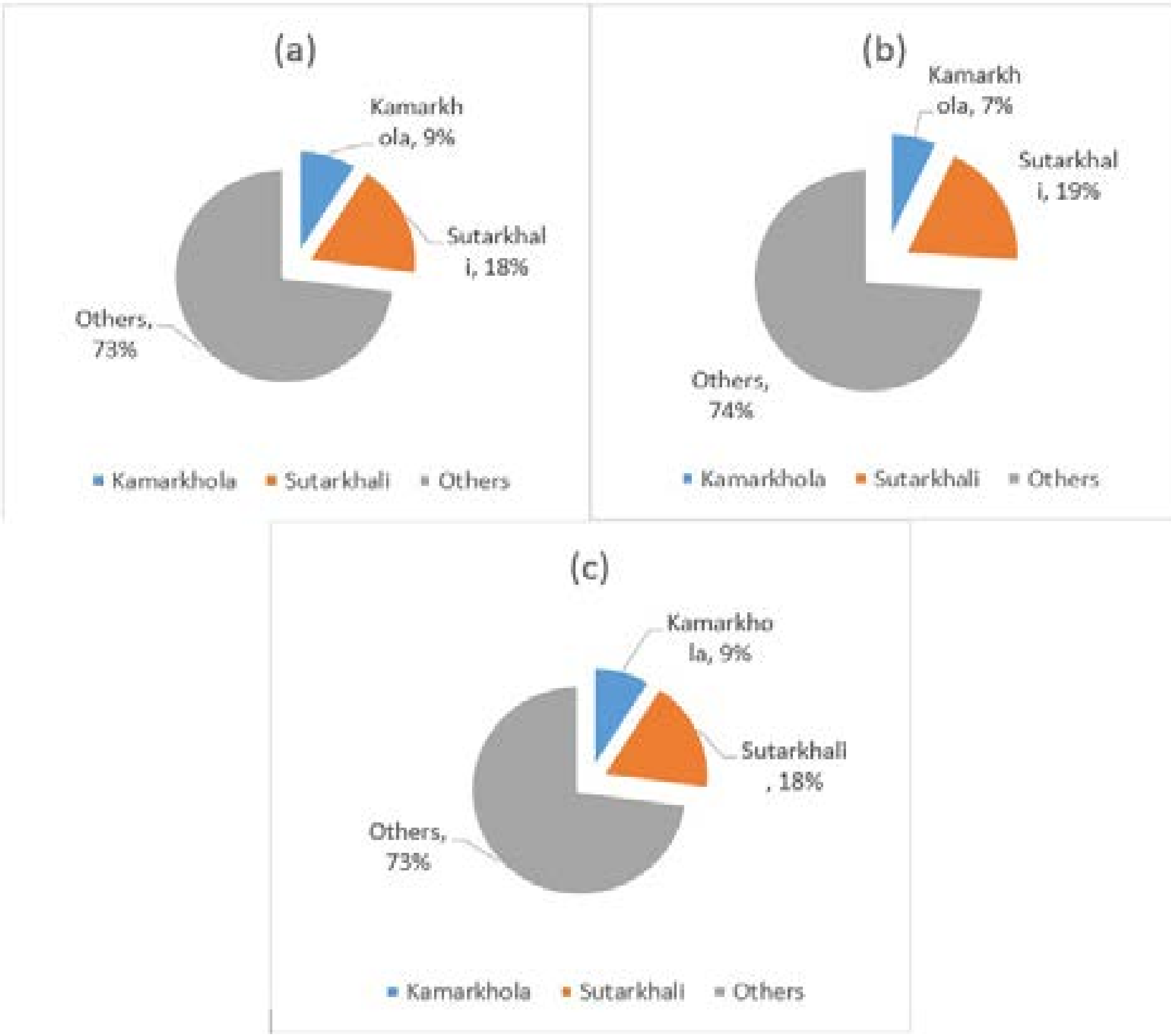
Source: Agriculture Office, Dacope upazila, Khulna

People of polder 32 informed that long-term water logging had changed the soil quality, which, in consequence, had affected the immediate cropping season along with the next three years' production. This had whipped the already affected poor people, as there was no agricultural production for three years at a stretch. People informed that before Aila they used to get 4.5-5.0 t/ha yield of aman rice. For the first two years after Aila, the loss was 100% and for the third year, they had been able to cultivate some lands, which were relatively highland, and got 3.75-4.00 t/ha yield due to residual salinity in the agricultural land. On the other hand, respondents of polder 31 informed that, although surge water from the polder area had receded within 17 days, due to the residual salt left by the surge water, they had missed one crop season. In the second year after Aila, they had come back to full agriculture, but got 20-40% less production than the year before the cyclone.

Production of aquaculture (white fish) was not possible for a long time because of salinity and pollution. Traditional practices of shrimp were hampered and lately, in many places, shrimp farmers had to abandon shrimp ghers (shrimp ponds) due to the pressure of local people, who blamed shrimp cultivation for the intensification of the damages. The charts in Figure 3 show comparative agricultural damages in the study area. Livestock, crop, and shrimp gher damages in Kamarkhola and Sutarkhali unions are compared with the total damages of Dacope upazila. The findings show that out of total damages, 27% of the livestock, 26% of the crop, and 27% of the shrimp gher damages occurred in Kamarkhola and Suatarkhali unions.

Livestock like cows, goats, hens, and ducks was the income source of the study area devastated by Aila. Respondents from Kamarkhola and Sutarkhali informed that the cyclone had damaged 75% livestock, which reduced people's farm income. Apart from the immediate death of livestock the death toll continued after Aila due to food and drinking water shortages. Moreover, poor and affected farmers were compelled to sell their remaining livestock rather than watching their brutal death.

Figure 3. (a) Losses of livestock, (b) Crop damages, and (c) Shrimp gher damages



3.1.2 Impacts on Livelihood

Shrimp farming was a major occupation (40%) along with small holding agriculture (30%) and wage labour activities (30%) in the south-western coastal region of Bangladesh as such. The Aila affected region followed a similar occupational pattern (Kumar et al 2010). The economy of this region had been totally hampered due to the cyclone. The most affected segment of livelihood was agriculture, since almost all productive agricultural lands had gone under saline water and, consequently, those farmers had become workless. A previous study had shown that 96% of the livelihood bases of the study area had been lost due to the cyclone (Kumar et al 2010). But people in the study area informed that actually all their livelihood opportunities had been lost in the early stages after Aila.

When reconstruction of the damaged embankment started, some people managed to get jobs in this reconstruction work, such as earth cutting and repairing. But, compared to the number of unemployed people, working opportunities were limited. Also, daily wages were less than the previous one. Wage labourers who used to earn BDT 150 to 300 daily before Aila, could manage to get only BDT 100 to 150 - if they could find work at all. Casual labourers found only 7-10 days work per month compared to 20-25 days in a normal year (UNDP 2010). Local people attributed increased number of workers in a situation of limited working opportunities as the reason of less number of working days.
Some fishermen informed they used to earn BDT 300 to 500 daily before the storm, but afterwards, having lost their boats and equipment, they had to depend on relief from local NGOs and government agencies. Lack of working opportunities and low wage rates increased out-migration of people to nearby areas. Most male workers migrated from this region to urban areas to seek jobs. As a result, the women had to do all the work in the fields and at home.

4.1.3 Changes in Land Use

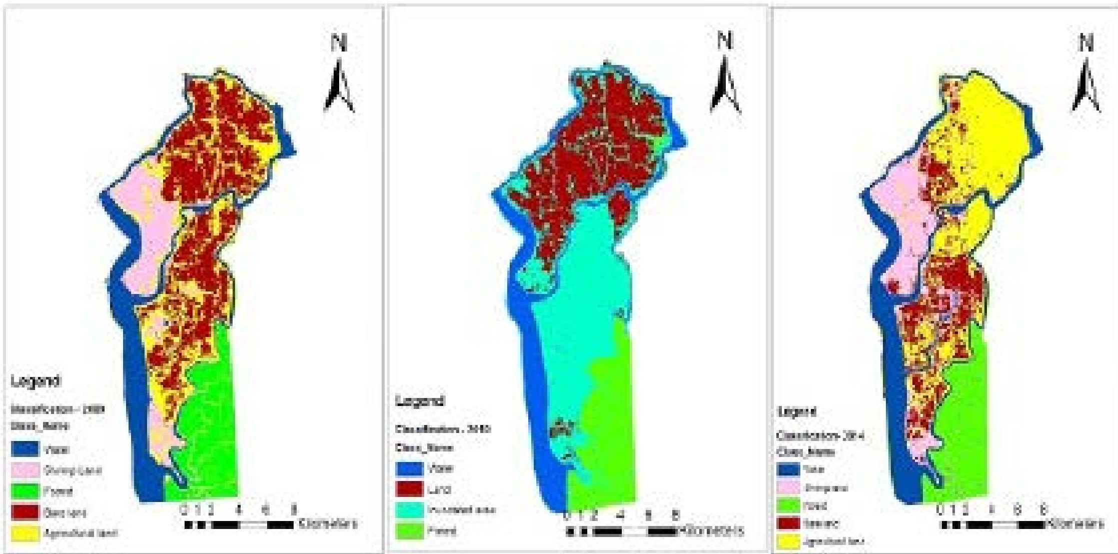
Aila had not only caused physical and social sufferings, but also changed the land use pattern in the study area. As Table 3 and Figure 4 show, before Aila (March 2009), agricultural land and shrimp cultivated lands had been 22.7% and 15.7% respectively. Shrimp cultivated lands were mainly found in the south-western part of polder 31 and in the middle and southern parts of polder 32. After Aila, in 2010, most of polder 32 except for a small portion in the north had been under water due to a storm surge that covered 39.8 % of the total area. The images in Figure 4 clearly illustrate that in 2010, almost the entire area had been inundated with surge water and no agricultural or shrimp cultivation was found in the image.

In contrast, people managed in 2014 to get back almost entirely to their previous practice. The classifications of the image for that year show agricultural land in polder 31 and in the northern part of polder 32 covering 30.7% of the total study area. Looking at the changes in land cover proportions over the periods, agricultural land use changed from 2009 to 2014 with an overall increase of 8.0%, while shrimp cultivated land was only found in the south-western part of polder 31 (estimated 11.5% coverage) with an overall 4.2% decrease.

Table 3. Land use classification

Class	2009	2010	2014
Bare land	27.8%	26.1%	18.5%
Agricultural land	22.7%	-	30.7%
Shrimp land	15.7%	-	11.5%
Inundated area	-	39.8%	-

Figure 4. Land use in polders 31 and 32, (a) before Aila (2009), (b) immediately after Aila (2010), and (c) in 2014



3.1.4 Impacts on Food Security

Cyclone Aila had the worst impact on the local food security in the study area. Local markets of the affected areas had become distorted and the supply of goods from nearby areas had decreased due to bad road conditions. In the study area, at some points, scattered food shops were found functioning rather than in a market as a whole. Prices of household products had increased (for example, the price of rice had gone up from 25 Tk/kg to 40 Tk/kg), whereas income sources of people had decreased immediately after Aila. As the local people's regular livelihood pattern changed, their diminished job opportunities put a challenge to them to manage their minimum food requirements. As a result, their calorie intake reduced to 1805 kCal/person/day from 2100 kCal/person/day (UNDP 2010).

Local people informed they experienced a huge change in their food habits after Aila. As they had to depend solely on relief supports at that time, they could barely manage their basic food requirements, let alone pay attention to nutritional value of the food. During the water logging period, neither crop farmers nor shrimp farmers could get any output from their fields. So the chain of economic loss in the agricultural sector, inaccessibility to local food markets in the affected areas, shortage of supply in the markets, and increased prices affected the food situation of the local people. Also, there was a severe scarcity of drinking water and dry foods among the affected dwellers. All these hampered their food availability and accessibility, leading to food insecurity.

3.2 Adaptation Strategies

It has been five years, since local people had this devastating experience of Aila. As life never stops, people in the affected areas had to start working as soon as they could after the disaster. People of polder 31 informed that they had been able to go back to agriculture a year after Aila, while it took two years or more in polder 32. But even then, people found agricultural production too little, due to degradation of soil and water quality.

Various NGOs such as the Bangladesh Rural Advancement Committee (BRAC) and Asroy Foundation had become very active in the affected areas immediately after Aila to help rebuild livelihood systems of the affected people. This, in turn, awakened people's interest in increasing productivity and stimulated them to change their traditional practices.

3.2.1 Identification of vulnerable groups

Damages vary from person to person and group to group, depending on their degree of vulnerability to shock or change. The impacts of any disaster have never been uniform for communities. Generally, activities of one income-generating group such as farmers, fishermen, and wage labourers affect those of other groups. As seen in the study area, shrimp farming was always protested against by crop farmers on account of its adverse impacts both on soil and water quality. So, there exists a never-ending conflict between income-generating groups, where shrimp farming always seem to benefit socially privileged groups.

But to survive, people just want to continue their traditional practices. Coping strategies of groups are different, depending on available resources, opportunities, and income-generating activities. Most shrimp farmers abandoned shrimp farming during the rabi season and are now practising sweet-water shrimp cultivation during the monsoon to avoid further degradation of soil quality.

3.2.2 Diversification of agricultural crops

People also switched to aman-rabi-fallow cropping pattern instead of an aman-fallow-fallow pattern. Respondents informed that previously, they used to cultivate only aman rice, but since Aila affected the region, a paradigm shift had been brought about in their traditional practices. In polder 31, people had started practising less water intensive and more saline tolerant cash crops cultivation like sunflower, sesame, and watermelon along with boro rice at small scale during winter. At the same time, in polder 32, people had begun growing sunflowers and watermelons instead of keeping land fallow throughout the rabi season.

Table 4 illustrates how local farmers had been gradually shifting to non-rice rabi crops from boro rice, as the former require less water and can tolerate comparatively more salinity than rice crop. It could also be seen in the field, that in the last two years, soil salinity had come down, thanks to natural processes and manmade interventions such as the washing out of salinity by rainwater and the application of gypsum and organic fertilizers. Apart from these developments, local farmers are being stimulated by various NGOs through training programmes and incentives to cultivate boro rice.

Table 4. Diversification of agricultural crops in Dacope upazila

Year \ Crop		Boro rice	Sunflower	Sesame	Watermelon
2008-09	Land area(ha)	755	0	2	300
	Crop yield (ton)	1844	0	2	1,26,000
2009-10	Land area(ha)	130	0	2	800
	Crop yield (ton)	407	0	2	37,655
2010-11	Land area(ha)	85	5	19	1326
	Crop yield (ton)	302	2	15	46,908
2011-12	Land area(ha)	55	15	40	2125
	Crop yield (ton)	215	10	34	10,200
2012-13	Land area(ha)	30	45	16	2500
	Crop yield (ton)	126	50	13	61,500
2013-14	Land area(ha)	65	90	20	2360
	Crop yield (ton)	264	135	14	63,965

Source: Agriculture Office, Dacope upazila, Khulna

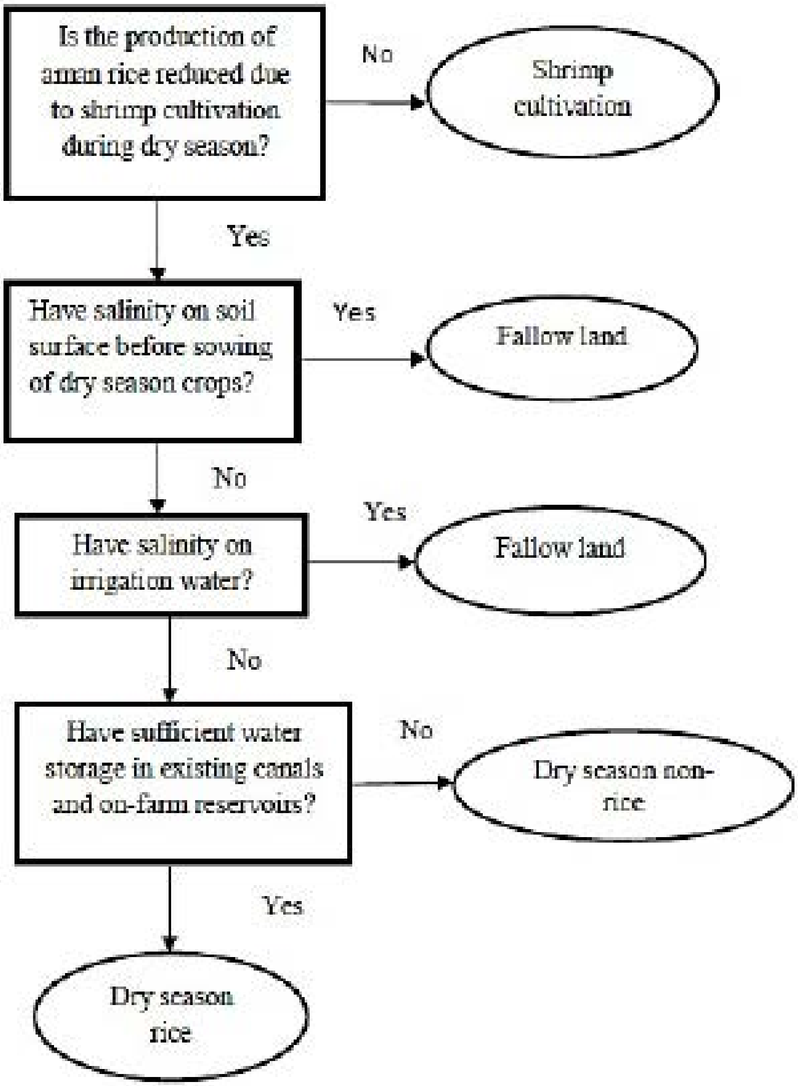
3.2.3 Better decision-making

From individual discussions with farmers, it was found that shrimp cultivation in the rabi season had resulted in a reduction of the next monsoon season's aman rice production. This had compelled them to shift to crop production instead of shrimp cultivation during the rabi season. During selection of rabi crops, they had to face the greatest challenge whether to grow rice or cash crops in the season. In this case, the amount of irrigation water is the controlling factor. Analysis of field information showed that the irrigation water requirement for sunflower was 190 mm with two or three irrigations throughout the growing period and the yield proved to be 1.38 t/ha. Farmers also informed that no irrigation was required for cultivation of sesame and the yield appeared to be 0.33 t/ha. In contrast, the irrigation water requirement for boro rice was 1080 mm with irrigation at an interval of seven days for the entire crop growth period and a yield of 5.30 t/ha.

Most farmers decide to grow non-rice crops during the rabi season because no irrigation water is required for those, or only a small amount, compared to rice. Obviously, if they can store sufficient water in existing canals and on farm reservoirs, they will be able to cultivate boro rice during the dry season.

During field visits, it was observed that some farmers had already constructed reservoirs within their farmlands to store rainwater during the monsoon. The Bangladesh Water Development Board is working in the study area for re-excavation of the existing canals. These activities have already resulted in increased crop production in the rabi season. Moreover, crop cultivation in the rabi season depends on the level of soil and water salinity. Farmers decided to grow crops at Electrical Conductivity (EC) of 4.0 dS/m of soil and to keep fallow land at EC of soil 10.0 dS/m before sowing. Their decision-making process has been illustrated in Figure 5.

Figure 5. Decision model for selection of rabi crop

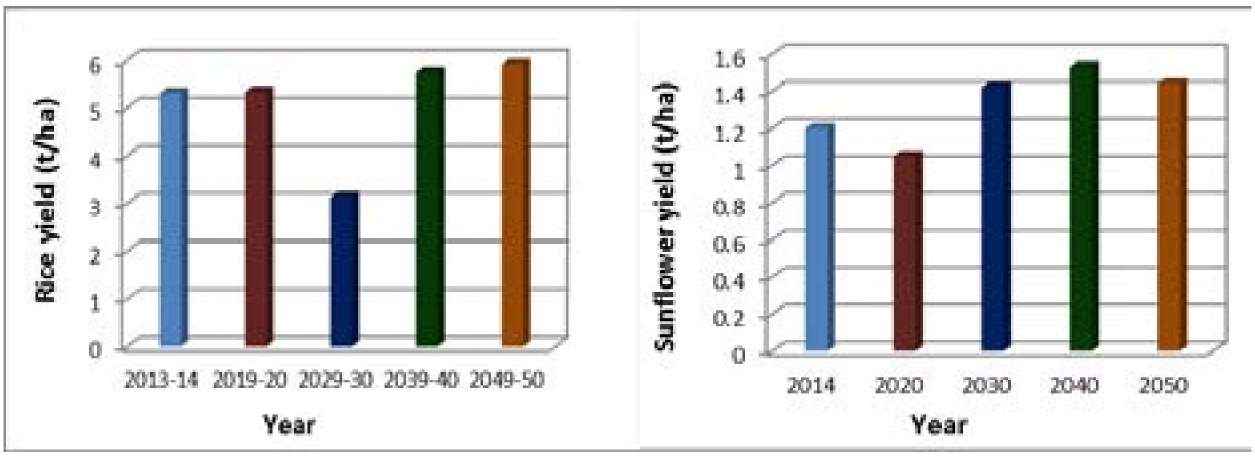


4.2.4 Prospects of rabi crops: A silver lining in the changed climatic condition

Simulation of the current yield of rabi crops was conducted by incorporating the necessary field information and other conservative data into an AquaCrop model. For simulation of rice yield, the minimum and maximum thresholds of salinity were taken as 3 dS/m and 11 dS/m, and for sunflower 2 dS/m and 12 dS/m respectively. The observed yield of rice from the field was 5.33 t/ha and for sunflower 1.20 t/ha. For 2020, 2030, 2040, and 2050, climatic parameters were used to calculate reference-crop evapotranspiration for the crop period. Then, future yields of rice and sunflower were simulated keeping the values of other model components the same as for the current year.

For rice and sunflower, there appeared an increasing trend in the yield of crops. This might be due to a lower reference-crop evapotranspiration (ET0) in future years, perhaps caused by higher wind speeds and increased temperatures, producing a higher vapour pressure. Less ET0 will lead to a lower water requirement for crops with higher yields. Also, future rainfall amounts appeared to increase, providing a sufficient water supply for irrigation, and so, ensuring an increased yield of crops.
The results (Figure 6) indicate that in future climate change scenarios, these rabi crops have good prospects. So, if a proper water supply is ensured for irrigation, with storage from monsoon rainfall in existing canals and on-farm reservoirs, and if crops are cultivated on a larger scale, an improved production and better profits can be achieved. This will provide economic improvement and sustainability to the local people.

Figure 6. Comparison of yield for different years (a) Rice and (b) Sunflower



3.3 Food Security: The Ultimate Goal

Food security can be ensured when access to food, especially economic access to food, is ensured, and the four aspects of a food production system -availability, access, utilization, and stability- are in place (FAO 2013). In the study area, livelihood security by ensuring crop cultivation throughout the year was considered an indicator for reducing food insecurity.

In an environment of high food insecurity due to hostile geographical settings of the study area, poor socio-economic conditions of the coastal community, and limited income-generating opportunities, the production of less water-intensive cash crops along with boro rice cultivation can add a new dimension to attain food security. The local people hardly can manage their food requirements for seven to eight months from their own crop production during the kharif-2 season. For the rest of the year, they depend on purchased food, which makes it difficult to achieve food security for people having poor economic access to food.

A less water-intensive cash crop production can be economically viable by ensuring higher profit, sustainable livelihood, and more access to food. Cash crops may have a direct effect on agricultural innovations, because they bring about higher economic returns and productivity in rural agriculture. Crops like sunflower have a good market value and can make considerable profit, since the investment cost is about 4000 Tk/ha for seeds along with other production costs, with a return of about 45000 Tk/ha.

For the study area, cash crop cultivation stimulates practices that enable crop cultivation throughout the year and stability of the crop production system. This simultaneously ensures livelihood security for farmers, agricultural labourers, and other income-generating groups through higher economic returns. If the area coverage under rabi crops cultivation can be increased, it can contribute to a considerable amount of profit and increased livelihood for each household every year. Besides, the amount of fallow land can be minimized and proper utilization of the land can be ensured. These will enable the farmers to generate capital for management, improvements, and innovations in crop cultivation and thereby ensure a sustainable livelihood. Also, better prospects of boro rice cultivation in the coming decades will ensure a sufficient staple food crop production, which will assist in attaining food security.

4. Conclusion

During cyclone Aila, the damages in Dacope upazila had been huge and polder 32 had been comparatively more affected than polder 31. This devastating event had affected the coastal infrastructures, human lives, properties, and especially agriculture. Aila had caused not only immediate but also prolonged sufferings to the affected communities. These impacts had resulted in changing of livelihoods, reduction of crop production, worsening of economic conditions, and ultimately food insecurity. People were then trying to cope with these adverse situations through different strategies. For instance, farmers found that the production of non-rice crops such as sunflower, watermelon, and sesame along with boro rice was more promising than their traditional cultivation of shrimp. These practices were resulting in increased income, subsequently leading to greater accessibility to food.

To supply irrigation water for large-scale cultivation of rabi crops, water management would need to be improved through rainwater storage in nearby canals and on-farm reservoirs. In conclusion, integrating the cultivation of cash and staple food crops may be the roadway to attain food security and better livelihood in the long run.

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References

Allen, R.G., L.S. Pereira, D. Raes, and M. Smith (1998) 'Crop evapotranspiration – Guidelines for computing crop water requirements', FAO Irrigation and Drainage Paper 56. Rome.

BARC (1999) 'BARC/UNDP/FAO GIS Project: BGD/95/006', Bangladesh: Bangladesh Agricultural Research Council.

BBS (2001) 'Information on Khulna and Satkhira district'. Community series. Dhaka, Bangladesh: Bangladesh Bureau of Statistics.

Bhattacharya, T. and R.K. Panda (2013) 'Effect of climate change on rice yield at Kharagpur, West Bengal', IOSR Journal of Agriculture and Veterinary Science, 4 (2): 06-12.

Ecker, O., Breisinger, C., McCool, C., Diao, X., Funes, J., You, L. and Yu, B. 2010. Assessing food security in Yemen. International Food Policy Research Institute. IFPRI discussion paper 00982.

ERDAS.1999. ERDAS Field Guide. IRDAS Inc. Atlanta, Georgia.

FAO. 2013. The state of food insecurity in the world 2013: The multiple dimensions of food security. Rome: Food and Agriculture Organization.

Hsiao, T., Heng, L., Steduto, P., Rojas-Lara, B., Raes, D., and Fereres, E. 2009. AquaCrop - The FAO crop model to simulate yield response to water: III. Parameterization and testing for maize. Agronomy Journal 101(3): 448-459.

Intal, A.G. and Valera, J.B. 1990. A descriptive model of cropping decision making application to crop diversification in integrated rice farms. Journal of Technology, 14(4): 37-47.

IPCC. 2007. Climate Change 2007, Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. UK and USA.

Islam, M.N. 2014. Agriculture Office, Dacope upazila, Khulna district. Personal Communication. By email. 30 January 2014.

Khan, M.A.H. and Awal, M.A. 2009. Global Warming and Sea Level Rising: Impact on Bangladesh Agriculture and Food Security, Final Report 10. Mymensingh, Bangladesh Agricultural University.

Khan, Z.H. 2014. Tidal river management (TRM) in the coastal area of Bangladesh. IWM, Bangladesh.

Kumar, U., Baten, M.A., Masud, A., Osman, K.S. and Rahman, M.M. 2010.Cyclone Aila: One Year on Natural Disaster to Human Sufferings. Khulna, Bangladesh: Unnayan Onneshan - Humanity Watch – Nijera Kori.

Lampayan, R.M., Saleh, A.F.M., Bhuiyan, S.I and Lantican, M.A. 1994. A cognitive model of farmer's rice crop establishment decision in rain-fed lowlands. In: International Agricultural Engineering Conference, Asian Institute of Technology, pp. 727-739. Bangkok, Thailand.

Murty, T.S. and El-Sabh, M.I. 1992. Mitigating the Effects of Storm Surges Generated by Tropical Cyclones: A proposal, Natural Hazards 6(3): 251-273.

Raes, D., Steduto, P., Hsiao, C. and Fereres, E. 2009. AquaCrop - The FAO crop model to simulate yield response to water: II. Main algorithms and software description. Agronomy Journal 101(3): 438-447.

Raes, D., Steduto, P., Hsiao, T.C. and Fereres, E. 2012. Reference Manual, AquaCrop Version 4.0, FAO: Land and Water Division, Rome.

Roy, K., Kumar, U., Mehedi, H., Sultana, T. and Ershad, D. M. 2009. Initial damage assessment report of cyclone Aila with focus on Khulna district. Khulna, Bangladesh: Unnayan Onneshan - Humanity Watch – Nijera Kori.

Steduto, P., Hsiao, T.C., Raes, D. and Fereres, E. 2009. AquaCrop - The FAO crop model to simulate yield response to water: I. Concepts and underlying principles. Agronomy Journal 101(3): 426-437.

Stricevic, R., Cosic, M., Djurovic, N., Pejic, B. and Maksimovic, L. 2011. Assessment of the FAO AquaCrop model in the simulation of rain-fed and supplementally irrigated maize, sugar beet and sunflower, Agricultural Water Management, 98: 1615-1621

Tsarouchi, G.M., Mijic, A., Moulds, S. and Buytaert, W. 2014. Historical and future land-cover changes in the upper Ganges basin of India. International Journal of Remote Sensing 35(9): 3150–3176.

UNDP. 2010. Cyclone Aila: Joint Multi-Sector Assessment and Response Framework. The United Nations.

USS. 2009. Information on Current Situation of Tropical Cyclone Aila. Dacope, Khulna: Project Office.

Wheeler, T. and Braun, V.J. 2013. Climate change impacts on global food security. Science, American Association for the Advancement of Science 341(6145): 508-513.

World Bank. 2010. Vulnerability of Bangladesh to cyclones in a changing climate potential damages and adaptation cost: Development research group, environment and energy team, policy research working paper 5280. Washington, DC: World Bank.

The Late Embrace of Urban Water-Service Privatization in India: A Political Economy Explanation

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Gregory Pierce

Abstract

Political and economic reforms in India have made private sector participation (PSP) in urban water delivery a viable strategy for state and city policymakers, against the expectations of many scholars. I provide a comprehensive analysis of the development of temporal, geographic, and stakeholder variations in urban water PSP in India. Regression models are used to explore state-level correlates of PSP as well as variations in city-level contract features. Findings emphasize the role of political party ideology in implementation and the decreasing cost and length of initiatives. They also suggest the prospects for future private sector participation in India.

Keywords: Water utility privatization, private sector participation, urban water, India

Introduction

India has only lately embraced private sector participation in local water service provision. As other countries experimented with privatized service, scholars flatly dismissed prospects for this strategy in India. The country's strong traditions of protectionism and local environmental activism seemed to rule out the possibility. Yet, Indian urban local bodies have increasingly included private partners in water service delivery arrangements since the late 1990s.

Using two recently available data sources, I explain the broader enabling environment and contemporary prevalence of urban water service privatization in India to answer two questions. First, how have national, state, and city-level factors enabled private sector participation to emerge as a viable alternative public service delivery? Moreover, how has the special context of India shaped the contract characteristics of privatization initiatives?

India's embrace of private sector participation (hereafter, PSP) lagged its broader economic liberalization, which started in the late 1980s. The strategy has also never been implemented unilaterally, compared to the privatization campaigns of other low and middle income countries (hereafter, LMICs). But, as in other LMICs, the central government eventually provided the legal and political framework for private sector partners to operate in service delivery.

Even so, Indian interest in PSP was not driven by multilateral pressure to the same extent as in other countries. Further, to date, the central government has enabled but not compelled PSP at state or city scale. Consequently, adoption of privatization varies substantially at the scale of the sub-national state. Much of this variation hinges on state size and its political affiliations.

At the city scale, privatization initiatives also differ from water projects in other LMICs. Positive features include the limited devolution of asset control to private partners, industrial water supply schemes that cross-subsidize service to households, and the prominent inclusion of domestic firms in initiatives. Moreover, it appears that the cost and length of projects has decreased over time, two factors that are generally favourable to cities. Negatively, there is a startling lack of competition in the implementation stage.

Control of the city by the Congress or the BJP influences contract terms in opposite directions; BJP influence tends to skew contract length and cost upward.

Reforms In Urban Governance And Service Delivery

How have developments in the political economy of India changed strategies to provide services in urban areas? The urban governance framework experienced wholesale reform soon after the country liberalized economically from the late 1980s to the early 1990s. The panchayati raj system of village administration, with nearly 250,000 functioning units throughout the country, has served as the dominant rural governance form for many years. But only in 1992 did the national parliament pass legislation granting cities an official status (Parliament 1992). The 1992 amendment recognized three types of urban local bodies (ULBs): nagar nigams, or municipal corporations for large urban areas, nagar palikas, or municipal councils for smaller cities, and nagar panchayats for peri-urban areas. In addition to administrative change, the population of India is increasingly moving from rural to urban areas, although from a very low base level. From 2001 to 2011, the percentage of the national population living in urban areas increased from 28 to 31. It is projected to reach 40 per cent by 2030 (Registrar General of India 2011).

Formal guidelines for political participation have also been recently established in urban areas. In municipal corporations, for instance, local elections are mandated -and usually held- every five years. Despite the newfound legitimacy of urban government in India, there remain several systemic financial and political obstacles to effective urban governance. While they now have means to lobby for central and state funding, ULBs remain under-funded and under-supported. Although incomplete decentralization of fiscal and political authority is common in LMICs, Indian municipalities have exhibited a unique inability to collect revenue (Annez 2010). Complaints regarding the corruption and ineptitude of urban service agencies are also ubiquitous (Goetz & Jenkins 2001; Davis 2003; Bardhan 2004). Recognizing systemic backlogs in urban service provision, the Indian Ministry of Urban Development launched the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in 2005 to improve basic service provision in urban areas (Ministry of Urban Development 2009).

Commercialization was already a de jure stipulation in the 1992 constitutional amendment, but JNNURM's emphasis on the de facto transfer of urban water supply and sanitation functions to ULBs shows the slow pace of real reform. Along with these changes, broader shifts in India's political economy and urban governance structure have spilled over to urban water service reform.

Reforms In Urban Water

Indian cities clearly need better water management. The country's water utilities perform poorly even in comparison to their resource endowment and capacity (Ruet, Saravanan & Zérah 2002; Rao 2009; Singh, Mittal & Upadhyay 2011). This provision reflects a broader national record of disinvestment in basic service provision compared to other countries in South Asia (Sen 2000; Dreze & Sen 2011).

McKenzie and Ray illustrate the status quo succinctly (2009). First, urban water utilities do not expand connections to all households within the city. Unconnected neighbourhoods, which are often poor and do not have formal status, rely on public standpipes, private vendors, or less secure sources. Even those households with in-home connections receive infrequent, low-quality water from utilities, causing many middle-class residents to rely on other sources. Moreover, many Indian water utilities are functionally insolvent and cannot obtain financing for infrastructure improvements[1].

While the central government has taken action to address this problem only recently, the change in resource allocation has been drastic. For instance, half of the Urban Infrastructure Development Scheme for Small and Medium Towns projects in the period 2006-2009 focused on water infra-

1. Despite the positive press surrounding it, the 1998 success of the Ahmedabad Municipal Corporation in raising its own bond funding remains quite unique in urban India.

structure (Ministry of Urban Development 2009). The 12th National Plan, published in 2011, states that the national government will raise its investment in the health sector, which includes drinking water provision, from formerly anaemic levels to 2.5 per cent of the total GDP. In addition to enhanced public investment, the government began with the 2002 National Water Policy to encourage external investment and private sector participation in the urban water sector.

Scholars have been slow to recognize the importance of PSP in India because implementation of the strategy is relatively recent; its popularity has grown slowly and meets opposition at every turn. To many, PSP in water, no matter its form or impact, is de facto 'privatization' of a public resource and represents a wholly negative symptom of neo-liberalism (Yeboah 2006; Aiyer 2007; Hall & Lobina 2007; Bakker 2013).
There is good reason for scepticism regarding the strategy's implementation in LMICs. The first era of PSP in urban water was an unmitigated disaster and the second phase was equivocal at best (Hardoy & Schusterman 2000; Araral 2009). PSP in India has largely taken place in a third, more cautious wave of privatization across LMICs. For an expanded discussion of how India's experience with PSP compares to and contrasts with that of LMICs more generally, see the work of Pierce (2014).

The Indian national government's first positive statement regarding public private partnerships (PPPs) in the water sector in 2002 ironically coincided with increased international scepticism regarding private involvement in urban water globally (Budds & McGranahan 2003; Estache & Rossi 2002). In the years 2002-2006, however, PricewaterhouseCoopers estimated that the number of PPPs roughly doubled in India (Harris & Tadimilla 2008). According to the World Bank's Private Participation in Infrastructure database, as of 2011, India ranked second only to China in the number of on-going initiatives. India's 12th National Plan, also published in 2011, projected this number to rise substantially (Planning Commission 2011). Scholars have just begun to analyse PPPs and other types of private sector involvement in urban water delivery, as noted in the following.

Theoretical Distinctives

Although this study contributes to the extensive literature on individual urban water- service privatization initiatives in LMICs, I do not summarize this literature here (for overviews of this literature, see Finger & Allouche 2002, Bakker 2009 or Pierce 2014). Instead, in this study I aim to contribute to three, more specific strands of water privatization scholarship.

The first body of research analyses how populous countries employ privatization in their urban water sectors. While water PSP trends in urban Latin America (Barkin & Klooster 2006; de Gouvello, Emilio & Brenner 2012), South-east Asia (Bakker 2007), South Africa (Flynn & Chirwa 2005; Hart 2011), and China (Wang, Wu & Zheng 2011) have been examined, the literature on national adoption of water PSPs almost exclusively utilizes qualitative methods and focuses on the first wave of urban water service privatization in the 1990s and early 2000s (Pierce 2014). Most of these studies do not attempt to measure rigorously the extent and form of private initiatives at the national scale. Their similar narrative of international intervention and rapid national implementation of PSP also largely contrasts with the Indian experience.

There is also an emerging academic literature on water privatization in India. Mckenzie & Ray (2009), Sarangi (2010), Gopakumar (2010), and Mahalingam, Devkar & Kalidindi (2011) examine the political and economic structures influencing the consideration, implementation, and regulation of private sector participation in Indian urban water- service delivery. These studies also provide a detailed analysis of a limited number of prominent PSP initiatives in India. At the same time, they exclusively employ qualitative methods and analyse a very limited range of cases. Similar to Vedachalam, Geddes & Riha (2014), the present study contributes to this body of scholarship by surveying a much larger range of Indian PSP initiatives and attempting to test their political and economic correlates quantitatively.

Finally, the analysis contributes to a nascent understanding of the sub-national and sub-regional determinants of private sector participation in urban service delivery. The body of literature on this subject remains rather small and limited to the United States (see Hefetz & Warner 2011) and Spain (Picazo-Tadeo et al. 2012). The statistical tests employed in the present study are limited in comparison to these studies, due to the current dearth of data available to conduct similar analyses in India or other LMICs. But this study, and that of Vedachalam, Geddes & Riha (2014), is the first to attempt econometric tests on sub-national determinants of PSP in India.

Data And Methods

I use the term private sector participation to describe a wide range of private sector interventions in household water service delivery, because it is the most broad descriptor of private interventions in India, throughout the remainder of this article. Because I am primarily interested in provision to urban households, I limit case selection to contracts, which require private firms to take some of the utility's responsibility to provide continuous water service to residential areas[2]. So, I do not include data on exclusive solid waste, sewage provision, or build-operate-transfer (BOT) projects. In BOT projects, the private firm works directly with the public or commercial utility, but only has an indirect relationship with households. I do include contracts that build infrastructure but also incorporate on-going service to households. Since I am interested in the factors contributing to PSP implementation, I include any case where full contract terms were announced and bid upon, whether or not these terms were fulfilled.

This is a broad definition of PSP. Future research should take a more narrow approach and distinguish between different types of private involvement. As justified by the explication of India's urban governance history above, the timeframe for the study is limited to the time period from 1992 to 2011. I applied these case criteria to two publicly available project lists: a 2011 publication by the Water and Sanitation Program of the World Bank, and a 2012 publication of PSP cases by the Indian non-profit organization Manthan Adhayayan Kendra[3]. Each list purports to enumerate the full extent of private sector participation in urban water in India.

2. Since I use data from the first term of signed or announced contract terms, I do not remove initiatives that did not carry out their full contract term, or where terms were re-negotiated.

3. I originally anticipated using the database of the Public Private Infrastructure Advisory Facility, a joint multilateral agency project, as a source for cases, but this was woefully inadequate for this study. It identifies only 12 water and sewerage projects that involved PSP in India in 1990-2011, as opposed to at least 30 projects identified by each of the two other databases.

Yet the two reports uncover slightly different cases of water PSPs and provide distinctive case-specific information. Using these two databases, I identified thirty-eight PSP initiatives spanning twelve Indian states and union territories. By these calculations, roughly one-fifth of India's urban population lived in a city that had experimented with private sector participation in water as of 2011. These thirty-eight cases form the basis for the following analysis. I use this data first to analyse the geography and timing of Indian PSP descriptively, and then employ regression modelling to discuss state and city-level correlates of PSP.

The National Geography And Extent Of Private Sector Participation In Urban Water

Reports from across the development policy spectrum establish a cohesive narrative on the arc of Indian urban water privatization since 1992 (Centre for Science and Environment 2010; Crisil Infrastructure Advisory 2010; Manthan 2012; Water and Sanitation Program 2011). This narrative shows several differences between India's and other LMICs' adoption of the strategy (see Table 1 for summary).

Table 1. Distinctive Characteristics of Indian PSP

Geography	LMICs	India
Take-off	1990s	Mid 2000s
Spread	Fast, national impetus	Slow, mediated by states
Type	From distribution to infrastructure	From infrastructure to distribution
Firms involved	Primarily foreign	Mix of domestic and foreign

The central government became receptive to private sector participation in the early 1990s (Manthan Adhayayan Kendra 2007; Centre for Science and Environment 2011). But actual implementation of projects largely stalled until the implementation of the 2002 National Water Law, and only by 2005 had a sizable number of projects become operational.

India's embrace of private sector participation occurred about a decade later than in other LMICs. PSP lagged behind the most dramatic general economic reforms in India by about ten years, similar to other LMICs. Urban water PSP in India cannot be traced directly to externally imposed austerity measures, but rather to a broader programme of internally driven economic liberalization. This differential path reflects a more prominent tradition of civil society activism and self-reliance within India.

Moreover, privatization has been implemented differentially across the country in terms of the volume and content of projects (Water and Sanitation Program 2011).This uneven, slow pattern of implementation contrasts strongly with the quick, uniform national programme of PSP employed in other countries. PSP was originally concentrated in southern states, but has now spread throughout the country. In addition, individual states often dictate urban water delivery arrangements, as discussed in detail further.

The scope of initiatives has also shifted from bulk water supply and infrastructure-only projects to arrangements that directly deliver water to households. In other words, Indian PSP has gradually moved closer to the end-user of water over time. Conversely, direct distribution schemes were tried first in other LMICs, resulting in political and social crises, which forced cities and private firms to reduce the scope of PSP in future initiatives. Moreover, whereas most early Indian initiatives were dominated by large multinational firms, the role of domestic operators has increased over time. The scope for domestic firms to gain expertise and market share appears to be most feasible in large countries -like China- that provide sufficient economies of scale for water firms to realize profits.

The country's 12th National Plan as well as a 2012 statement by the minister of Urban Development assert that the national government will increase its promotion of urban water. The data collection efforts corroborate the likelihood of PSP expansion. I identified thirty privatization initiatives that had solicited bids, but had not yet formalized contracts as of August 2012.

There is no guarantee that initiatives will reach the contract stage, but the large number of planned projects shows the intent and extent of on-going efforts to involve the private sector in urban water service provision. Although three states, Orissa (Odisha), Punjab, and Himachal Pradesh, have no current PSP initiatives in urban water, most projects will take place in states that already feature a large degree of private sector participation.

State Level Results And Discussion

My discussion focused till now on the national political-economic environment that enabled urban water PSP, but India is a federal nation, where sub-national states rely on central funding but also have guaranteed constitutional powers and influence over the central government (Eldon & Commins 2012). Line ministries at state-level hold decision-making powers in water resources management, whereas the national government can only enable or discourage state-level policies (Panagirya 2008). States create water legislation and form their own strategies for water provision (Manthan 2007). This remit includes the determination of water rights, supply of hydropower, and urban-rural allocations. State and parastatal agencies also exert a large degree of influence on city-scale water infrastructure, not only as the mediating distributor of centralized funds, but also as direct project implementers.

Indian cities rarely have the technical capacity to negotiate with private firms directly (Mahalingam, Devkar & Kalidindi 2011; Planning Commission 2011). To address the imbalance between private firms and urban local bodies, both the central government and many state governments have created supportive PSP entities. The national government's Ministry of Finance houses a Public Private Partnerships (PPP) agency, which in turn supports nodal PPP units at state level (Department of Economic Affairs 2012). Most states also maintain separate infrastructure development entities that assist in PPP implementation[4].

4. Jharkhand and Jammu and Kashmir are the only two states without a formal PPP nodal agency, and Jharkhand is the only state that contains an urban water PSP initiative but does not house a PPP cell.

Still, the impact of services provided by states varies widely. This point is illustrated by the vast disparity in implementation of water PPPs across states (see Table 2). State-level PPP agencies are supposed to build capacity within ULBs to work with the private sector.

Table 2. Urban water PSP initiatives, 1992-2011

State	Number	Cities	Year
Maharashtra	10	Pune, Sangli, Mumbai, Chandrapur, Ulhasnagar, Latur, Nagpur, Bhiwandi Nizampur, Pimpri-Chinchwad	1996
Gujarat	5	Surat, Morbi, Anand, Amreli, Bharuch	2008
Karnataka	5	Bangalore, Gulbarga, Belgaum, Hubli-Dharwar, Mysore	1997
Madhya Pradesh	4	Delwas, Bhopal, Khandwa, Shivpuri	2005
Chhattisgarh	2	Borai, Naya Raipur	1998
Jharkhand	2	Adityapur, Jamshedpur*	2006
Tamil Nadu	2	Tirupur, Madurai	2000
West Bengal	2	Kolkata, Haldia	2007
Andhra Pradesh	1	Hyderabad	1992
Assam	1	Guwahati	2010
Bihar	1	Patna	2010
Delhi	1	Delhi	2001
Rajasthan	1	Ajmer	2011
Uttar Pradesh	1	Meerut	2009

** Technically, Jamshedpur's water service was privatized in 1918, but for the purpose of this analysis -since the state of Jharkhand was not formed until 2000- I consider Adityapur as the site of the first PSP initiative in modern Jharkhand.*

In addition to describing variation in the number of initiatives, I model this relationship for 32 states and Union Territories[5]. The dependent variable in this analysis is the number of privatization initiatives in each state. Since the distribution of initiatives by state does not approximate a normal distribution and is over-dispersed (the conditional variance of the dependent variable exceeds the conditional mean), I employ negative binomial regression. The primary control variable is state population, which I expect to have a positive correlation to the number of PSP initiatives, since states with larger populations are more likely to have a greater number of projects. I include state income per capita, which I hypothesize will have a positive relationship with the number of privatization initiatives. Private firms will typically provide water services in cities where they expect to make a profit (Araral 2009; Bakker 2009); profit is not feasible in very poor Indian states[6].

5. I exclude the smallest six states and Union Territories, for which there is no prospect of urban water service privatization or reliable data for the relevant independent variables.

6.But, it may also be argued that very rich states are more capable of delivering adequate services through the public sector, so middle-income states may be more likely to facilitate privatization. I explored the possibility of a non-monotonic relationship between PSP and income to see if this is the case, but find that it adds no explanatory value.

I also include a proxy for the state's current technical capacity to provide service: the percentage of urban households that have access to safe drinking water. The most basic argument for private sector participation is that the private sector can provide water more efficiently than the public sector (Finger & Allouche 2002; Little 2010). Accordingly, states with lower levels of urban water service provision should be more inclined to privatize service when all other factors are held constant.

Finally, I created a variable to measure the potential ideological influence of state politics on PSP. Accordingly, I include a dichotomous variable that shows whether the BJP (solely or as a major coalition partner) won the last 2 state elections, which I expect will be associated with private sector participation. I found no major cause for concern regarding the collinearity of the variables. Data for population, income, and water resources predictor variables are taken from the 2001 census, since reliable state-level data is not available on an annual basis. 2001 also represents a defensible time point to assess pre-PSP conditions across states, given the fact that only six initiatives began before 2001.

Table 3 shows the results of the negative binomial regression model. Given the small sample size and exploratory nature of the analysis, I consider associations with $p<.10$ to be statistically significant. Population affects the number of PSP initiatives in the expected, positive direction. More notably, the presence of the BJP also has a significant and positive effect. Surprisingly, when tested in univariate analyses or in combination with other variables, state income and urban water access have no effect on the number of state PSP initiatives. Indeed, after controlling for population, politics, and income, the relationship between existing urban water service does not even operate in the expected direction. The size of state population and political ideology appear to be much better predictors of private sector participation in urban water than economic or technical factors. I also consider alternative specifications of the model to ensure its robustness[7].

Table 3. Total number of privatization efforts across Indian states (n = 32)

Independent variable	Coefficient	SE	P > |z|	95% CI
Population (millions)	.03391	.01049	0.001	.01334 -.05447
BJP	1.65971	.67806	0.014	.33074 - 2.98867
Per capita net state domestic product (Rs)	.00003	.00004	0.539	-.00005 -.00011
% urban households with access to safe drinking water	.00822	.02752	0.765	-.04573 -.06216

7. For instance, if the three states with the largest number of initiatives are excluded, this does not dramatically change the predictive value of the independent variables in the model. Not classifying Maharashtra as a BJP state may also be understating the influence of the BJP and Shiv Sena in influencing the state's urban policy, since these allied parties have an outsized influence in Maharashtra's cities. Finally, I consider whether the inclusion of unsuccessful PSP initiatives is determining the results, but find it is not.

City Level Results And Discussion

Although it yields valuable findings, the state-level model clearly has conceptual limitations. PSP projects may be conceived at the state scale, but they are implemented at the city or sub-city scale, and intra-state factors may greatly influence the implementation process. The data or appropriate temporal distance to thoroughly analyse the performance of urban water privatization initiatives across India is not yet available. Instead, I use econometric techniques to analyse political and economic factors that contribute to differences in two key PSP contract terms across cities: the type and length of contract.

This exploratory modelling takes advantage of the range of available political and economic contract-stage variables that I expect to correlate to two different outcomes: contract length and contract type. The independent variables I employ are city population, the year of contract initiation, the contract's inflation-adjusted cost, the origin of the private party, a binary variable indicating whether the initiative was 'all-inclusive,' and binary variables indicating whether BJP or Congress controlled the city.

1. Contract Type

This study excludes pure BOT projects but includes urban water PSP projects with an infrastructure-building focus (with some requirement to engage in on-going distribution to households) or an end-delivery focus. While neither model is clearly more beneficial to cities, projects focusing purely on distribution present more risk both to cities and private firms. A binary logit model delineates the differences between these two project types. Table 4 shows that infrastructure-focused projects are more costly than pure distribution projects, most likely due to the large fixed cost of construction. After controlling for inflation-adjusted cost, pure distribution projects have become more common over time. This shift likely reflects the change in political rhetoric to promote pilot '24x7' schemes that promise comprehensive solutions to water access deficiencies, discussed more extensively further on.

Also, the model shows that as a city gets larger, it is more likely to feature an exclusively distribution-focused project to serve households. Because the political economy of urban Indian rarely allows for complete outsourcing of water service, smaller cities can only attract private firms by promising higher-cost, infrastructure-focused projects. BJP or Congress control of the city does not determine project type, as a standalone explanatory variable or when added to the model above.

Table 4. Infrastructure-Focused PSPs in Indian cities (n = 31)

Independent variable	Coefficient	SE	P > |z|	95% CI
Population (thousands)	-.0044	.0021	.042	-.0086 - .0002
Year (normalized)	-.5659	.2925	.053	-1.1391 - .0074
Cost (Rs)	.0027	.0014	.046	.00005 - .0054

2. Contract Length

The contract length of these initiatives more clearly influences their potential impact on project stakeholders. Cities (and their residents) should generally favour shorter contracts, which give them more negotiating power over private firms. The opposite is true for firms, since shorter contracts reduce their guaranteed return on initial investment and the expected value of their revenue stream. The contract length of Indian urban PSPs in water more closely resembles a bimodal rather than continuous distribution. Accordingly, I classify projects dichotomously as either long (+20 years) or short (=< 20 years).

Table 5. Univariate associations with long contract length*

Independent variable	Contract Length, %		P > |z|
	Short	Long	
Congress (N=26)			
Yes	26.9	7.7	0.097
No	23.1	42.3	---
BJP city (N=24)			
Yes	8.3	37.5	0.019
No	37.5	16.7	---
All-inclusive scheme (N=32)			
Yes	21.9	3.1	0.041
No	31.3	43.8	---

**Fishers exact test used for comparisons due to small cell sizes*

But none of the standard variables that I use to try explain contract length -population, year or type of contract, or type of firm involved- are borne out in multivariate modelling as statistically significant correlates. Consequently, I focus on simple statistical associations (see Table 5). These relationships suggest an interesting and distinctively Indian political story. First, all-inclusive schemes that promise ‘24x7’ water supply are significantly shorter than other types of projects. In other words, cities appear to limit the potential risk of high-involvement initiatives by decreasing their mandated length.

The BJP and Congress were almost evenly split in terms of their control of mayorships (12 v. 11). Using the limited data I have for party status, I also find that BJP control of cities is significantly associated with longer length of projects, whereas Congress control is significantly associated with shorter length. This finding coheres with the general perception that the BJP favours privatization, whereas Congress remains more wary of the strategy. About sixty per cent of privatizing cities featured alignment between the ruling party of the city and state, suggesting that political coherence across scales may facilitate PSP implementation.

Conclusion

I have shown how the rise of private sector participation in India's urban water service was influenced by structural changes in the national political economy, urban governance framework, and water sector. But the implementation of private sector participation has been slow and uneven across India due to variation among states and the unique insularity of India toward foreign involvement. Yet the strategy appears to be gaining momentum, with domestic firms becoming more popular and all-inclusive schemes becoming more prevalent over time.

The results of this study have several clear implications. In terms of policy, the findings help to elucidate the effect of national and state level urban governance changes on urban service delivery in India. The study also expands our understanding of the conditions under which private sector participation in water delivery is likely to be implemented by highlighting the importance of varying political regimes, economic constraints (for cities), and economic opportunities (for firms). The influence of the BJP and Congress on implementation is particularly notable, and will have ramifications as the influence of these hegemonic parties wanes.

In terms of research methods, this study tests political and economic variables that had not been sufficiently explored in the context of a low or middle income country to date. The variables shown to have a statistically significant effect on the decision of cities to privatize their water service should be tested in comparable settings. Future research must attempt to go beyond the contract stage and, with more robust political data at the city level, employ methods used in high-income countries.

In terms of research content, there are several interesting avenues that stem from this research. To understand the dynamics of Indian water PSP better, we need to study the identity and enhanced role of Indian firms as well as the success and motivations of PSP resistance movements. Also, future research must come closer to quantifying the most important question with regard to private sector participation: What is PSP's effect on household welfare? While the contract-stage data do not allow us to evaluate directly the effectiveness of private sector participation in improving household service delivery, I suggest that future research can employ similar independent variables to explain differences in household access in cities implementing PSP. Though I am eager to examine this question, the data constraints currently appear prohibitive in India.

Looking forward, the debate over private participation in urban water will surely rage on in India. It is important for both PSP advocates and critics to evaluate the performance of the private sector against the status quo of urban water service and against the strategy's empirical track record, not against rhetoric. Further national and state reforms must enhance the capacity of city governments and ensure that contract terms are more favourable to cities. Without further reform, the historical legacy of empty promises regarding basic service provision made by both the public and private sectors to urban residents will continue.

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References

Aiyer, A. (2007) 'The allure of the transnational: Notes on some aspects of the political economy of water in India', Cultural Anthropology, 22 (4): 640-658.

Annez, P. C. (2010) 'Financing Indian cities: Opportunities and constraints in an Nth best world', (Policy Research Working Paper Series no. WPS5474). Washington, DC: The World Bank. Retrieved from http://documents.worldbank.org/curated/en/2010/11/13079759/financing-indian-cities-opportunities-constraints-nth-best-world

Araral, E. (2009) 'The failure of water utilities privatization: Synthesis of evidence, analysis and implications,' Policy and Society, 27: 221-228.

Bakker, K. (2007) 'Trickle down? Private sector participation and the pro-poor water supply debate in Jakarta, Indonesia,' Geoforum, 38 (5): 855-868.

Bakker, K. (2009) Privatizing water: Governance failure and the world's urban water crisis. Ithaca, NY: Cornell University Press.

Bakker, K. (2013) 'Neoliberal Versus Post-neoliberal Water: Geographies of Privatization and Resistance', Annals of the Association of American Geographers, 103: 253-260.

Bardhan, P. (2004) 'Governance issues in delivery of public services,' Journal of African Economies, 13 (AERC Supplement 1): i167- i182.

Barkin, D. and D. Klooster (2006) 'Water management strategies in urban Mexico: Limitations of the privatization debate', MPRA Paper, University Library of Munich, Germany. Retrieved from http://EconPapers.repec.org/RePEc:pra:mprapa:15423

Centre for Science and Environment (2011) 'Water PPPs: are they here to stay?'. Retrieved from http://www.cseindia.org/userfiles/fullstory_final.pdf

Crisil Infrastructure Advisory (2010) 'Perspectives on PPP design and implementation in water sector in India'. Retrieved from http://crisil.com/pdf/infra-advisory/5-theme-presentation-closed-door-session.pdf

Davis, J. (2003) 'Corruption in public services: Experience from South Asia's water and sanitation sector', World Development 32 (1): 53-71.

De Gouvello, B., J. L. Emilio and F. Brenner (2012) 'Changing paradigms in water and sanitation services in Argentina: towards a sustainable model?', Water International, 37 (2): 91-106.

Department of Economic Affairs (2012) 'Public Private Partnerships India Database', New Delhi: Ministry of Finance, Government of India. Retrieved from http://www.pppindiadatabase.com

Dreze, J. and A. Sen (2011, November 14). 'Putting growth in its place: It has to be but a means to development, not an end in itself,' Outlook India. Retrieved from http://www.outlookindia.com/article.aspx?278843

Eldon, J. and S. Commins (2012) 'Towards a framework for better donor engagement in fragile federal states: Lessons from Balochistan'. London, UK: HLSP Institute. Retrieved from http://www.hlsp.org/LinkClick.aspx?fileticket=1wBCQ5NePZs%3D&t

Finger, M. and J. Allouche (2002) Water privatization: Trans-national corporations and the re-regulation of the water industry. New York: Spon Press.

Flynn, S. and D.M. Chirwa (2005) 'The constitutional implications of commercializing water in South Africa'. In D. McDonald and G. Ruiters (eds), The age of commodity: Water privatization in Southern Africa. London: Earthscan.

Goetz, A. M. and R. Jenkins (2001) 'Hybrid forms of accountability: Citizen engagement in institutions of public-sector oversight in India', Public Management Review, 3 (3): 363-383.

Gopakumar, G. (2010) 'Transforming water supply regimes in India: Do public private partnerships have a role to play?', Water Alternatives, 3 (3): 492-511.

Hall, D. and Lobina, E. (2007) 'International actors and multinational water company strategies in Europe, 1990–2003', Utilities Policy, 15 (2): 64-77.

Hardoy, A. and R. Schusterman (2000) 'New models for the privatization of water and sanitation for the urban poor', Environment and Urbanization, 12: 63-76.

Hart, G. (2011) 'The contradictions of local government', South African Labour Bulletin, August/September 2011. Retrieved from http://www.wolpetrust.org.za/dialogue2011/Hart%20Wolpe%20Dialogue.pdf

Manthan Adhayayan Kendra (2007) Water: Private, limited; Issues in privatization, corporatisation and commercialisation of water sector in India. Bhopal, India: Aadarsh Printers & Publishers.

Manthan Adhayayan Kendra (2012) 'Database: PSP in water, sanitation, solid waste management and sewerage projects'. Retrieved from http://www.manthan-india.org/IMG/pdf/PSP_Database_-Sept_2012.pdf

Mahalingam, A., G.A. Devkar and S.N. Kalidindi (2011) 'What works and what doesn't: A comparative analysis of public-private partnership (PPP) coordination agencies in India', Public Works Management &Policy, 16 (4): 341-372.

McKenzie, D. and I. Ray. (2009) 'Urban water supply in India: Status, reform options and possible lessons'. Water Policy, 11 (4): 442-460.

Ministry of Urban Development (2009) 'Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT): Overview and salient features'. Delhi: Ministry of Urban Development, Government of India. Retrieved from http://www.urbanindia.nic.in/programme/ud/uidssmt_pdf/overview.pdf

Ministry of Urban Development (2012) 'Improving urban water supply and sanitation services: Advisory note'. New Delhi: Government of India. Retrieved from http://www.indiaenvironmentportal.org.in/files/file/Advisory_Note_uwss.pdf

Pierce, G. (2014). 'Beyond the Strategic Retreat? Explaining Urban Water Privatization's Shallow Expansion in Low- and Middle-income Countries', Journal of Planning Literature, 0885412214562427.

Planning Commission (2011) 'Faster, sustainable and more inclusive growth: An approach to the twelfth five year government of India plan'. Government of India Planning Commission. New Delhi: India Offset Press.

Public-Private Infrastructure Advisory Facility (2007) 'Public private partnership units: Lessons for their design and use in infrastructure'. Washington, DC: Public-Private Infrastructure Advisory Facility, World Bank. Retrieved from http://www.ppiaf.org/sites/ppiaf.org/files/publication/WB%20-%20PPP%20Units%202007.pdf

Rao, B. (2009) 'A ranking scheme for Asian water utilities', Working paper 9. Singapore: Institute of Water Policy.
Registrar General of India (2011) 'Census of India 2011'. New Delhi: Ministry of Home Affairs, Government of India. Retrieved from http://censusindia.gov.in/

Ruet, J., V.S. Saravanan and M.H. Zérah (2002) 'The water and sanitation scenario in Indian metropolitan cities: Resources and management in Delhi, Calcutta, Chennai, Mumbai', Occasional Paper 6, Centre de Sciences Humaines.
Sarangi, G. (2010) 'Towards a public-private partnership regime: An analysis of water-supply systems in urban India', ASIEN - German Journal on Contemporary Asia, 117: 45-57.

Sen, A. (2000) Development as freedom. New York: Random House.

Singh, M. R., A. K. Mittal and V. Upadhyay (2011) 'Benchmarking of North Indian urban water utilities', Benchmarking 18 (1): 86-106.

Vedachalam, S., Geddes, R., and S.J. Riha (2014) 'Public-Private Partnerships and Contract Choice in India's Water and Wastewater Sector'. Available at SSRN 2426629.

Wang, H., W. Wu and S. Zheng (2011) 'An econometric analysis of private sector participation in China's urban water supply', Utilities Policy, 19(3): 134-141.

Water and Sanitation Program (2011) 'Trends in private sector participation in the Indian water sector: A critical review.' Washington, DC: Water and Sanitation Program, World Bank. Retrieved from http://www.wsp.org/sites/wsp.org/files/publications/WSP-Trends-Private-Sector-Participation-India-Water.pdf

Yeboah, I. (2006) 'Subaltern strategies and development practice: urban water privatization in Ghana', The Geographical Journal, 172 (1): 50-65.

Water into whine: Why deliberative governance of South Asia's rivers is little more than a talk shop

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Introduction

Deliberative governance of South Asia's transboundary waters is an eminently good idea – in theory. Deliberative (or discursive) governance is the beguiling notion that decisions about socio-political issues such as river management can and should be made by consensus reached through inclusive, honest, thorough round-table discussions. It is a theory of democracy that emphasizes active civic participation and implies stakeholders and end-users must be consulted and involved in any decisions that may affect them.

In the case of managing South Asia's transboundary rivers, there are strong arguments for using deliberative governance. For a start, it is a region culturally predisposed to public debate and with a strong commitment to pluralistic democracy. At the same time, it is a region with few institutional mechanisms for multi-lateral governance of shared issues such as natural resource management or climate change adaptation. The South Asian Association for Regional Cooperation (SAARC), for example, is widely considered to be weak and ineffective. In this institutional vacuum, deliberative governance could flourish as a means of semi-formal political decision-making that involves non-state actors and stakeholders who are directly relevant to the issue at hand, rather than only those who are represented in the existing institutions.

Moreover, transboundary waters are not limited to political boundaries and states are not the only stakeholders in river governance. Involving those who use water in plans about how it is to be managed and developed is sensible. After all, there are likely to be unforseen and unintended consequences of policies undertaken with only one set of interests in mind. When a hydropower dam is to be built, for example, it is not only those who receive electricity that will be affected, but also those who must be displaced, or those whose fishing livelihoods are undermined by altered river flow patterns. Or if new anti-pollution regulation closes tanneries and mines, there will be a loss of jobs and investment. There are always trade-offs and linkages to be considered, but these may not always be immediately obvious and can only be uncovered through discourse.

Taking a deliberative governance approach would bring such concerns to light before projects are begun. Discussions with stakeholders could lead to the development of more equitable, mutually beneficial solutions to water management problems. And of course any decisions that are made with the participation of end-users are likely to have more support and 'ownership' of the solution being implemented.

What, then, is the problem with deliberative governance of transboundary waters in South Asia?
There seems to be little political will to tackle the region's growing water crises, and even less political will for taking deliberative governance as a serious approach for managing South Asia's

rivers. And where deliberative governance does exist, it does not address the power asymmetry between actors. With India as the largely un-challenged hydro-hegemon, there is much distrust and resentment between riparians that get in the way of open discussion and equitable resolution of shared problems. Until that is rectified, attempts at deliberative governance of transboundary rivers will not succeed in increasing cooperation or positive-sum outcomes of the region's water problems.

The most popular manifestation of deliberative governance in South Asia is through 'Track II dialogue'. This is the bringing together of government and non-government entities to discuss socio-political problems, usually through workshops or round-table meetings. The main proponent and facilitator of Track II dialogues on transboundary water issues is the World Bank-funded South Asia Water Initiative (SAWI).

Although having an outside, international organisation to provide a neutral, independent facilitation of politically sensitive issues is often necessary, such meetings are unlikely to institute change without domestic political will for it. In other words, SAWI's support for Track II dialogue only provides a space in which issues can be discussed, but does little to encourage decision makers to take serious action on increasing cooperation over the management of transboundary waters in South Asia. It seems unlikely that these efforts at Track II dialogue will have much effect at all without the political will of decision makers. The first task of deliberative governance, therefore, is to create this political will – which is, of course, easier said than done.

Further, bringing together government and non-government actors does not necessarily even out the power asymmetry between them or provide tangible options for increasing the 'issue power' of weaker actors (i.e. the negotiating strength the overall weaker party has in a particular dispute). Multilateralism and the political atmosphere conducive to negotiating positive-sum outcomes cannot be achieved without addressing systemic power inequalities between actors. Yet, this is an aspect of transboundary water interactions not often considered by or incorporated into the initiatives of non-state actors working in South Asia.

Initiatives for improving transboundary water interactions must first and foremost address the power asymmetry between actors, and acknowledge that power is fluid and asymmetries exist at every level and may differ across domains. That means an actor with low overall power but high issue power may be able to negotiate equitable outcomes; it is not a foregone conclusion that the hegemon's will always prevails. Creating opportunities for leverage (such as through issue linking) and facilitating negotiations is one way of deliberative governance providing tangible mechanisms for addressing power asymmetry.

The region is dominated by the hydro-hegemon, India, which not only has the most political, economic, military, and soft power in the region, but also occupies a central geographic location – Pakistan, Nepal, Bhutan, and Bangladesh all share borders with India, but not with each other. This does not mean that India is a regional bully, but it does mean that deliberative governance of transboundary waters requires India's participation and consent.

It seems a lost opportunity that current efforts at Track II dialogue do not focus on making India (that is to say, Indian government and non-government actors) take a greater leadership role in the management of the region's rivers. After all, the original Greek meaning of hegemony is 'leadership buttressed by authority' (as opposed to dominance, which is 'leadership buttressed by coercion.') [1]

Is deliberative governance worth pursuing in the management of South Asia's transboundary waters, if it has no political will behind it and if it does not address power asymmetry between actors? Of course.

Deliberative governance may not be currently very effective at increasing multilateralism and benefit sharing, but it is not doing any harm. And although the Track II dialogue in the region is not much more than a repetitive talk shop, it is through talk that paradigms shift. The process of shifting the dominant paradigm of water governance is a long and slow one, made up of an incremental and uncontrollable series of minor positive changes that ultimately add up to large-scale progress.

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1 Zeitoun, M., & Warner, J., 2006, 'Hydro-hegemony - a framework for analysis of trans-boundary water conflicts', Water Policy, Vol. 8 (2006), p. 438

Book Review

Diverting the Flow: Gender Equity and Water in South Asia

Margreet Zwarteveen, Sara Ahmed, Suman Rimal Gautam, Editors.
Zubaan 2012. 623 pp.

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This book belongs to a series produced by SaciWATERs, the South Asian Consortium for Inter-Disciplinary Water Resources Studies, under the Crossing Boundaries Project, that seeks to further inter-disciplinary and gendered analysis of water management in South Asia. The book engages with critical issues surrounding the interface of gender with questions of water provisioning and access, technology, and agrarian change.

The contributors –a mix of academicians and practitioners – draw on research and policy experience in India, Nepal, Bangladesh, and Sri Lanka, providing a nuanced analysis of gender as a social construction located in time and space, and its interface with other axes of social differentiation mediated by a predominantly male, techno-centric hydrocracy. As the editors rightly point out in the opening section, these factors make the 'water sector' somewhat gender insensitive in South Asia.

Though the region has well developed water histories, they seem to be silent on issues of gender, even though, as several subsequent contributions point out, women have been an important part of social movements and struggles around water. Women have lacked space in formal arenas of water management that has been predominantly masculine and dominated by engineer(ing). New policy and legal provisions have done little to change this.

Subsequent sections provide insightful case studies that show the different ways in which this manifests itself. Section 2 discusses the interface of water laws and policies with gender. Seema Kulkarni and K.J. Joy offer a critical gendered analysis of policies for decentralization. Driven often by a donor agenda and a belief in the potential of community-based natural resource management, decentralization came to be seen as a 'one size fits all' panacea for the ills of the water sector, especially during the late 1990s. Kulkarni and Joy, however, argue that contrary to its professed goals, decentralization does not necessarily lead to an inclusion of women and marginalized groups into water governance. There is instead a need to rethink the reform agenda and mark a paradigm shift to democratic decentralization.

Priya Sangameswaran, drawing on different conceptualizations of the 'right to water' and its links with gender, highlights the several paradoxes and controversies surrounding its institutionalization and operationalization as a human right. Drawing on the experience in Sri Lanka, Athukorala and Rajepakse argue that, though women have played an important role in localized struggles for water, as is also argued elsewhere in the book, their presence is inconspicuous in statutory arenas. Water rights are tied to land rights and land titles are conferred on men; they also enjoy an edge over women with respect to inheritance.

Further, the management of irrigation systems takes shape through farmer organizations that rely predominantly on male title holders.

Section 3 pays attention to gender issues in drinking water supply and sanitation. Drawing on work in Bangladesh, Joshi, Fawcett, and Mannan critique neo-liberal emphases on cost recovery and privatization, noting that they are not consistent with the commitment to the attainment of the Millennium Development goals. Nitish Jha notes that a careful analysis of the gender based division of labour has policy implications; it can provide some insights into improving participation in water supply schemes. Farhana Sultana points out that the arsenic crisis in Bangladesh needs to be seen as a broader socio-ecological crisis, rather than as one of drinking water provision only. Mere technological fixes may not provide solutions as long as they are divorced from the lived experiences of women and the rural poor. Kathleen O'Reilly raises the level of debate one step further, looking at how meanings of 'modernity', 'women', and 'water' themselves are socially constructed over the course of water supply interventions. Also, how a 'traditional' woman becomes 'modern' through the social meanings attached to new responsibilities in water management, to training, and increased mobility.

This means that in discourses on development and empowerment it is necessary to question implicit assumptions and biases regarding what constitutes development, modernity, or empowerment.
Some very refreshing insights appear in section 4. It deals with questions of the gendered dimensions of agrarian change, often overlooked in mainstream discourses of both gender and the water economy. In India, and more generally South Asia, groundwater markets have for long been debated for their equity, efficiency, and sustainability implications. Anjal Prakash, drawing on his study of groundwater markets in Gujarat, places the debate in a gendered context. He shows how the exploitation of women's labour has been a fundamental aspect of agrarian economy in general, and groundwater economy in particular. Likewise, Buechler and Mekala provide a refreshing perspective on the use of waste-water in agriculture that is most commonly researched from a very instrumental angle - with respect to its implications for livelihood security and agricultural productivity. They show, instead, how caste, class, and gender intersect to establish a hierarchy in the use of wastewater.

There is a need, therefore, to reconceptualise the 'waste-water user' for further research and policy making on its use.

Contributions in section 5 use a socio-technical lens to explore the gendered dimensions of water technology. They suggest the relevance of placing studies of technology in their institutional context. Bhawana Upadhyay, noting that the literature on irrigation technology in Nepal has been silent on questions of gender, observes that especially in landless and small cultivator households, women are more involved in the overall activities of vegetable farming and in operating treadle pumps. The social dynamics of households and communities – in particular, intra-household gender relations - need better appreciation to understand the impact of new water technologies. Similarly, in the context of arsenic and fluoride contamination of groundwater, Nandita Singh argues that the impacts of new technologies need to be seen in the context of the gender-based socio-cultural realities of the users; simply installing new technologies does not imply that women will be comfortable using them. Furthering the debate on the social impacts of large dams, Lyla Mehta shows that these impacts are gendered. Displacement and resettlement are gendered processes; the benefits of large dams are gendered and so are social movements against large dams.

Section 6 is devoted to a discussion of strategies for gender mainstreaming in water policies and programmes. Panda and Sannabhadti draw on the experience of SEWA -Self- Employed Women's Association- in Gujarat in fostering collective action among women, challenging the stereotype that water management is a technical affair and a prerogative of men. Drawing on her research in Nepal, Udas notes mainstreaming gender to be a politically contested process.

Policy implementation is not a linear process, but an interactive one. The implementation of gender-related policy objectives depends on their translation by implementing actors with different perspectives, beliefs and norms. These beliefs and norms are further shaped by the organizational and professional culture to which they belong. The interface of organizational culture and personal identity shape the outcomes of gender policy in water.

These perspectives and experiences are nicely summed up in the respective contributions by Kuntala Lahiri-Dutt and Frances Cleaver. Women and their needs and rights typically go unheard and unseen, even as they are widely involved in water related work. How women experience the impacts of water interventions depends on where they are located spatially and socially. This is not to suggest that they are passive recipients of change.

On the other hand, their experience is further shaped by the exercise of human agency in responding to these changes.

The book is indeed a timely contribution to the discourse on gender and water in South Asia. It raises the level of debate on gender and water management more broadly, highlighting the complex relationships between questions of technology and agrarian change on the one hand and the intersection of caste, class, age, and other axes of social differentiation that shape gender as a form of power relationships with the other. The insights challenge some of the widely held assumptions about aspects of the water economy as well as the social practices and norms in which water management and governance are embedded.

It seems that the way forward -as the editors rightly point out in the introduction- is to have a greater dialogue among engineers and social scientists, academics and practitioners, government and civil society. Though they all differ in perspective and orientation, they seem to cherish a common ideal – that of a better water future for men and women alike!

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