Article

Rainwater Harvesting In Chennai: What Made It Work?

IIM Kozhikode Society & Management Review
5(1) 91–106

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Abstract

Sustainable water management is vital for sustainable development, especially in light of threats such as climate change, growing population, rising prosperity and industrialization. India is facing increasing freshwater scarcity, particularly in urban centres such as Chennai, and is struggling to manage water resources. It is widely believed that Chennai has had a very successful experience with rainwater harvesting since its 2002 law mandating it for every building. This article tries to find out what has made RWH work in Chennai, at least to the extent it has worked, as many such policies in our country either tend to fail or at least run a very high risk of failure. The article argues that Chennai has been a case of non-government agents from the public leading the charge to start with and later working with government agents. It is this broad alignment of government and non-government agents that helped make the policy fairly successful. The policy directives essentially reinforced the general practice that was already being followed by local practitioners and experts of RWH. The government aggressively pursued a tight implementation timeline in 2003 to push for rainwater harvesting implementation before north-eastern monsoon. The article examines and provides evidence for the key assumption that RWH is a partial success in Chennai. It also provides evidence for the strong role of non-government agents in making it a successful venture. The article provides valuable insights into achieving sustainable water management in cities in India and elsewhere.

Keywords

Policy analysis, government agent, non-government agent, groundwater, sustainability.

Introduction

> *Water is essential for all life. There are no substitutes. Water is not renewable, so we have to take care of the amount of freshwater that was available for the dinosaurs. So the water is reused. The problem is that growing population, increasing standard of living, food production and industrialization will put a lot of pressure on water resources.*
>
> (Olsson, 2012, p. 1)

There is increasing evidence of growing demand for water, a non-substitutable resource, leading to its scarcity, albeit with significant variations. The magnitude of water scarcity depends on geographical, seasonal and other factors. Though the total amount of freshwater available on our planet for human consumption may potentially be sufficient for current and future needs (Lee, 1999, pp. 1–4), there is still a significant shortage of freshwater availability in many parts of the world. Thus, there is a need for solutions to achieve a better use of locally available freshwater (Rijsberman, 2006; UN-Water, 2015). Further, the scarcity has grown in importance due to climate change driven uncertainties (UN-Water, 2015). With about 18 per cent of global population, but with only 4 per cent of world's renewable water resources and 2.4 per cent of World's land, India is particularly facing the shortage of available freshwater (Government of India, 2012).

> Low consciousness about the scarcity of water and its life-sustaining and economic value results in its mismanagement, wastage, and inefficient use, as also pollution and reduction of flows below minimum ecological needs. (GOI, 2012, p.1)

It is, therefore, crucial for India to adopt sustainable water management to fulfil its needs, particularly in its burgeoning

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cities that account for half of its economy and nearly one-third of the population (Kumar, 2015, p. 22). As the United Nations (UN) noted in the United Nations World Water Development Report 2015:

> Water is truly at the core of sustainable development. It is inextricably linked to climate change, agriculture, food security, health, equality, gender and education, and there is already international agreement that water and sanitation are essential to the achievement of many sustainable development goals. (UN-Water, 2015, p. vi)

For sustainable development, rainwater harvesting (RWH)[1] holds enormous potential, as apart from saving energy it can also efficiently solve the issue of the scarce supply of water in cities (Olsson, 2012, p. 244). Hence, water sector experts and practitioners see RWH as an essential choice for sustainable development, and this ancient practice, thus, has found a significant place in India's National Water Policy, 2012 (Agarwal, Narain, & Khurana, 2001; CGWB, 2011; Iyer, 2007).

Chennai seems to have well implemented the RWH policy unlike other Indian cities that have either failed to do it or have not even tried it (CSE, 2012). Also it is one of the Indian cities that made it mandatory to have RWH in every building since 2003 (Metrowater, 2013). Earlier, RWH was mandatory only for new buildings and that too was not taken seriously. It is widely believed that the city has become much better off in terms of freshwater availability,[2] thanks to the strict 2002 RWH policy and its successful adoption by citizens.

What made RWH a success in Chennai, at least till the time the data is available,[3] and what lessons can we draw from it for other cities, at least in India if not globally? This article argues that non-government agents played a crucial role in making it a success. Without them, in all likelihood, it would have failed. Furthermore, it also examines the assumption that RWH is a success and shows the extent to which it worked. It presents the evidence through an analysis of the 2002 amendment of the Chennai Metropolitan Area Groundwater (Regulation) Act, 1987, as well as the events leading up to it and the key related developments (Government of Tamil Nadu, 2002).

The article is largely structured around the three R's of reforms used by Amartya Sen (Sen, 2005)[4]: the reasons that led to the creation of a strong RWH policy in Chennai, the range of ways and means used by the agents and the reach of results of the policy. It also applies other public policy analysis frameworks to include relevant analysis notes alongside the Chennai RWH story.

While news coverage on RWH in Chennai has been fairly wider, academic research on the same has been meagre. This article brings a fresh approach in the academic arena of RWH. Though most of the articles have noted the presence of non-government agents, none of them have examined their importance and impact on RWH (Coelho & Reddy, 2004; Nair, 2001; Srinivasan, 2008). This article tries to fill this important gap. In addition, most of the articles have highlighted the success of RWH measures in Chennai, but neither the evidence of success have been shown clearly nor the reasons have been examined (Coelho & Reddy, 2004; Srinivasan, 2008). This article re-examines the success as not a one-time affair but as an on-going performance.

Policy Success and Role of Non-government Agents

Failure of government reforms is commonplace; often they fail to deliver at all or do way below expectations. However, in the case of Chennai, the results have been somewhat different. Public and even experts seem to be satisfied, if not happy, with the outcomes of RWH policy (Coelho & Reddy, 2004; Potter, 2011). Hence, it becomes even more important to introspect what has been done differently in Chennai that made RWH work, or whether there were some exceptional people who led it to success. This article shares some powerful insights drawn from the Chennai case, which could be of much broader interest and an example and inspiration for policy-making situations, especially in India, where people have to own up their constitutional responsibilities (Basu, 2013, p. 486). An example that shows policy success with people's participation is worth serious research; it would help policy makers in pursuing experimentation to achieve successful involvement of people. It can lead a powerful change in the process of policy making and implementation. It throws light on practical ways in which public could be brought into implementation of policy process, which, at present, has not been happening in India.

Importance of Water: Availability and Quality

There is a close relationship between water and several key measures of development, including health and poverty (Bakker, 2007). While lack of access to clean water is closely related to poverty, contaminated water is the single largest source of human disease and death among poor (Olsson, 2012, pp. 6–7). A study specific to India shows that piped water has reduced diarrhoea among children (Jalan & Ravallion, 2003). Studies by World Resources

Institute (WRI), the UN and others show crucial links between water and development. It is thus evident that in developing countries, including India, the health of millions is adversely affected due to water issues (Montgomery & Elimelech, 2007).

Failure to access clean water could be due to water scarcity or the costs associated with it. Regardless of this, every person needs an adequate amount of water of reasonable quality for essential needs, such as drinking, cooking and personal hygiene. Similarly, every business needs it for diverse purposes. Water management issues have also gained attention in businesses in recent times. As per WRI, experts at World Economic Forum 2013 named water as one of the top four risks facing businesses in the twenty-first century (Steer, 2013). Moreover, there is increasing evidence to show growing water scarcity. In India, available water per capita in 2001 was 1816 m^3, which was reduced to 1545 m^3 in 2011 (Press Information Bureau, 2012). The quality of water also declined in the same period, while efforts were made to reverse the trend (CGWB, 2011). Moreover, the problem of water scarcity is likely to get worse as a result of increasing population.

Reasons for 2002 Amendment Mandating RWH

Water Scarcity in Chennai

Recurring droughts, rapid growth and uncontrolled groundwater depletion summarize the picture before the 2002 amendment of Chennai Metropolitan Area Groundwater (Regulation) Act. Water scarcity in Chennai is a natural phenomenon, with only 830 m^3 per year of freshwater available per capita. This is way below the global norms of 1000 m^3 as a minimum necessity and also against the Tamil Nadu average of 1400 m^3 (Potter, 2011, p. 81). Unlike many other large cities, Chennai is not situated on the banks of any major river, though it does have a few small rivers with limited water (CMDA, 2008, p. i). In fact, it used to be a fishing village prior to the establishment of a trading centre by the British (*The Hindu*, 2009). It can be said in hindsight that it is not naturally suited to be a large city, at least as far as local freshwater resources are concerned. Unlike most other cities, Chennai could not have supplied water to its citizens using local freshwater resources such as natural reservoirs, as Chennai did not have this luxury (Nair, 2001). As a result of this shortage of local surface water, Chennai started exploiting groundwater right from the British period, with the piped water supply system. It had to develop man-made reservoirs or tanks to ensure availability of clean water. The efforts to develop reservoirs and tanks crossed the city boundaries in a big way in 1969 when it commissioned three new groundwater wells based on a United Nations Development Program (UNDP) study in 1965 (Metrowater, 2015a). After 20 years, Chennai had to commission three more groundwater wells based on another UNDP-assisted study in the early 1980s.[5] Another smaller groundwater source called Southern Coastal Aquifer was identified along the shore, which was also put in use. However, the groundwater sources in the Araniar–Koratalaiyar river basin fell way short of the estimated water volume. By 1990, it became half of the original supply estimate of 180 mld (million litres per day), apparently due to a combination of factors such as recurring droughts and over-exploitation for agriculture.[6] In Chennai, even the shore sources ran into trouble as sea water gradually came inland into the aquifer, by as much as 9 km at one point, which severely restricted the supply potential (Nair, 2001).

By 2002, Chennai had heavily exploited groundwater for decades without any significant effort to ensure the long-term sustainability of this source. Natural recharging of groundwater was limited due to the concrete surface all over the city, thanks to its rapid growth. Piped water supply was never enough for everyone. As demands from citizens and businesses increased, water started coming in tankers and plastic containers from as far as 220 km without the local replenishment of groundwater or surface-water reservoirs.[7] Now the situation is such that the government municipal supplier, Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB, widely known as Metrowater), has started using multiple sources, including several lakes as far as 250 km from the city (Venkatachalam, 2015).

Apart from groundwater, rain provides another regular source of freshwater. Although Tamil Nadu has significant annual rainfall, Chennai suffers from the volatility of rainfall. Figure 1 presents Chennai rainfall records that show that this volatility was particularly at its lowest in the year 1999 when there was a major drought.[8] From 1998 to 2004, only two years had slightly above average rainfall. The rainfall was below average otherwise. Both groundwater and rainwater increasingly failed to meet the needs of the people of Chennai. Water scarcity became a major issue for Chennai's public and a huge challenge for the government.

Recognition of Water's Total Value

In general, as humans, we recognize the value of the same good differently under different conditions. When it is available in plenty, even though it is essential for survival

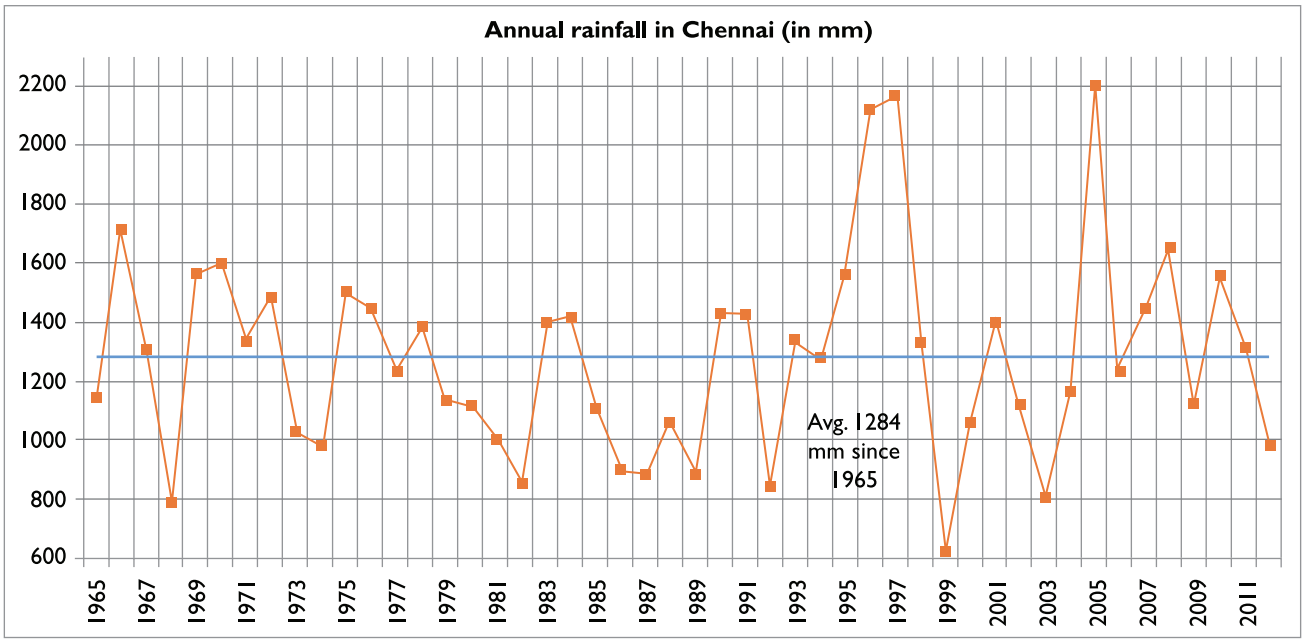


Figure 1. Fluctuation of Annual Rainfall in Chennai

Source: Metrowater (2015).

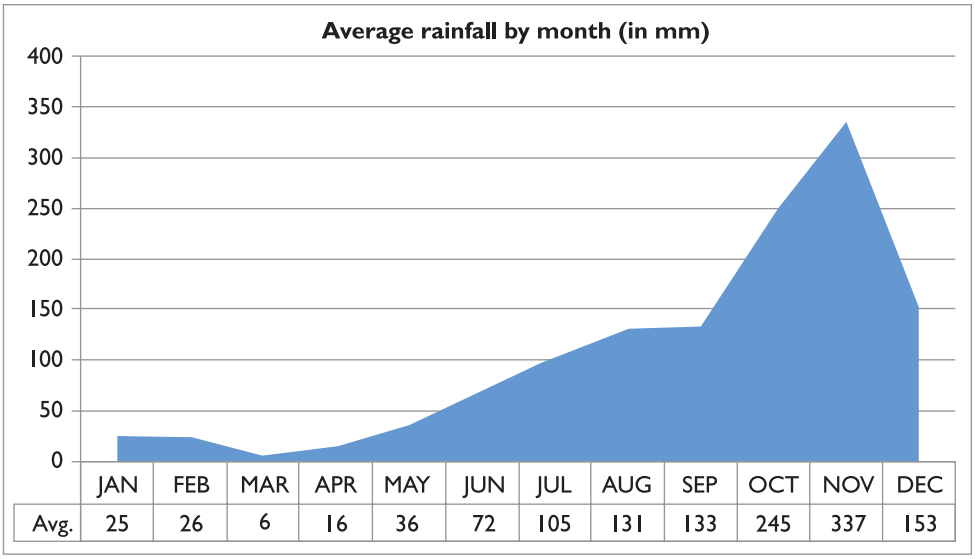
such as water or air, we may not value it highly until such time that it becomes scarce. Adam Smith wondered about this in *The Wealth of Nations*, 'Why is water, which is essential for life, so cheap while diamonds which are nothing more than pretty stones so expensive?' (Olsson, 2012, p. 9). The answer to this came in terms of the concept of incremental or marginal value as opposed to its total value. The total value of water is much higher than diamond as water is required for survival but diamond is not. In extreme situations, people may trade their diamonds to get drinking water to survive. However, once we have enough water available, the value for the next incremental unit of water becomes low, to an extent that we may not be willing to pay much for it or may even demand it for free. However, the incremental value of diamond is always high due to its overall scarcity. As Butler (2010, p. 28) from Adam Smith Institute states, 'Individuals do not think they would get much benefit from an extra cup of water, but they see greater benefit from owning an additional diamond'.

As water became scarce in Chennai during the droughts and summers, people started recognizing the total value of water. Water scarcity had started hitting people in a very significant way. It led to an increase in the marginal value, which started reflecting in increased prices of container-supplied water and even many skirmishes that happened over it, if not wars. In the summer of 2001, in some places, an average middle-class family had to spend as much as Indian Rupees (INR) 2,000–3,000 per month for container-supplied water (Coelho & Reddy 2004). The same phenomenon was seen in the summer of 2015 as well, when poor people had to pay significantly higher prices for water (Lakshmi, 2015).

Summer Shortages and People's Response

There was not enough water available in summers, which led to serious shortages, especially for the poor who had to walk to avail clean water and even pay for it. Figure 2 shows that there is a very high seasonality of rainfall in Chennai, with almost 90 per cent of annual rainfall occurring in the six months from July to December and almost half of it in just two months (October and November).

There was no significant effort to capture and store the rainwater during the months when it rains abundantly almost every year in Chennai or, for that matter, in basins outside Chennai with supply wells. As a result, the surface and groundwater levels continued to diminish in most places, leading to a major crisis in Chennai. Traditional temple tanks in the city were virtually dead, and open wells had been either abandoned or closed. Groundwater levels had dipped even in shore areas, well below the normal levels that experts would recommend (Potter, 2011; interview with Raghavan, founder of Rain Centre, 2013, July–August).



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Avg.	25	26	6	16	36	72	105	131	133	245	337	153

Figure 2. Rainfall in Chennai, showing Its Concentration around a Few Months Late in Year

Source: The averages presented in the figure are based on historical data from Metrowater for the years 1965–2002 (Metrowater, 2015).

Most people dealt with this scarcity by finding an alternative to get water, if they could, especially from private suppliers in tankers. People also bought water in 20-litre plastic bubbletop tanks, especially for drinking. These alternatives came at a much higher price than the flat fee charged by Metrowater or the cost of pumping one's borewell (Nair, 2001). Perhaps, there was no one untouched by the crisis. Public frustration had built up over the prolonged issue, which was also made an election issue for the state assembly. News reporters covered it. When parts of Chennai were flooded during a downpour while the city was reeling from acute water shortage, one of the reporters vented, "What a waste!" (Ghosh, 2001). It was slowly becoming clear, at least to some, that water crisis could be dealt with at the local level and rainwater could help.

But not everyone was satisfied with merely writing about it or simply waiting for water to be provided for by someone else. Some individuals decided to take the matter in their hands and started creating awareness about sustainable water supply.

The Emergence of Public Practitioners of RWH

Chennai had already witnessed several severe droughts well before 2002, such as those in 1983, 1987 and 1988. These droughts had triggered some residents of Chennai to explore RWH as an option to secure freshwater supply. R. Ramani, working at Oil and Natural Gas Corporation (ONGC), was catalyzed into action by the 1983 drought when he noticed the damage that it was causing—increased salinity of water at less than 10 m below ground and drying of wells (CSE, 2015).[9] Since 1988, he started working on RWH at his home. But it was not easy for him to succeed with problems of salinity and iron. He continued his experiments, and by 1990, he had converted his house into a self-proclaimed model house for RWH. By trial and error, he had discovered the right filtration, piping and other details that gave him potable quality water. He created different levels of quality of water depending on the type of usage. After his retirement from ONGC, Ramani went on to work on at least 130 different projects. He also established a trust named Ramadies to offer RWH-consulting services. Ramani was not alone (Interview with Jude, a reporter based in Chennai and involved in rainwater harvesting, 2013, July-August). Another motivated practitioner, Sekhar Raghavan, came together with Ramani to establish the Rain Water Centre under Akash Ganga Trust, which still drives many of the non-government actions on RWH in Chennai (CSE, 2015; Rain Centre, 2013).

Despite all odds—technical and social—and without having the government mandate, Ramani and Raghavan are among the few who popularized and implemented RWH in their neighbourhoods and their spheres of influence (CSE, 2015; interview with Raghavan, 2013). In hindsight, it is clear that the role played by these individuals in preparing the ground for mandating RWH as a solution to water scarcity in Chennai was crucial. They acted instead of waiting for someone else. They found solutions based on experiments instead of waiting for

experts to arrive from somewhere. They conducted door-to-door campaigns to show a way and proved by example that it is feasible and even cost effective.[10] They thus, in true sense, set the agenda for government to act and enforce scaling up of what they did in their limited local circles.

Agenda Setting

Chennai's situation in 2001–02 can be analysed using Kingdon's window of opportunity schema, revealing how government and non-government actions aligned (Kingdon, 1984).

In the early 1990s, water scarcity in Chennai was at least a hardy perennial issue if not a full-blown crisis. It was a well-known problem without a suitable solution. RWH practitioners became prominent in the late 1990s and started showing the way with examples. Slowly but surely, the old problem of water scarcity across Chennai seemed to have found a solution, and that too with very little or no cost implications. This was in sharp contrast to river-linking projects that came at a huge cost to governments and required complex negotiations across states. This article analysed the situation of Chennai in 2001–02 using Kingdon's window of opportunity schema as summarized in Figure 3 (Ayyar, 2011). The alignment of the solution, problem and political streams led to the opening of the window of opportunity.

The relevance of RWH was evident by the late 1990s with the success of Ramani, Raghavan, other public practitioners and even government's own efforts. Earlier in 1994, Chennai Metropolitan Development Authority (CMDA) did come up with a rule mandating RWH for new buildings. Although a partial solution, this was not enforced seriously, perhaps because there was a lack of conviction or even will in the then ruling government to consider RWH as a solution, or maybe some other methods were preferred. More likely, the solution was perhaps not politically palatable at that time. RWH might have been seen as a political plank of an opposition party. It was not until the change of power in Tamil Nadu that the political stream aligned to open the window of opportunity for addressing the water scarcity issue in Chennai. Starting 2001, with the new government in power, the momentum slowly built up with one action leading to another, both in the government and the public domain. All the reasons for the use of RWH were well in place by then and it was mandated soon after that (interview with Raghavan, 2013).

Policy Analysis: Problem Definition

It may appear fairly straightforward that the problem in this context is the scarcity of water in Chennai. But is that what the policy documents stated? As an example, the municipal order dated 19 July 2003 that mandated RWH in Chennai stated that the objective of this change was to 'augment groundwater resources' (Government of Tamil Nadu, 2003, p. 5). Note that it does not mention the issue of water scarcity; instead, it mentions a means to the solution. In doing so, it limits the focus to groundwater alone and not to water scarcity, in general. It leaves out important aspects like surface water, including 39 temple tanks in Chennai, which has been a traditional source of supply. The proposed solution (RWH) to water scarcity became so prominent in the minds of policy actors that it hijacked the problem itself. The solution (RWH) or at best the means (groundwater) seems to have dictated the policy, not the problem (water scarcity).

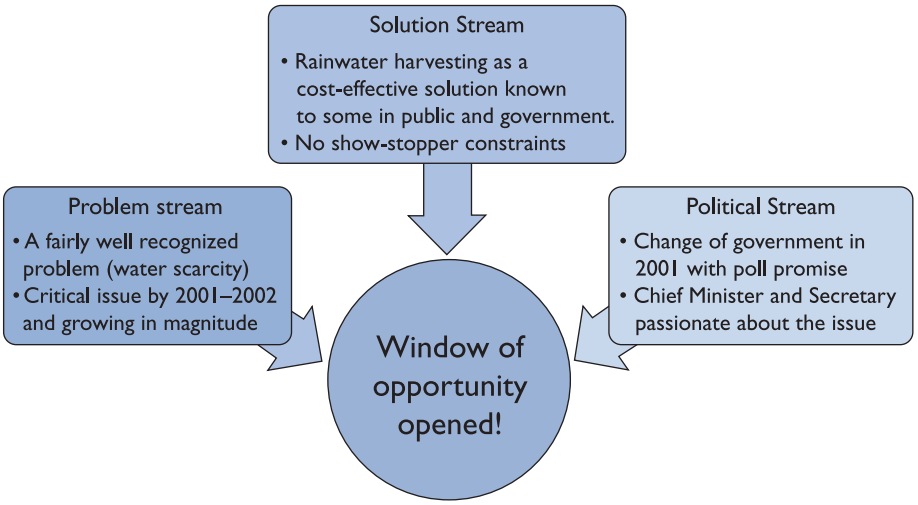


Figure 3. Kingdon's Schema on Agenda Setting Applied to Chennai RWH in 2001–02

Source: Author's own creation using a concept from Kingdon (1984).

This narrow focus on the RWH solution or groundwater is reflected throughout this policy's artefacts and actions. In terms of statutory changes, the government amended the 1987 Act to introduce the regulation of extraction and transport. But, it addressed only groundwater management. The actions did not make broader changes in water management beyond groundwater or RWH. Even within RWH, the policy scope was not comprehensive, perhaps due to the lack of a clear definition of policy objectives and corresponding goals. For instance, CMDA's rules were not modified to include the options selected by the state government for RWH. Its rules allowed only one model of RWH as per an earlier (1994) modification. This and other such hurried actions led to a disjointed set of policy directives that provided lower-level officials plenty of scope to harass citizens and builders applying for approval to construct a building. These issues impacted scope and impact potential of RWH policy and limited the reach of the results. Till date, unless the specific method of RWH mentioned in the CMDA 1994 rule is shown in the building approval plan, the building plan becomes subject to rejection due to non-compliance.

Groundwater alone is not enough for the diverse needs of public. However, the urgency to act and the conviction that RWH is the right solution seem to have blinded policy actors from taking an adequately broad perspective required for addressing the problem at hand. The same trend of rushing into action without adequate thought is seen to continue in the range of ways and means used in effecting the policy.

The objective of the policy in our analysis is assumed to be an 'augmentation of groundwater resources'. It would be used later on to assess the success of the policy in qualitative and quantitative terms while no specific goals were published by the policy makers.

Range of Ways and Means Used

The range of ways and means used by the government and non-government agents is summarized in Table 1, with a focus on actions till October 2003 when the amended groundwater act became effective (Agarwal et al., 2001, pp. 199–200; *The Hindu*, 2001, 2013).

Government Actions

As can be seen in Table 1, the efforts started much before 2002 on both sides, and it may give the impression that both sides were heavily involved and equally serious about it. But almost all of the government efforts had one actor as the common driving force, Shantha Sheela Nair, an IAS officer, while there were several actors in the non-government sphere. Shantha played a decisive role in water management and is sometimes referred to as Chennai's water woman (CSE, 2015). She was the secretary of Municipal Administration and Water Supply (MAWS), Tamil Nadu, when the 2002 amendment was formulated. She took up this role in 2001, after Jayalalitha became the

Table 1. Range of Ways and Means Used for Implementing 2002 RWH Policy in Chennai

Year	Government Actions	Non-government Actions
1987	Madras groundwater act created to license groundwater extraction	Several non-government actors have started using RWH
1990		Ramani's self-christened RWH model house opened to public
1994	RWH mandated for new buildings but not enforced strictly	
1995		Sekhar Raghavan starts door-to-door campaign to promote RWH
2001		*The Hindu* (Goutam Ghosh) seeks action on water management
2002	October: Amendment with October 2003 deadline for RWH in all buildings	January: AG Trust formed by Ramani, Sekhar and others to promote RWH
2003	July: Ordinance with deadline advanced to August 31; Government empowered to install RWH	August: Rain Centre inaugurated by Jayalalitha
2003	September: Government machinery inspects and installs RWH	
2003	October 10: Amendment comes into effect and strictly enforced	Survey by Rain Centre shows over 99 per cent compliance but only 50 per cent technically sound
2013	Metrowater launches a survey to assess success of policy	Most of the pioneers have gone to other fields or spread beyond Chennai

Source: A number of sources already provided in the text.

chief minister of Tamil Nadu once again, and got into action immediately by forming a high-level committee of officers and a public representative (interview with Raghavan, 2013) on the issue of groundwater depletion. The committee started meeting every week to review the progress of efforts. This led to the 2002 amendment, which mandated RWH in all buildings and added teeth to regulate extraction and transport of groundwater. Earlier, Shantha's efforts had led to mandating RWH in new buildings and to the identification of alternative RWH models. She wrote in *The Chennai Experience* (Nair, 2001) to show how Chennai was leading the country in urban RWH.

Shantha was supported by Jayalalitha in mandating RWH and implementing it strictly. CMDA also supported the policy of RWH and ensured that no new building would come up without RWH.

Both Chennai Metrowater and Chennai Corporation come under MAWS, which made it somewhat easier to coordinate the efforts. However, gaps between government departments in India are usually hard to fill and even Shantha could not bridge all the gaps. While Metrowater, with the responsibility of doing something about water scarcity, acted in several ways, the corporation hardly played any role in the management of the crisis despite huge opportunities. Perhaps the most telling example of it is the absence of management of rainwater collected in storm drains that are managed by the corporation.[11] These drains carry enough freshwater to serve most of Chennai's needs every year (interview with Raghavan, 2013). Storm water continued to be released to the sea (Sivanappan, 2006). Ironically, the same water was later taken from the sea for desalination at a huge cost.

On the finance side of this policy, neither any huge budget was required nor was there any need of large projects to be commissioned. This made it easier for the government to prioritize this issue and focus on ensuring enforcement.

Perhaps the most visible part of government efforts was communications. This is one area that is visible even today on the Tamil Nadu Government websites, with pages dating back to the 2001–03 timeframe when the communications machinery was in full swing. Wide-ranging means were used, which included participatory programmes involving schoolchildren, placing posters in buses (in Tamil and English) and canvassing through multiple websites and officials across government bodies (Metrowater, 2015a).

The core of the implementation tactic adopted by the government was 'carrot and stick', with the stick visible right from the start and a promise of several carrots in future. The 'stick' was the mandatory RWH implementation and disconnection on non-compliance, even forceful implementation of RWH for non-compliance with charges levied as property tax. In a clever tactic, the obligation of compliance was not only limited to the building owner, but was also extended to anyone who occupied the building, thus making it much easier for compliance inspectors to find a responsible party as long as the building was in use. The 'carrot' was water itself that would come in due course from nature but with a higher probability of it remaining available underground for Metrowater or someone else to pump it for consumption, post-RWH implementation. Furthermore, it was expected that the water price would go down once water tables increased from charging of the groundwater table. Existing borewells and pumps in Chennai would be able to meet a much larger proportion of the demand. Thus, demand for water from outside Chennai would decrease, leading to lower price and elimination or reduction of conflicts over water.

Non-government Actions

We have already observed the central role played by non-government agents in the 'Reasons for 2002 Amendment Mandating RWH' section. Now, we will further detail that role and its variety. Several non-governmental organizations (NGOs), individual social workers and even private builders worked on RWH, as awareness about it gained momentum in Chennai. To name some of the private players, Indukant Ragade is known in Chennai RWH circles as a builder who voluntarily adhered to 1994 CMDA rule, making RWH mandatory (interview with Raghavan, 2013). R. Jeyakumar from the construction industry worked on making RWH popular and wrote in publications such as *Making Water Everybody's Business: Practice and Policy of Water Harvesting* (Agarwal et al., 2001, pp. 201–206). They showed through their work that RWH is cost-effective and simple. Over time, they could show through results that it also requires low maintenance if done properly in the first place. K. R. Gopinath is perhaps best known as an RWH builder from Chennai, now practising outside Chennai. He started with promoting RWH in Chennai as a community service when he was the president of a community club. He helped adopt RWH in several companies in Chennai (CSE, 2015).

At an individual level, M. N. Mitra started RWH at his apartment complex. Although he had no support from other residents initially, he made it work which eventually led to a turnaround of views and support in his complex. He started a trust, Tree, Rains and You, to promote RWH and, in particular, the concept of baby wells (a small well) as a cost-effective alternative to storm drains. He also roped in his employer. However, Mitra is not the only

person who led such efforts in a small but significant way; several others are also there, some known in the public domain and many more who are not (Interview with Jude, 2013, July-August). Some important public figures are: Venkataram of P. N. Welfare Association, Mangalam Balasubramaniam who worked on reviving temple tanks and D. V. Subramanian who pushed for harvesting water from public spaces, such as flyovers (CSE, 2015).

Huge efforts were made by non-government agents to communicate and involve people. M. S. Swaminathan Research Foundation acted as the supporting NGO for a talk in Chennai on 6 May 1997, which helped people express their views about water harvesting (Agarwal et al., 2001). There was at least one paper writing contest on RWH. Several door-to-door campaigns were organized by various individuals and NGOs. In fact, a number of new NGOs came up in this period. These NGOs provided support to the local community in learning not just about RWH but water management, in general, and also implementing it fruitfully.

Furthermore, there is not one common product or service that people blindly purchased or adopted. They have rather used their ingenuity in finding new ways to capture and use water. They have also gone back to traditional practices, such as the use of temple tanks to store water. Such ingenuity and creativity of public not only showed the breadth of ways and means used for implementation of RWH, but also made a difference in widening the reach of results. On the other hand, this also reflected the narrow mandate of installing RWH as given in the government policy.

Analysis of Range of Ways and Means Used

This section analyses the two ways in which the range of ways and means was used. The first is directly taken from Amartya Sen's article *The Three R's of Reforms* (Sen, 2005) and the second from general policy-analysis perspective.

According to Sen,

> It is not only important to remember that the *ends* of institutional reform and policy change have to be 'person related' and 'even-handed', but also to acknowledge that the *means* to pursue those ends involve a variety of institutions—not just the invoking of a few magic bullets. (Sen, 2005, p. 1973)

The means in this case certainly involved multiple institutions as shown in the preceding sections, especially in non-government actions. Not only were private individuals and NGOs involved in this campaign, but builders and businessmen also joined hands, though to varying degrees. As stated earlier, government institutions were not involved to the extent it was necessary, evident in the lack of efforts by corporation in using storm drain water. Lack of coordination among government institutions was also evident as there were notable gaps in the rules between CMDA and Metrowater. Furthermore, it was obvious that other departments were also not involved to the extent it was necessary. For instance, there was an acute shortage of training and certification of plumbers on the basics of RWH. If the government did not have the enough in-house capacity or skills, other agencies could have been involved to train and certify the adequate number of plumbers or other technicians on the basic RWH methods. It should have been possible for the government, given the enormous scale of public works undertaken by the Tamil Nadu government, union government or even private agencies. As noted in the beginning of this article, RWH is fairly simple, but it does not mean that anyone can do it without technical support. For this, some basic skills and knowledge are required, which were not provided when people needed them, especially in the rush period from August to October 2003. Given the scale of the effort (all of Tamil Nadu), even bare-minimum support was missing for most RWH projects. Material supply was also less, especially the pebbles required for wells. People used whatever material they could find, which led to suboptimal solutions or, in the worst case, to solutions that became defunct in 1–2 years.

There was a lack of consideration of options and their prioritization in the area of policy analysis, somewhat similar to the case of considering solution options, as has been shown in the 'Reasons for 2002 Amendment Mandating RWH' section. Perhaps the most noticeable one was the way the scope of the effort was determined. The project had embraced entire Tamil Nadu without any rationale. While the scarcity was acute only in Chennai and possibly a few other areas, it is hard to imagine that the entire state would have the same issue at the same magnitude everywhere. It was equally perplexing to see that the entire project was planned to be completed at the same time, which in practice got limited only to the rushed six weeks between 19 July and 31 August 2003. It was realized only then that the progress of work was very slow and the north-eastern monsoon was already at the doorstep. Giving one date for the entire state helped in keeping it simple, but such over-simplification often comes with drawbacks. A few drawbacks in this case were scarcity of right skills and material supply, if not the dilution of the mandate itself, especially outside Chennai.

Another unused but important avenue for RWH has been noted earlier: the surface of the city not covered by

buildings such as public roads and railroads. The corporation could have been asked to capture all the water from public spaces which would have given one massive boost in captured water volumes. Nevertheless, it argued that the water was dirty and it was not possible to clean it (interview with Raghavan, 2013). This argument, however, does not appear very logical as even sewage water is routinely treated around the world and is made potable. In Chennai, the only challenge was to preserve the rainwater running on roads, which practically was easier to treat than sewage water.[12] At least, it could be easily used for non-potable purposes or for recharging groundwater table after minimal treatment (Lemonick, 2013).

Looking beyond RWH, there were other government efforts in securing water supply for Tamil Nadu. As an important example for Chennai, the Tamil Nadu Government had worked earlier with the Andhra Pradesh Government during the tenure of two chief ministers, M. G. Ramachandran and N. T. Ramarao. They obtained agreement of the governments of Karnataka and Maharashtra on the so-called Telugu Ganga project. This project was formulated to provide 15 TMC (thousand million cubic feet) water from Krishna river to Chennai. However, much less amount of water was delivered to Chennai from this river, despite a lot of efforts put by Sai Baba's Trust (*The Hindu*, 2004). Today it provides only about 5 TMC of water to Chennai and there are efforts to revive this source.

Putting these points together, it can be argued that the government did look at multiple options and chose to mandate RWH only for buildings, as it involved almost no cost. However, this logic for avoiding adequate spending is not very powerful as water has been shown to have strong causal links with development and growth, apart from links with electorate's satisfaction with the government (UN-Water, 2015). Besides, people were already paying to private parties for water and they could have paid to the government as well, in case such a requirement would arise. The government could not have ignored these aspects and avoided the reasonable level of spending, especially when it would damage its performance in the event of another scarcity. In all likelihood, the narrow focus could be due to other reasons such as government's lack of desire or effort to bring different departments together, or due to over-reliance on the RWH solution that both the public and government were already experimenting with.

Reach of Results

Before examining the results, it is necessary to recognize that the augmentation of groundwater resources can be taken as the policy objective in this case. Broader water management or scarcity management was not addressed by the 2002 policy or related efforts. The reach of results can thus be assessed primarily on the groundwater level, using both before and after pictures. Furthermore, the conclusions are based on piecing together data from different sources and somewhat different time periods.[13] To address this limitation, diverse sources and experts were consulted.

Purposes Served

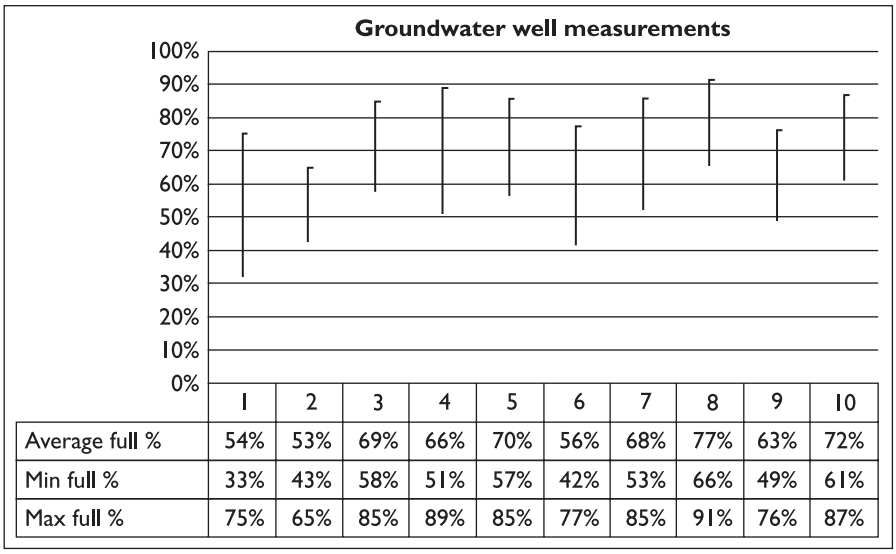
In general, RWH essentially serves two basic purposes (Rain Centre, 2015; Sivanappan, 2006): (a) to provide water for immediate use (including local storage before use) and (b) to provide water for later use through recharging of the groundwater table.

Since the policy concerned the latter, most of the 'Reach of Results' section would be devoted to that. But it would be incomplete without a brief assessment of the former, especially because it holds the most significant appeal to change people's behaviour as part of reforms. Water for immediate use directly provides supply, often at no incremental cost. When R. Ramani proudly offered recycled rainwater to a visitor telling that he was fully self-reliant for water, or when in 2002 the prime minister of Singapore, Goh Chok Tong, drank treated sewage water showing how it was really pure water, it had a dramatic and lasting impact, not just on ordinary citizens, but also on policy makers (Lemonick, 2013; Shah, 2015). It provided immediate evidence of one's argument as opposed to a future increase in the groundwater table that is usually a lot more complex to demonstrate.

Immediate Use

There is no data available from public on change in the immediate use of water due to this policy. Anecdotal evidence suggests that about 1 in 20 buildings uses water from RWH as a source of immediate use (interview with Raghavan, 2013). This is the current scenario. Although the scenario before 2002 is not available, it would be safe to assume that very few buildings had RWH at that time as its installations were new in Chennai. Further, amongst those who make use of RWH water, an even lesser use it as potable water. There is no specific percentage available for this segment of users.

While this may look like a small number (only 5%), it is not so small an achievement if we consider the fact that buildings in Chennai traditionally have water tanks for the storage of water from piped water supply. Thus, the only tank in the house was already in use. Mixing of rainwater with piped water was not recommended until it was converted into potable quality with a somewhat



	1	2	3	4	5	6	7	8	9	10
Average full %	54%	53%	69%	66%	70%	56%	68%	77%	63%	72%
Min full %	33%	43%	58%	51%	57%	42%	53%	66%	49%	61%
Max full %	75%	65%	85%	89%	85%	77%	85%	91%	76%	87%

Figure 4. Average Groundwater Level in Chennai after Years of RWH

Source: Metrowater (2015).

Note: This chart is a simplified summary view of the monthly recording of water level at 10 locations available at the Metrowater site. The water level is combined with the depth of the well to arrive at the height of the water table. It is averaged over 2011 and 2012. It shows that there was a lot of water in the wells in Chennai after several years of practice of RWH.

expensive treatment.[14] Everyone who was making the immediate use of rainwater had either built a second tank, or built two tanks by design (likely after 2002), or had invested in filters to mix treated rainwater with piped water. This shows that people were willing to go through the rigours of installing RWH. There were probably some other factors, such as having only one tank or the habit of buying groundwater from private sector, which contributed to a majority not investing in RWH.

Groundwater Recharge

There are some measured observations and a lot of commentary on groundwater-recharge results. Across these different sources of observations, the primary research question is: Did the groundwater table improve in terms of the level of water at various observation points? The consistent answer across sources is: Yes, there is an observable difference and there is significantly more groundwater post-RWH as compared to the pre-RWH period (CGWB, 2011, p. 60). Both quantitative and qualitative evidence show this and it is summarised later in this section.

The next important question is: Whether this improvement can be attributed to RWH or could it be due to some other factors, such as significantly better rains in post-RWH years? The average annual rainfall based on data from years 1965 to 2002 is 1,266 mm, whereas the same for the years 2003–2012, the post-RWH period, is 1,351 mm (Metrowater, 2015b). The data show that the average rainfall in the post-RWH period is only marginally higher. This difference alone cannot account for a large increase in the groundwater table.[15] Based on the rainfall data, it is clear that the improvement was due to RWH and not because of better rainfall. Moreover, many years prior to the introduction of RWH witnessed very high rainfall, especially 1996 and 1997, as shown in Figure 2. But did such high rainfall in those years result in any significant increase in the groundwater table? For Chennai, the data available on this is not very clear. However, experts are of the opinion that the impact of the years with heavy rainfall was limited only to surface-water reservoirs, and the rest of the rainwater was largely lost due to the absence of RWH and other water management practices in most of Chennai (interview with Raghavan, 2013).

Details of Water Table

The Metrowater website shows the water table level in comparison to the well-depth level as a measure of how much of the water table is full with water. This is an absolute measurement and not relative to the past as data are available only for the years 2010 and 2011. Nevertheless, it gives very specific data for 10 observation points in Chennai as shown in Figure 4. It shows that every single observation well has more than 30 per cent water at all times (Metrowater, 2015c). On an average, the wells are filled with half or more water.

It is important to note here that in the pre-RWH period, the residents of Chennai were struggling to find water in their borewells at existing depths and were often digging deeper in search of water. Open wells were more or less defunct as they had long become useless, given the absence of water, or were out of fashion in the city. There is limited recorded data available for exact comparison of data points but the earlier points in this paragraph are powerful and very consistent across sources. Every source confirms that the water table level increased significantly. A complete time-series data would provide more rigorous comparison. This experience is not unique and other studies have also struggled for past data (Coelho & Reddy, 2004, p. 79). The generalized measurement of average increase in the water level, as shown by one key expert, is 6–8 m (Business Line, 2010). Metrowater measured a net average increase of 4 m (Metrowater, 2015a).

Another important qualitative evidence can be seen in the rise of water level in all the 39 temple tanks in the city. It is said that all these tanks became dry before RWH efforts were initiated. Now, all of them have water. Open wells in Chennai have also become operative. Each interview and every single paper claims that water table levels have improved (interview with Krishnamurthy, volunteer at Rainwater Club, 2013, June–August; interview with Raghavan, 2013; interview with Jude, 2013).

Earlier Efforts

Even before the amendment of 2002, the Tamil Nadu government had started claiming the success of RWH, however not entirely without a reason. Shantha Sheela Nair wrote in *Making Water Everybody's Business* in 2001 how Chennai was showing powerful results in terms of groundwater recharge (Nair, 2001). At that time, it was based on data from those regions where voluntary RWH efforts by the public had started compared to the areas without RWH efforts. It was claimed that the average groundwater level improved by more than 2 m, from a depth of 6.8 m in 1987 to 4.55 m by 1998, owing to RWH. However, this was a partial result and not uniform or widespread at that time.

Broader Benefits

There are several ways in which the RWH policy resulted in benefits in indirect or direct terms. We have discussed below a few important gains from this policy:

- *Spreading awareness:* Chennai performed very well in increasing awareness about the importance of water management. The role of individuals and community in managing water has also been commendable. The message was not only limited to Chennai boundaries, but it also percolated beyond the city through people and websites. Thus, whenever we search a rainwater project outside Chennai, such as in Bangalore, we do come across website links on Chennai (interview with Krishnamurthy, 2013).
- *Democratization and decentralization:* Given the involvement of individuals and community actors, and the empowerment that it brings, democratization and decentralization can be argued as benefits from RWH. It is also the reversal of the historical trend wherein the public expect the government to provision everything. It also provided an alternative supply option from private players.

Overall Policy Analysis

As prescribed in an article by Amartya Sen (Sen, 2005), person-related and even-handed reach of results are the two aspects of the RWH policy in Chennai. People with access to groundwater, such as those with private borewells, benefited due to the increase in the groundwater level. Even those without access to groundwater benefitted indirectly as the scarcity of water reduced and availability increased. Thus, the results in Chennai were related to people, either directly or indirectly. Furthermore, some water sources were either developed or enhanced, arguably as an unintended consequence or as a separate effort altogether, such as temple tanks and reservoirs. These results are related to the even-handed distribution as groundwater, lakes and tanks are by nature a shared pool. In contrast, the limited means of access or social constraints could make it inaccessible to some. Furthermore, not all RWH sites are equal or effective. A survey conducted by Rain Centre (Raghavan, 2004) showed that only half of the RWH structures were effective while officially over 99 per cent were compliant. Thus, we can say that despite unequal contribution, everyone benefited from the same common pool to varying degrees.

Some researchers have applied the game theory concepts (Coelho & Reddy, 2004, pp. 77–81) to examine the policy and its effects. The pre-RWH period matches well with 'the tragedy of the commons game' where a public good (groundwater) is over-exploited in the absence of a suitable regulatory mechanism. This improved with the amendment of 1987 Act, including the identification of extraction limits. The post-RWH period is explained well with 'the prisoner's dilemma game' wherein the risk

of defection (stopping RWH or ignoring whether it is really working at one's building) is real and is a risk to the sustainable optimal result. Overall, their conclusions broadly match those pointed out in this article. First, although it is undeniable that the RWH policy led to an increase in groundwater tables, the costs were not distributed evenly and the benefits were not as transparent as they should have been, due to the absence of adequate monitoring and governance. Second, the sustainability of benefits is also questionable given the poor quality of implementation. Third, the potential has not been fully realized, especially in terms of the volume of water captured and the quality of output.

Rushed Implementation

While the government had issued the amendment in October 2002, it failed to effectively communicate the RWH timeline as October 2003. Apparently, the timeline was not included in any communications to the public, possibly because the communication machinery on RWH did not modify the materials as it had already been active for a while. Possibly the officers involved also did not have a sense of the seriousness with which the chief minister or Shantha Sheela Nair took the policy. When the chief minister reviewed progress in July 2003 and found huge gaps in implementation, it was decided to convey the message strongly. The government issued an ordinance on 19 July 2003 to seek implementation by 31 July 2003, earlier than the October timeline (Government of Tamil Nadu, 2003). It followed up with an order on 21 July 2003 that was sent to all government departments. It empowered the government to ensure the implementation of the RWH policy after 31 August 2003 and recover charges from owners.

This last-minute rush had a serious impact on the quality of RWH implementations, while it helped in conveying a sense of urgency to all. If a large number of non-government actors were missing, the rushed timeline would have led to a complete failure instead of a reasonable level of success that was achieved. It was the momentum built by several passionate members from the public and their voluntary followers who produced good-quality RWH installations that actually captured rain and recharged ground tables. The government agents (such as those from CMDA) quickly used this rush period and the empowerment vested upon them as an opportunity to harass public and took advantage of it by giving the official stamp of RWH implementation. Apart from performing a poor job, often someone in their clique made money out of this opportunity. Such a rushed implementation of the policy did not recharge groundwater, at least not for long, as job done was of poor quality. It is obvious that without public actors, the results of RWH would have been altogether different.

Fertile Ground for Further Research

There are several areas of further research around Chennai RWH. Some of these are highlighted in the following:

- Public and government worked together to a certain extent, at least in the given direction if not on key technical details. What made this possible? We could draw more lessons in terms of policy life-cycle stages that may be of interest for policy making in general, especially to absorb people participation into it.
- Assess the lessons from Chennai for other cities; develop a model that allows mapping of context across cities based on a variety of parameters thus facilitating drawing of relevant lessons.[16]
- The impact made by RWH actors, originally from Chennai, on places outside Chennai or Tamil Nadu.
- Explore potential for the use of non-building rainwater, such as those from roads and rails, both quantitative (volume of water) and qualitative (making water useful, the cost associated with it and convenience of doing it).

Concluding Remarks

The success of 2002 amendment, RWH mandate and regulation, is well supported and widely acknowledged, whereas the extent of its implementation as well as quality provide ample scope for improvement. The reason for success is also explained to be a combination of government's will that succeeded due to the active role of several passionate non-government actors and their followers. The 2011 report on Indian cities by Central Groundwater Board (CGWB) noted for Chennai that 'roof top rain water harvesting made mandatory by the State Government has improved the water level condition but due to lack of periodical maintenance, the effect has reduced over the period of time' (CGWB, 2011, p. 60). This provides insights into Chennai's initiatives to sustain RWH efforts, and other cities should learn from this experience. Furthermore, other cities can also aim for the achievement of alignment between government and non-government forces at the right occasion (politically) to help open the window of opportunity for policy making toward sustainable development practices, such as RWH.

The findings of this article also support the fact that RWH is one of the approaches that can lead to a real win–win situation for the government and the public. It is a low-cost solution for every stakeholder. In a way, it is waste prevention; catch the water before it is lost or becomes dirty. RWH is the key to sustainable development, especially in those cities in India which witness heavy rainfall every year. To conclude, people with personal passion and know-how in the subject may be able to complement government's policies, directions and efforts in a significant way, which can lead to better results.

Acknowledgements

I would like to acknowledge the help of Deepak Malghan for introducing me to Avinash Krishnamurthy of Rainwater Club and to Avinash for the interview and several pointers. I would also like to thank Jayaram Nair, my friend in Chennai, who introduced me to Jude, his neighbour and a reporter involved in RWH. I am thankful to Jude for the interview and to Sekhar Raghavan for multiple rounds of interviews, information over emails and numerous pointers. Lastly, my thanks goes to Veena Srinivasan for discussing her Chennai papers with me.

Notes

1. Rainwater harvesting helps in capturing rainwater in one way or the other, which can then be used. It also helps in charging the groundwater table. Rainwater could be captured directly on a building's roof or on ground, or indirectly through capturing water that is running off, say in a storm drain or during seasonal flooding (Rain Centre, 2015). It is generally regarded as a fairly simple and low-cost technique. It has been in practice in many parts of the world from ancient times, leading to very successful results in areas facing severe water scarcity (Singh, 2009).
2. The belief that Chennai is now better-off in freshwater availability is only based on the water table level and not on its quality, which is also an important aspect regardless of RWH.
3. The data used in this report have been collected by the author from the implementation phase up until 2013 interviews. Data from more recent times are not available, while there is some anecdotal evidence of less strict adherence at present.
4. The construct was explained in Amartya Sen's 2005 paper *The Three R's of Reforms* (Sen, 2005). He presented 'Reach', 'Range' and 'Reason' to the Global Development Network in New Delhi as the three core factors to be considered when working on any reform. It refers to the reach of results to be achieved, the range of ways and means to be used and the reason for choosing the priorities. While it can be argued that the use of RWH is not a major reform, urban water is definitely an increasingly important topic and it might require major reforms in the coming decades, if not in nearer future, given the scarcity of usable water in cities and its growing demand (CSE, 2012). Moreover, the three R's construct fits well as a post-facto analysis framework for the purposes of this article.
5. These six wells are in a basin called Araniar–Koratalaiyar Basin and they continue to serve Chennai till date (Metrowater, 2015a).
6. Recall that this was the period when governments across much of India gave away virtually free borewells, pumps and even the energy needed to run them, for farming purposes.
7. Viranam tank, which gets water from Western Ghats rains via Kaveri River, is 220 km from Chennai and it has been serving Chennai since 2002. Private tankers are said to have come from even farther (Raghavan, 2013).
8. The data are from the Chennai Metrowater website (Metrowater, 2015b). They provide monthly rainfall data from January 1965 till recently.
9. The government also took a serious note of sea water penetrating the groundwater table deep inshore and worked on injecting freshwater at multiple points along the shore aquifer (Nair, 2001).
10. Cost estimate in 2001 ranged from INR 5,000 to 10,000 for a typical independent house. The Metrowater online calculator showed a saving of INR 14,000 over 900 days with an investment of INR 5,000 for RWH based on a market price of INR 500 for 5,000 l of water (Coelho & Reddy, 2004, pp. 71–72).
11. Even though the Corporation did some work on RWH, those limited efforts were found to be of little impact as water collected from public spaces was usually let out into storm drains, leading to the sea (Raghavan, 2013; Sivanappan, 2006).
12. Singapore and Australia have been in the press in the last few years for cleaning sewage water for drinking. Both the countries have been promoting treated water for drinking. While we may not do the same for various reasons, such as cost, it is still useful to recognize the basic fact that water is not really manufactured by humans. Almost all the water we consume is simply recycled water, either by nature's design or by human design. Both nature and human-made processes are entirely capable of producing potable water, regardless of where it came from during its almost never-ending life.
13. One researcher, Veena Srinivasan, has recognized the issue of different water sources and developed a comprehensive model of water supply across sources (Srinivasan, 2008).
14. It might be considered expensive by some at the individual house level, but the cost is much lower at the community or building level because of pooling. Also, the cost of the potable water level of treatment varies depending on various factors and it is not detailed here.
15. The difference in average rainfall was tested using the statistical method of *t*-test to confirm with 95 per cent confidence that it is not significant (*t*-stat = –0.0626 and *t*-critical two-tail = 2.160).
16. This may be a complex and ambitious task given the attempts by one set of scholars, notably Elinor Ostrom, in developing design principles for common pool resources, and the counter by other scholars of virtual impossibility of generalization (Agrawal, 2001). Nevertheless, the analysis of this valuable phenomenon and more observations on it would reveal a clearer picture based in India, if not a clear generalization.

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