CASE STUDY

ICT FOR PUBLIC PARTICIPATION IN RIVER WATER QUALITY MANAGEMENT – AN ASSESSMENT OF KNOWLEDGE, READINESS AND WILLINGNESS

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Abstract

Public participation in water resources management and use of information and communication technologies (ICTs) for engaging with public have both been studied extensively albeit independently by researchers. The use of ICT for managing water resources in developing nations like India has mainly been top-down and technical in nature and has not found much role in participative and deliberative decision-making processes. The objective of this study is to understand the role that ICT can play in participative river management. Based on a face-to-face questionnaire survey with 2706 respondents along the River Yamuna in India and key informants' interviews, the study aims to explore the knowledge, readiness and willingness of the public to use ICT for participation in river water quality management projects and their perception about the technology that would be most effective for that purpose. The findings reveal the familiarity of people with television and mobile phones across different socio-economic groups. However, knowledge of computer and the internet was stated mainly by the higher income and the literate groups confirming that the impediments associated with trickling down of technology is not just limited to access but also to lack of education. Gender-based differentiation in knowledge and readiness was also observed in the study. ICT for receiving information was the key role perceived by the respondents, and higher order participation roles like consultation, virtual representation and monitoring were perceived only by the educated class. The paper suggests "belongingness" to the river and "benefits" from the participation process as the two key drivers for willingness of the public to participate.

Keywords: Public participation, Information Communication Technology, Water quality management, Knowledge, Readiness

Introduction

There is a widespread understanding that information and communication technology (ICT) can play an important role in capacity building and participation of citizens in decision making (Greenberg, 2005; Kozma, 2005; Irawan, 2014), especially in the context of developing countries. Deliberations in the field of information and communication technology for development (ICT4D) formally started in 1980s and the focus was primarily on information systems (IS). The field gained impetus after the conference in New Delhi, India in 1988, organised by Federation of Information Processing (IFIP) on the "Social implications of IS in developing countries" (Walsham, 2010). It proposed that the ICT platform can be leveraged to connect the diverse set of stakeholders like government and non-governmental agencies, private firms, donor agencies, investors, political groups and the citizens, who are linked directly or indirectly with the development process resulting in transparency and participative decision making (Heeks, 2009). The growth of mobile phones in the last decade has led to a surge in the use of ICTs in most developing countries (Loh, 2015). An eminent development studies scholar Robert Chambers had this to say about ICTs –"…cornucopia of potentials through email, internet, video conferencing, participatory GIS, mobile phones, SMS, blogging, twitter and beyond…a whole new domain of participatory interaction has opened up (Chambers, 2010 p. 29)".

Nevertheless, it is apparent from the literature that ICT4D projects globally have not seen substantial success (Chaudhuri, 2012; The World Bank, 2016). An eminent scholar in ICT4D, Richard Heeks described most projects as resulting in "partial failure, sustainability failure or complete failure" (Heeks, 2009). A Microsoft programmer who visited India in 2004 for using technology to improve education later described the work in the field of ICT4D as 'empty sloganeering that collapse[s] under critical thinking' (Lamont, 2015). The World Development Report published in 2016 on 'Digital Dividends' by the World Bank Group mentions that the benefits being derived from the digital technologies do not commensurate to the speed with which the technology is penetrating and, in some cases, the digital revolution has played a role in widening the inequality gap (The World Bank, 2016).

The growth of ICT in India in the last two decades has been remarkable. The percentage of the Indian population using the internet has grown from 0.1% in 1998 to 36.4% in 2016 (Internet World Stats, 2017). While the overall growth in the number of internet users in India appears promising, the penetration in the rural area stands only at 16% and is a major impediment in trickling down of the development benefits to the last mile (The Economic Times, 2017). But the reason for the digital divide cannot be solely attributed to lack of access to technology. It is a more complex issue and is embedded in the social, political,

institutional and cultural fabric of the community which makes the technology available, accessible, affordable and comprehensible to the people (Liew, Vaithilingam and Nair, 2014; The World Bank, 2016). India currently ranks at 36th position globally in terms of internet inclusion based on availability, affordability, relevance and readiness (Deloitte, 2017). The penetration of television in India went up to 64% in 2017, which is a jump of 10% from 2013. Unlike the internet, it is encouraging to see that television ownership in rural India is 17% higher than in urban India (Business Standard, 2017). The number of mobile phone users in India stands approximately at 700 million of which the smartphone user base is about 300 million and is expected to reach 468 million by 2021 (Statista, 2018).

Prima facie, ICT in India is seen as a popular tool for awareness generation, running of online education programmes and for consultation with the public on developmental issues (Jyoti et al., 2017). It has also contributed significantly to improved accessibility and transparency in government services (Walsham, 2010). ICT-based applications like geographical information system (GIS) are helping in better planning of utilities, mapping of resources and infrastructure development (Gouveia et al., 2008). The capability of ICT as an information-sharing tool is also being used for empowering people by giving them remote access to data, helping them take more informed decisions and collaborating with them for effective planning of projects (Unwin, 2009). Other applications like computerized milk collection centres, telemedicine centres, e-government services, and improved access to microfinance through smart cards have also been experimented in rural India with mixed outcomes (Kumar and Best, 2006; Abraham, 2007; Noir and Walsham, 2007; Ghosh, 2011).

Ict for Public Participation in Water Management

Smart water management has become a key policy subject in the 21st century especially in the backdrop of growing water scarcity due to growth in population, industrialization, rapid urbanization and more frequent extreme weather events due to climate change (International Telecommunication Union (ITU), 2011; Pagani and Aiello, 2012). Innovations around ICT have enormously benefited the water sector, as the design, operation and optimization of water infrastructure as well as the wastewater systems have improved manifold with the use of information technology (Swinford and Jeffrey, 2000; Guimaraes Pereira et al., 2003). Today, we use advanced modelling tools to plan projects and use smart-metering to optimize water supply, estimate demand and forecast the need with greater certainty (International Water Association, 2016).

Article 14 of the European Commission (EC), Water Framework Directive (WFD) impresses upon comprehensive ecological protection of water bodies with public participation being key requirement of the river basin management planning process (RhineNet, 2008; Woods, 2010). People who advocate public participation have found that co-management practices result in a more equitable and transparent process, which helps in avoiding conflicts (West, 1989; Jentoft, 2000). Further, it is believed that public participation helps in generating a sense of ownership of the resource and also maintain a long term commitment from the community for its management (Whittington et al., 2008). Swinford and Jeffrey (2000) suggest a close link between water resources management, public participation, and the inclusion of ICT for participation, referred to as 'e-participation', in the decision-making process (Swinford & Jeffrey, 2000). Researchers believe that e-participation can help in strengthening collaboration between governments and citizens resulting in improved access to information, public participation in policy-making, and facilitation of electronic consultation (Panopoulou, Tambouris and Tarabanis, 2014).

Notwithstanding the growth in the application of ICT, the public in developing countries by virtue of inherent disparities still experience difficulties in access to the ICT and its applications. The United Nations Development Program (UNDP) has drawn from Arnstein's 'A ladder of citizen participation' (Arnstein, 1969) and International Association for Public Participation's (IAP2) 'spectrum of public participation' (Korff et al. 2010; Luyet et al. 2012), and suggested a model, as shown in Figure 1, on the processes involved in getting the people at the last mile involved in participation (PIWA and UNDP, 2011).

Barriers in Using ICT for Public Participation

Researchers studying the use of ICT for development have come out with several barriers to implementation of e-participation. The first are the problems associated with the cultural barrier that is the social context in which the technology is implemented including community readiness and gender inequality (Robey and Rodriguez-Diaz, 1989; United Nations Development Programme, 2016). The second barrier is related to the need for indigenization of the technology

Information	Consultation	Representation	Volunteering	Monitoring
One-way relationship in which citizens receive information Citizens are viewed solely as the users of information. The impact may not be significant.	Two-way interaction via forums, opinion surveys, polls, etc. Formulating opinions on issues May help in defining the content of policy.	Presence within institutions where decision-making takes place. Citizens can set up an agenda and define its content in partnership with governmental bodies.	Can enable the most excluded and vulnerable people participate Also reflects the commitment of citizens to be involved in the development of their community	Watchdog role; monitoring public policies; inspection; evaluation of public services.

Figure 1: Processes involved in citizen participation in the most vulnerable communities, Source: (PIWA and UNDP, 2011)

to suit the local context (Bhatnagar, 2000). The third is linked to the design of the application, as it needs to be simple, user friendly and in the native language in order to incorporate wider interests (Korpela, Soriyan and Olufokunbi, 2000). Fourth is the infrastructure limitation, as most developing countries are placed at much lower position in Networked Readiness Index (NRI) due to absence of last mile connectivity and inability to leverage the benefit even when the technology is in place (Baller, Dutta and Lanvin, 2016). Lastly, the limitation of democratic governance in terms of openness to public interactions comes as a major impediment in public participation (PIWA and UNDP, 2011).

In the backdrop of the advancement of ICT, India seems an exciting case to study the role that ICT can play in participative management of natural resources. Though there are studies focusing on use of ICT in the scientific context, very few detailed studies have delved into its use in the social setting linked to public participation in water quality management. Our analysis adds to this discussion by understanding the preparedness of the people to adopt ICT for river water quality management with a focus on two key questions: First, by assessing the knowledge of the ICT tools and familiarity with internet and its applications, we have examined the readiness of public to use ICT as a participative management tool; and second, we have examined willingness to participate by analyzing public commitment and the benefits that public perceives from participation.

To meet the objectives of the study, a survey was conducted along the 360 km, middle stretch of River Yamuna in India, where several efforts made by the Government of India (GoI) since 1993 in the name of Yamuna Action Plan (YAP) to clean the river have not yielded encouraging results (TEC, 2009; Misra, 2010). The stretch comprised 22 km of a critically polluted segment of the River in Delhi (referred as Stretch 2) (Sharma, Kansal and Pelletier, 2015) and a relatively cleaner stretch in the upstream (referred as Stretch 1) and the impacted stretch in the downstream of Delhi (referred as Stretch 3) (Paliwal, Sharma and Kansal, 2007; Dhillon, George and Mishra, 2013). A mixed method approach consisting of a face-to-face questionnaire survey with the public and semi-structured interview with the key informants was undertaken to achieve the goals of the study. The questions were asked in the native language of the respondents, that is Hindi, and the interviewer recorded the answers to ensure response to every question in the survey instrument. The semi-structured interview with key informants helped in gaining insight into perception of resource managers on the use of ICT for public engagement in water quality management of the river.

Materials and Methods

Data Collection

Data on the readiness of the public to use ICT tools, the type of tool that would be most effective for public engagement, their willingness to engage in water quality improvement programmes were collected using a structured questionnaire survey and analyzed with respect to independent variables, which are gender, income, education and location, for each stretch. The questionnaire was coded to enable ease of analysis.

The first section of the questionnaire focused on the demographic status and location aspects of the respondent. The information was recorded by assigning codes for variables;

- gender - male- 1, female- 2
- income category - low income (LI)- 1, medium income (MI)- 2, high income (HI)- 3
- level of education - illiterate-1, semi-literate- 2, literate- 3 and
- location - stretch 1- 1, stretch 2- 2, and stretch 3- 3

The second section assessed the readiness of public to use ICT tools. This was ascertained firstly by seeking response on familiarity with popular ICT tools. The options given were 'Radio', 'Mobile phone', 'Television (TV)', 'Computer', 'Automated Teller Machine (ATM)' and 'None of the above'. Secondly, they were asked about their knowledge of the internet. The respondents could reply in either Yes (1) or No (0). Those who gave 'yes' as an answer, were asked to select the purpose for which they accessed the internet. The options given were 'Sending E-mails', 'Social Networking', 'Gathering Information', 'Banking and E-Commerce' and 'Entertainment'. Finally, the respondents were asked about their perception of ways in which ICT can be used for participation in river water quality management. The options given were 'Information', 'Consultation', 'Virtual representation', 'Monitoring', 'Cannot help' and 'No idea'. The respondents could choose multiple options in each of the choice-based questions.

The third section focused on understanding the perception of the public on the ICT tool that would be most effective in public participation. The respondents were asked to choose from the options 'Newspaper/Posters', 'Radio', 'Television', 'Street play', 'Mobile Phone', 'Computer with internet', 'None shall be effective' and 'No idea'.

The fourth section delved with understanding of willingness of the public to engage in water quality improvement initiatives. Research has shown that perceived benefits by the public from participation and sense of ownership of the resource affects the willingness to participate (Jingling et al. 2010; Brandt & Svendsen 2013). Thus, willingness to participate was computed using seven questions and the respondents were asked to record their answer using a five-point Likert scale with 1 representing strongly disagree and 5 representing strongly agree. The questions sought responses on i) attributing responsibility for river cleaning; ii) keenness to participate in river cleaning projects; iii) belief in linkage of public engagement with better results and the perceived benefits from cleaning of river which are iv) monetary; v) health; vi) improvement in quality of life; and vii) increase in quantity of usable water.

Sampling and Analysis

Semi-purposive sampling was used since the study required a broad spectrum

of respondents (Crona et al., 2009; Sovacool et al., 2012). The questionnaire was administered face-to-face on 2706 individuals in the three stretches: Stretch 1 (n = 834), Stretch 2 (n = 1168), and Stretch 3 (n = 704). A sampling grid was designed to sample participants representing key independent variables such as gender, education and income. The demographic attributes of surveyed population sample are shown in Table 1. Descriptive statistics were calculated across all variables to summarise the data and to gain understanding of its distribution and spread. The numerically coded data were statistically analysed using Kruskal Wallis and Mann Whitney U-tests (Steinwender et al. 2008; Larson & Lach 2008; Casado-Arzuaga et al. 2013) (as the variables did not follow normal distribution) to see if there was any significant difference between means of responses obtained from independent groups of the variables like gender, income groups, etc. The responses from key informant interview were also considered after content analysis to understand the perception of resource managers. The seven questions, which used five-point Likert scale to measure willingness to participate, were further analyzed using Principal Component Analysis (PCA) and Factor Analysis (FA) to group variables into important factors for ascertaining the drivers for willingness to participate.

Table 1: Demographic Attributes of Surveyed Population (n=2706)

Item	Sub Group	Percent	Item	Sub Group	Percent
Location	Stretch 1	30.8	**Gender**	Male	53.5
	Stretch 2	43		Female	46.5
	Stretch 3	26.2	**Income* (INR)**	Low (LI) < 5000	36.3
Education (Number of years)	Illiterate ≤5	30.5		Medium (MI) 15000-60000	31.6 32.1
	Semi- Literate 6-12	30.4		High (HI) > 60000	
	Literate > 12	39.1			

*1 US Dollar~64 INR

Results and Discussion

Readiness of Public to Use ICT Tools

Familiarity with ICT Tools

Table 2 shows the summary of mean usage of commonly used ICT tools among the respondents. Mobile phones (88%) and television (87%) emerged as the most popular tools. Significant difference was observed in the use of mobile phones between gender groups (p=.046) with access to the phone being higher in males than females. The use of mobile phones was observed to be less among illiterate and lower income groups in comparison to literate, semiliterate and middle and higher income groups. Likewise, the use of television was found to be low among illiterate (69%) and lower income (76%) groups. The lower access to ICT among females, lower income and illiterate groups substantiates the digital divide

prevalent among the respondents. The average percentage users of radio were 56% with highest use being reported in Stretch 1 (87%) which is mainly rural. The use of computer and ATM was reported to be highest among the higher income and literate respondents suggesting a close linkage between education, income and use of ICT. Only a miniscule percentage i.e. 3% of the respondents were not familiar with any type of ICT tool.

Table 2: Mean Values Of Type Of Ict Tools Used By The Respondents; Response Code -Yes-1, No-0

Description	Radio	Mobile	TV	Computer	ATM	None of these
Overall	Mean of total respondents	.558	.882	.867 .398	.415	.033
Gender	Male	.598	.942	.847 .430	.467	.021
	Female	.513	.814	.889 .362	.355	.048
Location	Stretch 1	.868	.976	.787 .553	.583	.024
	Stretch 2	.517	.860	.873 .352	.368	.039
	Stretch 3	.258	.808	.950 .292	.293	.036
Education	Illiterate	.512	.765	.688 .067	.108	.073
	Semi-Literate	.561	.879	.927 .238	.355	.024
	Literate	.593	.976	.959 .780	.700	.009
Income	LI	.517	.753	.763 .140	.136	.066
	MI	.541	.930	.891 .277	.377	.018
	HI	.622	.983	.960 .812	.769	.012

Knowledge and Purpose of Using the Internet

46% of the respondents who were interviewed were familiar with the use of the internet. Though the percentage of internet users among the respondents was found to be higher than the national average of 36%, differentiation in the use on the basis of socio-economic attributes was observed in the study. The internet usage was found to be highest among the literate (81%) and the higher income (80%) groups and least among the illiterate (10%) group, reinforcing the difference in access between the 'haves' and the 'have nots'. Difference on the basis of gender was found when combined with education. Higher percentage of illiterate as well as literate men were found to be familiar with the internet than women in the same category confirming disparities on the basis of gender.

The respondents who were familiar with the use of internet were asked to lay down the purpose of accessing the internet. Overall 41% of the respondents who were familiar with internet used it for sending e-mails., 38% for gathering information, 31% for social networking and entertainment, and 23% for banking and e-commerce. The respondents from higher income and literate groups were the ones who used the internet the most for all the mentioned purposes, semiliterate and medium income groups used mostly for e-mails, social networking and entertainment and the lower income, illiterate accessed internet mainly for

entertainment like listening to songs or watching movies. Difference on the basis of gender was observed on the use of internet for banking and e-commerce implying monetary decisions being largely a male dominated role.

Public perception of ICT use for participation in river water quality management

48% of the total respondents felt that ICT can be used for information sharing and creating awareness among the public on water quality issues. Difference in perception was observed on the basis of gender with more men (52%) finding ICT useful for information sharing as against women (41%). The use of ICT for consultation, virtual representation in deliberations and monitoring and evaluation of projects addressing river pollution were mainly perceived by the literate and higher income respondents who were also the ones more familiar with the use of ICT tools and internet. Significant difference was observed in the perception of education groups (p=.026) and income groups (p=.018) on the use of ICT. While literate and higher income groups identified with ICT as an enabler for public engagement, the lower and middle income and illiterate and semiliterate groups were unable to perceive considerable use of ICT in public participation. This can be attributed to the association between education and income with access to knowledge and use of ICT.

The opinion of key informants from Delhi Jal Board (DJB), Delhi Pollution Control Committee (DPCC) and National River Conservation Directorate (NRCD) also converged with that of the people. The officials mentioned that ICT tools especially television and radio were used in the past to create health and education related awareness campaigns and have led to transformative changes like in the case of pulse polio. They stated that most websites have an option for booking a service, registering complaints and providing feedback but the process is largely one way and benefits only a small segment of literate community. Existing use of ICT for sharing information on river water quality and its associated impacts did not resonate in their responses. It was evident from the findings that vast majority of people including water managers still view ICT as an information dissemination tool rather than a public engagement tool and are unable to perceive its use for higher forms of participation like consultation, representation and monitoring.

Public Perception of ICT Tool that Would be Effective for Public Participation

60% of the respondents felt that television is the most effective medium for engaging with public. The reason for this is two-fold; firstly, the inability of people to comprehend the meaning of participation beyond information dissemination mechanism and secondly, penetration of television in most households. Information sharing through newspaper and street plays were the other options which people felt would be effective in public engagement. However, radio, mobile and internet were not considered as effective, even though mobile was reported as the most popular ICT tool being used by the respondents. The DJB official reiterating the ineffectiveness of mobile phone said that, 'even though mobile coverage in India is near hundred percent, no one reads unwanted SMS (Short Message Service)'. He instead suggested that screening of films at the community centres and street plays can be a good option for rural areas, and the internet and social media can be used for targeting literate and higher income groups.

Significant difference was observed between gender groups (p=.002) on the use of tools. While males felt that newspaper, television and street play shall be equally effective, females felt that television would be more effective than other tools. Significant difference in the use of newspaper as a tool for public engagement was also observed between education groups and income groups. The illiterate and lower income groups felt that it would be less effective than the literate and higher income groups. The reason for this was that literate community had access as well as the ability to read newspaper in comparison to the illiterate group. The official from the DPCC mentioned publishing of water quality data on their website but also highlighted that the data that are present in the public domain are highly scientific and it is challenging for common people to comprehend and interpret.

Willingness to Participate in River Water Quality Improvement Programmes

The findings of the survey support studies that attribute sense of ownership and perceived benefits as reasons that drive participation. With an average score of 4, the respondents attributed the responsibility of keeping the river clean to the community and expressed keenness to participate in water quality improvement programmes. The respondents with a mean score of 4.5, strongly agreed that engaging with public would lead to better results of intervention initiatives. Further, two components were extracted using PCA and FA to determine grouping of variables into important drivers that could help in willingness of public

Table 3: Extraction of Factors for Grouping of Variables

Rotated Component Matrix

	Perceived Benefits	Belongingness
Acknowledgement of responsibility	-.079	.763
Keenness to participate	.210	.735
Public engagement, better result	.375	.692
Monetary benefit if the river is clean	.677	.100
Health will improve if the river is clean	.790	.236
Quality of life will improve if river is clean	.804	.192
Quantity of usable water will increase	.679	.011

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

to participate in river water quality improvement programmes. The factor loadings are shown in Table 4. The first factor that has been extracted can be named as "perceived benefits" as items like improvement in health, monetary gain, improvement in quality of life and increase in quantity of usable water load heavily on it. The second factor can be called "belongingness" as items like attributing of responsibility to public, keenness to participate and linking of public engagement with better results load on it.

Conclusion

The research, while on one side very succinctly brings out familiarity of people with television and their readiness to use it for receiving information related to river water quality, on the other side it also underlines a major shortcoming in terms of the inability of vast majority of respondents to perceive the role that ICT can play in higher forms of participation like consultation, virtual representation in deliberations and monitoring and evaluation of projects. Mobile phone, which emerged as one of the most commonly used ICT tool among the respondents, was primarily being used for voice calls and entertainment and was not perceived as an effective tool in public participation in managing river water quality. Experts believe that mobile telephone can play a substantial role in creating awareness among people and therefore exhorting them to participate (Khan et al., 2014; Mhagama, 2015). User-friendly applications can be developed to consult people on river water quality projects and also inform them about various ways in which they can contribute. Though India successfully boasts of being the second largest market base for mobile phones (TRAI 2015), the limitation in its applicability can be attributed to moderate internet penetration in India (Internet World Stats, 2017) as well as lack of awareness, knowledge and skill among people related to its multiple use. Regardless of ICT being used extensively in India for water management, its systemic use in any form of public participation for river water quality management did not resonate in the responses received from public as well as the government officials. Further, the inability of people to comprehend the meaning of participation beyond information dissemination mechanism was also evident from the study as both public and government officials gave examples of ICT being used only for one-way processes rather than for comprehensive engagement.

The study also brought to light the differentiation in access and use of ICT on the basis of gender, education and income levels. Females, lower income groups and illiterate were found to have lower access to television and mobile phones substantiating the prevalence of gender-based disparities and digital divide between the 'haves' and the 'have nots'. Alongside, the use of computer and internet was also found to be highest among the higher income and literate respondents suggesting a close linkage between education, income and use of ICT. Policy makers must take note of this and invest in training programmes on ICT tools to address the inequity around its use and ensure readiness of people to use ICT across different socio-economic groups. Notwithstanding, public commitment in terms of willingness to participate in river cleaning programmes was found to be strong. The respondents believed that engaging with public would lead to enhanced effectiveness of the intervention measures. The study finally suggests feeling of "belongingness" and "perceived benefits" from participation process as the two key drivers for willingness of the public to participate. It is pertinent that policymakers take these findings into consideration while designing river action plans and use the flexibility and versatility being offered by ICT to engage with all stakeholders for improved results. Finally, while deciding the use of ICT tools, it would also be worthwhile for the planners to invest in studying the socio-cultural context of the participatory process and accordingly decide on the type, scope and scale of participation.

References

Arnstein, S. R. (1969). A ladder of participation. *Journal of the American Institute of Planners*, 35(4), 216-224. https://doi.org/10.1080/01944366908977225

Baller, S., Dutta, S., & Lanvin, B. (2016). T*he global information technology report 2016: Innovating in the Digital Economy,* WEF report. Retrieved from http://online.wsj.com/public/resources/documents/GITR2016.pdf

Bhatnagar, S. (2000). Social implications of information and communication technology in developing countries: Lessons from Asian success stories. *Electronic Journal of Information Systems in Developing Countries*, 1(4), 1–9. https://doi.org/10.1002/j.1681 4835.2000.tb00004.x

Brandt, U. S., & Svendsen, G. T. (2013). Is local participation always optimal for sustainable action? The costs of consensus-building in Local Agenda 21. *Journal of Environmental Management,* 129, 266–273. https://doi.org/10.1016/j.jenvman.2013.07.020.

Malvania, U. (2017). Rural India has 17% more homes with TVs than cities. Business Standard. Retrieved from http://www.business-standard.com/article/economy-policy/rural india-has-17-more-homes-with-tvs-than-cities-117030300023_1.html

Casado-Arzuaga, I., Madariaga, I., & Onaindia, M. (2013). Perception, demand and user contribution to ecosystem services in the Bilbao Metropolitan Greenbelt. *Journal of Environmental Management,* 129, 33–43. https://doi.org/10.1016/j.jenvman.2013.05.059

Chambers, R. (2010). Paradigms, poverty and adaptive pluralism. IDS Working Paper, 344, 59. https://doi.org/10.1111/j.2040-0209.2010.00344_2.x

Chaudhuri, A. (2012). ICT for development: Solutions seeking problems?. *Journal of Information Technology,* 27, 326–338. doi: 10.1057/jit.2012.19.

Crona, B. I., Rönnbäck, P., Jiddawi, N., Ochiewo, J., Maghimbi, S. & Bandeira, S. (2009). Murky water: Analyzing risk perception and stakeholder vulnerability related to sewage impacts in mangroves of East Africa. *Global Environmental Change*, 19(2), 227–239. https://doi.org/10.1016/j.gloenvcha.2009.01.001

Deloitte. (2017). *Connecting the next billion: Propelling towards $5T economy*. Retrieved from https://www2.deloitte.com/in/en/pages/technology-media-and telecommunications/articles/connecting-the-next-billion.html.

Dhillon, M. K., George, M. P., & Mishra, S. (2013). Water quality of River Yamuna – *Delhi stretch,* 3(5), 1416–1423. doi: 10.6088/ijes.2013030500012.

Ghosh, A. (2011). Initiatives in ICT for rural development: An Indian perspective. *Global Media Journal*, 2(2), 1–8. Retrieved from http://www.caluniv.ac.in/global-mdia journal/Winter%20Issue%20December%20 2011%20Commentaries/C7%20-%20Ghosh.pdf

Gouveia, C., Fonseca, A., Gouveia, C., & Fonseca, A. (2008). New approaches to environmental monitoring: The use of ICT to explore volunteered geographic information. *GeoJournal*, 72, 185–197. https://doi.org/10.1007/s10708-008-9183-3

Greenberg, A. (2005). ICTs for *Poverty Alleviation: Basic Tool and Enabling Sector.* Stockholm: Sida. Retrieved from http://ictlogy.net/bibliography/reports/projects.php?idp=325.

Pereira, A. G., Rinaudo, J.-D., Jeffrey, P., Blasques, J., Quintana, S. C., Courtois, N., … Petit, V. (2003). ICT

tools to support public participation in water resources governance and planning: Experiences from the design and testing of a multi-media platform. *Journal of Environmental Assessment Policy and Management,* 5(3), 395–420. https://doi.org/10.1142/S1464333203001383

Heeks, R. (2009). The ICT4D 2.0 manifesto: *Where next for ICTs and international development?* (Manchester Centre for Development Informatics Working Paper 42). Retrieved from Organisation for Economic Co-Operation and Development website https://www.oecd.org/ict/4d/43602651.pdf

International Telecommunication Union. (2011). *ICT for smart water management.* Retrieved from http://www.itu.int/net/itunews/issues/2011/01/36.aspx

International Water Association. (2016). *The Impact of ICT in the water sector.* Retrieved from http://www.iwa-network.org/the-impact-of-ict-in-the-water-sector

Internet World Stats. (2017). *India internet usage and telecommunications reports.* Retrieved from http://www.internetworldstats.com/asia/in.htm

Irawan, T. (2014). ICT and economic development: Comparing ASEAN member states. I*nternational Economics and Economic Policy*, 11(1–2), 97–114. doi: 10.1007/s10368-013 0248-5.

Jentoft, S. (2000). Co-managing the coastal zone: Is the task too complex?. *Ocean and Coastal Management,* 43(6), 527–535. doi: 10.1016/S0964-5691(00)00042-9.

Jingling, L., Yun, L., Su, L., & Baoqiang, Z. (2010). Public participation in water resources management of Haihe river basin, China: The analysis and evaluation of status quo. *Procedia Environmental Sciences,* 2, 1750–1758. doi: 10.1016/j.proenv.2010.10.187.

Jyoti, C., Islam, I. S., Wahid, F. W., Bass, J. M., & Priyatma, J. E. (2017). Information and Communication Technologies for Development. *14th IFIP WG 9.4 International Conference on Social Implications of Computers in Developing Countries,* ICT4D 2017. Retrieved from https://link.springer.com/content/pdf/10.1007%2F978-3-319-59111-7.pdf

Khan, S., & Singh, S. K. (2013). Assessment of the impacts of point load on River Yamuna at Delhi Stretch, by DO-BOD Modeling of River, using MATLAB Programming. I*nternational Journal of Engineering and Innovative Technology,* 2(10), 282–290.

Korpela, M., Soriyan, H. A., & Olufokunbi, K. C. (2000). Activity analysis as a method for information systems development: General introduction and experiments from Nigeria and Finland. *Scandinavian Journal of Information Systems*, 12(1), 191–210. Retrieved from http://aisel.aisnet.org/sjis

Kozma, R. B. (2005). National policies that connect ICT-based education reform to economic and social development. *Human Technology,* 1(2), 117–156. DOI: http://dx.doi.org/10.17011/ht/urn.2005355

Lamont, T. (2015). Blinded by technology: *Has our belief in Silicon Valley led the world astray?*, The Guardian. Retrieved from https://www.theguardian.com/technology/2015/aug/30/kentaro-toyama-geek-heresy interview-technology

Larson, K. & Lach, D. (2008). Participants and non-participants of place-based groups: An assessment of attitudes and implications for public participation in water resource management. *Journal of Environmental Management,* 88(4), 817–830. doi: 10.1016/j.jenvman.2007.04.008.

Liew, E. J. Y., Vaithilingam, S., & Nair, M. (2014). Facebook and socio-economic benefits in the developing world. *Behaviour and Information Technology,* 33(4), 345–360. https://doi.org/10.1080/0144929X.2013.810775

Loh, Y. A. (2013). Approaches to ICT for development (ICT4D): Vulnerabilities vs. capabilities. *Information Development,* 31(3), 229–238. https://doi.org/10.1177/0266666913513198

Luyet, V., Schlaepfer, R., Parlange, M. B., & Buttler, A. (2012). A framework to implement Stakeholder participation in environmental projects. *Journal of Environmental Management.* 111, 213–219. doi: 10.1016/j.jenvman.2012.06.026.

Mhagama, P. (2015). Expanding access and participation through a combination of community radio and mobile phones: The experience of Malawi. *Journal of African Media Studies,* 7(3), 267–280. https://doi.org/10.1386/jams.7.3.267_1

Misra, A. K. (2010). A river about to die: Yamuna. *Journal of Water Resource and Protection*, 2(5), 489–500. doi: 10.4236/jwarp.2010.25056.

Noir, C. and Walsham, G. (2007). The great legitimizer: ICT as myth and ceremony in the Indian healthcare sector. *Information Technology & People,* 20(4), 313–333. https://doi.org/10.1108/09593840710839770

Pagani, G. A., & Aiello, M. (2012). An ICT overview of water management. Retrieved from http://www.cs.rug.nl/~andrea/publications/ictWMgt.pdf

Paliwal, R., Sharma, P., & Kansal, A. (2007). Water quality modelling of the river Yamuna (India) using QUAL2E-UNCAS. *Journal of Environmental Management,* 83(2), 131–144. https://doi.org/10.1016/j.jenvman.2006.02.003.

Panopoulou, E., Tambouris, E., & Tarabanis, K. (2014). Success factors in designing eParticipation initiatives. *Information and Organization*, 24(4),195–213. doi: 10.1016/j.infoandorg.2014.08.001.

E-governance and citizen participation in West Africa: Challenges and opportunities. (2011). Retrieved from http://www.undp.org/content/dam/undp/library/Democratic Governance/IParticipation/e-Governance and Citizen Paticipation in West Africa (UNDP IPAO Report English).pdf

RhineNet. (2008). *A guide to public participation according to Article 14 of the EC Water framework directive, framework*. Retrieved from http://www.rivernet.org/rhin/pdfetdocs/rheinnetzbericht_e.pdf

Robey, D., & Rodriguez-Diaz, A. (1989). The organizational and cultural context of system implementation: Case experience from Latin America. *Information & Management,* 17(1), 229–239. https://doi.org/10.1016/0378-7206(89)90046-3

Sharma, D., Kansal, A., & Pelletier, G. (2015). Water quality modeling for urban reach of Yamuna river, India (1999–2009), using QUAL2Kw. *Applied Water Science.* doi: 10.1007/s13201-015-0311-1.

Sovacool, B. K., D'Agostino, A. L., Rawlani, A., & Meenawat, H. (2012). Improving climate change adaptation in least developed Asia. *Environmental Science & Policy,* 21, 112–125. https://doi.org/10.1016/j.envsci.2012.04.009

Statista (2018) Mobile users in India 2013-2019. https://www.statista.com/statistics/274658/forecast-of-mobile-phone-users-in-india/

Steinwender, A., Gundacker, C., & Wittmann, K. J. (2008). Objective versus subjective assessments of environmental quality of standing and running waters in a large city. *Landscape and Urban Planning,* 84(2), 116–126. doi: 10.1016/j.landurbplan.2007.07.001.

Swinford, A., & Jeffrey, P. (2000). Designing ICT tools to support participative catchment management processes. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.576.8041&rep=rep1&type=pdf

Yamuna Action Plan- A Bilateral Project of Government of India and Japan on River Conservation. (2009). Retrieved from http://52.7.188.233/sites/default/files/YAMUNA ACTION PLAN Vision-document.pdf

Internet penetration in rural India abysmal: Report. *The Economic Times*. (2017). Retrieved from https://telecom.economictimes.indiatimes.com/news/internet-penetration-in-rural-indiaabysmal-report/60884092

The World Bank. (2016). *World Development Report* 2016: Digital dividends. World Development Report. doi: 10.1596/978-1-4648-0671-1.

Telecom Regulatory Authority of India (2015). Retrieved from http://www.trai.gov.in/sites/default/files/PR-No%3D47.pdf.

United Nations Development Programme. (2016). Human Development Report 2016. New York: United Nations Development Programme. doi: eISBN: 978-92-1-060036-1.

Unwin, P. T. H. (2009). *ICT4D: Information and Communication Technology for Development.* Cambridge University Press. Retrieved from http://ictlogy.net/bibliography/reports/projects.php?idp=1237

Walsham, G. (2010). ICTs for the broader development of India: An analysis of literature. *Electronic Journal of Information Systems in Developing Countries,* 41(4), 1–20. https://doi.org/10.1002/j.1681-4835.2010.tb00293.x

West, N. (1989). A preliminary review of water quality parameters and recreational user perceptions of nearshore water quality. *Journal of Coastal Research*, 5(3), 563–572.

Whittington, D., Davis, J., Prokopy, L., Komives, K., Thorsten, R., Lukacs, H., … Bakalian, A. (2008). How well is the demand-driven , community management model for rural water supply systems doing?: Evidence from Bolivia, Peru, and Ghana. Manchester, UK: Brooks World Poverty Institute, The University of Manchester.

Woods, D. (2010). *The European community water framework directive: An introductory guide.* Marlow, UK: Foundation for Water Research.

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