Watering India's smart cities

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Water is often absent from discourse on smart places. India's smart city drive detracts from the need for basic infrastructure, even whilst setting it as a priority in policy. The very act of framing it as 'smart' overshadows service provision with headline-grabbing projects that are aimed at wealthy residents and leave those without access to basic infrastructure further behind. This chapter puts water at the centre of discussions of smart places in India by considering the situation in Mumbai in the context of India's smart cities agenda. Rainwater harvesting could become a smart technology to provide more water, but these need to be functioning and maintained systems and not 'eyewash' to tick a box. This chapter calls for water-centric urban planning to create smart and just places.

Key Words: Water; India; infrastructure; maintenance; governance

1. India's Smart City Agenda

India's cities have the potential to be world-class. Smart places are central to the Government of India's imagination of modern India, as indicated by the drive to create one hundred smart cities in India. Prime Minister Narendra Modi launched the Smart Cities Mission in 2014 as a flagship programme in his first term of office that would shape the future of 100 cities (Das, 2020). This plan ostensibly works towards the Sustainable Development Goals (SDG), specifically SDG 11: Sustainable cities and communities, which is in turn beginning to become synonymous with smart cities (Kaika, 2017). The documentation for the initiative puts basic infrastructure front and centre in the rationale (Ministry of Urban Development, 2015; Chakrabarty, 2019) but framing them as smart issues has at the same time directed attention elsewhere.

Kaika (2017) says that smart cities might change the aims, but the *how* also needs addressing to create the radical change to our cities that we need. India's Smart Cities Mission attempts to use the ideals of various smart city narratives to address the challenges of urbanization (Ministry of Urban Development, 2015). In doing so they are continuing trends of privatisation and market-led urbanisation that focusses on small affluent urban areas (Kaika, 2017; Joshi 2016). As Das (2020) points out, the aims of the Smart Cities Missions were laudable, a focus on the means took precedence over the outcomes, leading to market driven initiatives that favour the elite. The smart cities programme is driven from the centre and as such is also disempowering local governments (Tandon, 2020; Joshi, 2016, Jadhav, 2019). This leads to

smart places and digital technologies being used as technical fixes for social problems (Chakrabarty, 2019).

The Government of India's Ministry of Urban Development, which heads the Smart Cities Mission, avoids the difficult task of defining what a smart city is by quite rightly pointing out that there is no definitive concept and they are multi-faceted entities (see also Hollands 2008). The instructions for entering the competition give more clues as to what is seen to constitute a smart city by setting out criteria (Ministry of Urban Development, 2015). The initial competition was launched in 2015 and it has drawn a lot of attention from the media both in India and internationally. The competitive system and the overall mission have been widely critiqued by both journalists and academics such as Sampath (2016), Datta (2015a and 2015b) and Das (2020). Water access is an issue for the poor, whereas high-tech solutions are the preserve of the rich. Here we address how the smart cities framing can be used to encompass a more inclusive approach to designing and retrofitting places.

This chapter considers how smart city aims and processes can be reconciled by focussing on water. The chapter is based on over a decade of research on water in India and particularly drawing on discussions from September 2017 in Mumbai, Maharashtra. It should be noted that Mumbai is not part of India's Smart Cities Mission and resisted inclusion in the Smart Cities Challenge competition to become one of the 100 smart cities. This could be interpreted as a choice to spend money in other ways and/or to keep more control at local government level, rather than with national government and private companies (Das, 2020). Places can still be smart outside of official bench-marking schemes. I start by introducing Mumbai's complex relationship with water as experienced through water shortage and flooding events. I then discuss rainwater harvesting as a technology being used to address some of these concerns. I will re-think rainwater harvesting as a smart technology to address water shortage and consider how the legislation surrounding rainwater harvesting fits with the Government of India's drive to create smart cities. We should not discount technologies because they are not traditionally labelled as 'smart'. I then consider the effectiveness of implementing the legislation in Mumbai through the concept of 'eye-wash' and also bring in the issues of maintaining smart places once they are created. Finally, I draw these threads together to rethink smart places through the lens of water justice. There is little point in a smart system that regulates water supplies digitally and remotely, when there is no water supply.

2. Water Shortage in Mumbai

"The rain is lashing the apartment window. The monsoon rains have been devastating in Mumbai this year, leading to floods, transport chaos, diseases and accidental deaths. In recent years the monsoon rains have been 'scanty' and water shortages have been common." (Extract from author's notes on 22/09/2017 in Mumbai).

Water shortage and flooding often go hand-in-hand. When researching flooding in Vietnam, I found that farmers would rapidly start talking about drought, and when looking at water shortage in India, people often talk about flooding. "There is too much population on an island, and all is concrete. Need to let the water go down, but sea water is also rising, so water will be salty soon. If you don't wake up now, it will be too late" (resident and activist interviewed in Mumbai on 19/09/2017). At some points in the year, it seems that there is water everywhere in Mumbai as the monsoon rains pour down, but most of that rainwater runs over the tarmac and concrete straight into the sea. Mumbai was hit by severe floods in 2005 and again in 2017.

Several people told me that the floods in September 2017 were even worse than the widely reported ones in 2005. Respondents complained that the roads were flooded to mid-calf level after just 10 minutes of rain downpour. This is due to several factors including poor maintenance and the concretization of the metropolis.

In August 2017, a well-renowned doctor's car broke down in the flood waters just five minutes from home. Dr Deepak Amrapurkar decided to walk the short distance, but he fell into an open manhole and drowned. The man-hole cover had been deliberately removed by local residents in the (mistaken) belief that it would ease the inundation of their apartment building. This tragic example highlights the need to create smart places and systems to monitor drainage (Debroy, 2017). The municipality seem to have largely relied on the famous 'Mumbai spirit' to deal with the disastrous floods. Anti-tamper systems could be fitted onto water and drainage systems. This could also link to maintenance of drainage and water infrastructure and be used to log when maintenance occurs. Even with improved drainage, flooding can still occur. Smart solutions could use remote monitoring to identify places of water inundation and co-ordinate a response. This could also draw on that 'Mumbai spirit' of strong civil society by encouraging residents to use social media platforms to update on serious flooding events or use citizen science in other ways. So far there is no evidence of using these techniques. Considering flooding goes beyond the scope of this chapter, but it is an interlinked issue to keep in mind when considering water shortage.

Water shortages are not new to Mumbai. They can even be seen as designed into the original mains water supplies and then built upon since then. The provision of mains water in Mumbai has roots in the colonial planning of the city when the existing wells and tanks were insufficient due to drought and urbanisation (Zérah, 2008). In response, The Water Department was created in 1860 to supply water from lakes through a centralised infrastructure system that is provided and controlled by the government (Gandy, 2008; Zérah, 2008; Anand, 2011). The colonial government did not have aspirations that mains water would be universally provided and the first system that brought water from Vihar reservoir, finished in 1860, only supplied water to wealthy households (Anand, 2011; Gandy, 2008). The water system was popular with wealthy residents and an increase in the number of connections, combined with droughts led to the extension of the Vihar system and creation of the Tulsi scheme by 1879 (both of which still serve South Mumbai), followed by the ambitious Tansa scheme completed in 1948 (Gandy, 2008). Even with these expansions there were still insufficient and uneven water supplies into the city at the time of India's independence. Post-independence there have been several more schemes bringing water from distant lakes. The most recent of which is the Bhatsai scheme completed in several phases from 1983 until the present day and several more schemes to increase water supplies are in preparation (Bambale, 2012).

Although the network of supply pipes has been extended, it has not kept up with urban growth and a shortage of water supply has been created. Mains drinking water now comes from several reservoirs or lakes outside the city but is only supplied for a few hours per day to each area of the city (BrihanMumbai Municipal Corporation, 2003; Sule, no date). Water is only supplied to buildings that the municipality consider legal and water is not supplied to informal settlements constructed after 1995 (Bambale, 2012). By 2003 the municipality had acknowledged the water shortage and that the problem had accelerated faster than expected:

“The present water demand of Mumbai is 3400 MLD¹ against supply of 2900 MLD. This difference was expected to grow much higher in 2021 when the projected demand would be 5400 MLD for a projected population of 15.60 millions. But the population is almost there today itself & the city is facing water shortage in some areas.” (BrihanMumbai Municipal Corporation, 2003: 1)

The Municipal Corporation of Greater Mumbai (MCGM, also known as BMC) states that in 2012 water supply levels to Mumbai were 180 litres per person per day, which is higher than supplies to London (Bambale, 2012). However due to not all residencies being supplied, the poorly maintained and inefficient network, leakages and thefts, the per capita water supply is much lower than that and the dream of a 24/7 supply for all residents is a long way off (Graham et al., 2013; McKenzie and Ray, 2009). The difficulties in accessing water for the urban poor majority are a daily struggle. New legislation (in line with Sustainable Development Goal 6) that pledges to supply piped water to all citizens by 2024 has been announced by the Government of India in Modi’s second term (Shrivastava, 2019; Baby and Reddy, 2019)

The MCGM still bears the sole responsibility for the lucrative water supply in the city, unlike the privatised electricity supplies (BrihanMumbai Municipal Corporation, 2003; Zérah, 2008). Ruet et al (2002) explain that the water supply is still public because of the economic benefits as the returns far outweigh the expenditure, making water a good source of revenue for the MCGM. Although this in some ways limits the commodification of water resources, the lack of an autonomous water agency reduces the efficient management of the system (Bakker, 2010). However, Ruet et al (2002) point out that the number of divisions within the MCGM with responsibilities for part of the water infrastructure, and the large number of other institutions involved at the state level in provision of water, has created a very complicated system that has led to failures. And corruption is also a serious problem across all parts of the water supply system (Asthana, 2008).

Piped water is only delivered to each area for a few hours a day, even to rich households (Button, 2014). At the domestic scale water supply issues are frequently experienced and this provides a lens for viewing the situation of water security in Mumbai as a whole. The variance in supply is foregrounded when there is failure in the system. “The water is finally back on! [...] There was water to flush the toilet and for one tap in the kitchen only. This means it probably comes from a tank or a borewell, definitely from a different source. It turns out the pump was broken and needed a new baring. The baring was fitted late this morning. So, I can shower before meeting friends for dinner. No rain today so it is HOT.” (Extract from author’s notes on 18/09/2017 in Mumbai). Many wealthy Mumbai residents cope with these shortages by creating a portfolio of water supplies (Button, 2017a). This means that there is a constant supply of running water in apartments, but it comes from a variety of sources that are carefully managed. This portfolio increasingly includes rainwater harvesting and could be the key to retrofitting more inclusive smart technologies.

3. Rainwater Harvesting as a Smart Technology

‘Smart’ does not necessarily mean digital. Technology does not have to be digital and smart interventions do not need to be large and expensive to be effective. Solutions need to be all-encompassing throughout cities and move away from a system of “greening by numbers and

¹ Million Litres Daily

indicators” (Kaika, 2017: 90). Labelling a process ‘smart’ invites the applicants and policy makers to sidestep the requirement to improve infrastructure as a small tick-box hurdle to be overcome, rather than the primary goal of the endeavour. The grounded, often dirty sometimes hidden and always expensive, basic infrastructure hardware is easy to pass over when there are shiny new possibilities on offer in a smart city vision.

Interest in the environment and ‘green’ technologies that are central to smart places has not been high until recently in India and this could be because the technologies do not address the main issues or are at the wrong scale.

“India needs technologies that are cheap, small and rectified for the needs of society. Simple, small things. Every house has an ‘Aqua Guard’ [water filter] can this be solar powered? Most people have a balcony, can they have solar lighting? Cheap and simple. Need some crisis to make everyone take notice.” MCGM official (interviewed in Mumbai 14/02/2010)

The need for appropriate technologies that address not just the requirements of the population, but also the capacities and culture are required. The 20th century emphasis on large-scale centralised energy infrastructure that was developed in response to industrialisation in the Global North may not be appropriate in contemporary Mumbai where de-centralised water responses are taking centre stage. Thus South-South appropriate technology transfer might yield better results, with due attention given to site specificities. When the technology is appropriate and provides cost-effective solutions to the problem, such as rainwater harvesting and water shortage, a precedent is created that can be used to implement further technology interventions and legislations.

Rainwater harvesting is mandatory in Mumbai for all newly constructed domestic buildings with a plot area of over 1,000m² since October 2002 and over 300m² since June 2007 (Municipal Corporation of Greater Mumbai, 2003 and 2008). This legislation was brought in to address concerns over water shortages in Mumbai and has been retrospectively presented as an environmental policy. The environment has moved up the political agenda due to the impacts of extreme weather events and international pressures and the MCGM has included rainwater harvesting as a prominent part of the *EcoHousing* scheme (Municipal Corporation of Greater Mumbai, 2009). It is a policy that sits between water, environment, housing and planning legislation by changing the nature of water provision and controlling development. This means that housing, and corresponding legislation, is used as a conduit to govern water provision. Developers are not granted an occupation certificate giving permission for people to live there until a rainwater harvesting system is in place and will not be connected to the mains supply without a rainwater harvesting system in place. So far legislation has been for new buildings only, but there is a rising trend in residents retrofitting rainwater harvesting systems to increase water supplies, and also to reduce localised flooding (Button, 2017a; Button, 2017b).

A huge number of factors influence the design of a rainwater harvesting system and each system must be designed for the specific site and building(s) but there are certain commonalities. By considering rainwater harvesting schematically, we can see places where smart technology could enhance the functionality. This could be in the collection, storage, withdrawal and/or usage of rainwater. It should be noted that rainwater is not to be used as potable water, but it collected for use in purposes other than drinking, cooking and bathing.

Figure 16.1 about here

The three routes that harvested rainwater takes are:

A. Water is stored in a tank and the rainwater can be easily accessed and used. This pathway directly replaces water that was previously supplied by water tanker. Water is made available instantly from the water stored in the tank, but it is quite limited, unless an extremely large tank is available. As this is a limited supply, it is not the favoured route, but is often used in conjunction with pathway B. Water is available instantly and in the long term when the two routes are combined. They can be included separately or with route B supplies from an overflow from the tank in route A.

B. Water is used to recharge the ground water (or sometimes an aquifer) and water is then later withdrawn using a well to be used in the building and grounds. This is the route that I found to be favoured in retrofit because it allows for a large volume of water to be added to the water table. The amount of water that is replenished and that withdrawn might differ and there is no regulation of this. Currently the amount withdrawn seems to be less than put in, as the level in wells has risen slightly, but this may not be the case in all systems and may not continue in the future. Metering the water put in and withdrawn would be one way to monitor this and smart metering could help regulate water supplies across a neighbourhood. The collected rainwater is not bounded (as in A) and might flow away from the original property and be withdrawn elsewhere, as shown by route C. Route B is also popular because it reduces the risk of mosquitoes breeding in the water whereas in route A chemicals would need to be added to reduce the mosquitoes.

C. This is the route favoured by developers of new-build properties and fulfils legislative requirements. If percolation happens in gardens, then it can be used to water them as it drains away and such soakaways are popular. The water may be withdrawn by wells on other properties and so might improve the local water security. The rainwater in pathway C replenishes the local water table (or aquifer) as in route B, but it is not directly withdrawn for use in the building. There is no monitoring of how much water enters a soakaway and this would be useful information for designing and operating smart places.

The differentiation in the water supplies that facilitates environmental innovation also limits the joining up of systems. Even when three towers are in the same compound, they have separate rainwater harvesting systems retrofitted because they are each run as a separate co-operative. Water supplies can be linked together so that we can create places with smarter water supplies. Then measure and monitor water in these complex situations to improve efficiency and make responsive infrastructure. However, the recharge and the withdrawal of water from rainwater harvesting systems are not measured. Installation of meters would be a start to making smart water systems in Mumbai.

Figure 16.2 about here

Rainwater harvesting systems can require a lot of space. This makes them difficult to retrofit, especially in low-income homes and neighbourhoods, where roofs are smaller and there is less open space. Water must be collected, and then stored and/or percolated to recharge the groundwater. Rainwater harvesting could be a key technology in smart places to supply water and also to reduce localised flooding by introducing permeable surfaces, such as green spaces.

A plentiful water supply then makes the greening of places possible, as shown in the image above where the harvested water is filtered through tiered flowerbeds, both using and also creating the green space. The unusual system pictured makes good use of the grounds of the apartment building. The vegetation in turn improves and cools the local micro-climate making more usable outdoor places in hot and humid areas. Smart places that put water at the centre become green spaces.

4. Creating and Maintaining Smart Rainwater Harvesting Systems

I have heard from rainwater harvesting consultants and installers several times in the last decade that property developers approach them, not to install systems, but to loan them the equipment to make it look like the rainwater harvesting is in place, so that the buildings can be signed off for occupancy. There must be a smart way to check and monitor systems. ‘Eye-wash’ is a term used by rainwater harvesting consultant Gurjeet Singh Bedi to describe the situation when a (rainwater harvesting) system looks good but does nothing. This is his feeling about many companies that install rainwater harvesting systems. He says that they are marketing companies really, who then call in contractors who do not do a good job. For example, one large real-estate developer is now using his company for a development of 25 residential towers because they have been disappointed with work of other rainwater harvesting installers. “They now want quality” (Gurjeet Singh Bedi interviewed in Mumbai on 24/09/2017). This reflects the growing water shortages and global concerns around water security. Developers are realising that water saving technology is a good investment and so they should install systems that work from experienced consultants. It is an extension of the concept of greenwash. Not that something is described and marketed as ‘green’, but rather when a ‘green’ technology is installed and does not work or is simply made to *look* as if it has been installed. These eye-washes create mirages of smart places.

There is doubt over whether rainwater harvesting legislation is being effectively enforced, as emerged in several interviews and media reports suggest that only fifty percent of new buildings have systems in place after construction (Kulkarni, 2012). This could be symptomatic of the builders not benefiting directly from installation, and so only providing the bare minimum to be within regulations. Providing additional environmental systems would create savings for the residents, but the builder would incur the costs. The matter of checking the systems was raised with the chief engineer of MCGM who explains the process of checking rainwater harvesting systems are in place:

“Building proposal department gives certification. This is done post construction but a licensed architect checks during the construction process.” MCGM Chief Engineer (interviewed in Mumbai 10/02/2011)

A more detailed explanation of this was not forthcoming and leaves the implementation of the rainwater harvesting legislation in doubt.

“To be honest, it’s so easy to get around it... So even though it’s mandatory on paper, erm, I think not more than 20-30% of the developers are doing it.” Property Developer (interviewed in Mumbai, 16/12/2009)

“It’s not monitored. Honestly, it’s not monitored and that’s where I feel that the citizens are not aware of how to do, where to do, the requirement. Many a time it starts off very well, you know if functions for 3, 4 years and then it collapses.” BMC Official (interviewed in Mumbai, 20/01/2011)

This sentiment was echoed by many people in Mumbai. “Legislation is not working” (architect and educator in conversation in Mumbai on 21/09/2017). She told me that there is no groundwater recharge from systems and tanks cost *crores* (tens of millions) of rupees. Therefore, developers take plans for water plants but then do nothing. She is starting to think that addressing the water shortage at the level of the individual building may not be the answer and a centralised system might be more effective.

Practitioners voiced concerns over whether the systems are installed and also whether they are then subsequently maintained. The issue of maintenance is a crucial one that arose in many interviews, with particular doubt as to whether it was being carried out at all.

“There are certain mandatory things, as you know, that have come in also. But it’s not enough just to make them mandatory. It is important to see how these things are implemented and maintained and after 10 years, are they done?” Environmental Architect (interviewed in Mumbai, 18/11/2009)

There is the question of whether there should be some obligation for follow-up monitoring of projects and whether this would be on the part of the developer, the installer, the municipality or the residents.

“Maintenance is part of users’ responsibility. We run awareness campaigns. Very important – we see ourselves as social engineers.” MCGM Rainwater Harvesting Officer (interviewed in Mumbai, 10/02/2011)

At the time of interview there was no plan to follow up the installation of rainwater harvesting to check maintenance, as it is considered an issue for private self-governing. Maintenance is a constant issue in India. Maintenance of systems must be folded into smart places and planned from the beginning. This must be a long-term solution as updates to technology will also be needed regularly.

Maintenance is vital to keeping the rainwater harvesting process flowing. This kind of ongoing maintenance and repair can be seen as a kind of resilience that does not just return the system back to its original state after a breakdown but allow it to change and to bounce *forward* (Shaw and Theobald, 2011). “Repair and maintenance are not incidental activities. In many ways, they are the engine room of modern economies and societies.” (Graham and Thrift, 2007: 19). Maintenance creates instability in a system. Graham and Thrift (2007) and de Laet and Mol (2000) acknowledge the transformative potential of maintenance through incremental change or ‘tinkering’. This maintenance can lead to innovation as systems are incrementally adapted and improved. Leaves, litter, dirt, bacteria and mosquitoes are the focus of maintaining a rainwater harvesting system and the levels of these could be monitored using digital technologies. This taming of rainwater and exclusion of other elements combines to provide safe clean water to be used in domestic practices (Kaika, 2005). This is particularly significant in Mumbai where maintenance often doesn’t happen, but in smart places it can be vital for the process to happen.

Maintenance is daily, annual or sometimes on an *ad hoc* basis, or indeed a combination of these, depending on the specific system involved at that moment in time and space. Some rainwater harvesting systems require intensive annual maintenance; others require daily upkeep and monitoring; finally some *ad hoc* maintenance is needed along the way. The systems require different types and levels of maintenance, but one commonality is that the maintenance is largely undertaken to *exclude* certain unwanted parts from the system. The below image

shows one of the consultant's employees clearing leaves from the rainwater harvesting collection system. This task is undertaken during the dry season (winter), after the leaves have fallen but before the rains begin again. Before the monsoon the filters of all rainwater harvesting systems must be cleaned. The leaves, litter and dirt are removed before the collection process starts and these unwanted materials exert their agency and disrupt the process by blocking pipes and filters. This annual maintenance also involves the removal and cleaning or replacing of the gravel and sand in the traps and filters.

Insert figure 16.3 here

The above image shows a rainwater harvesting system being physically dis-assembled for cleaning and maintenance. This annual maintenance is carried out either by employees of the consultant who designed the system or by the *watchman* (janitor) in other buildings. This depends on the consultant used and the length of time since installation of the retrofit. In new builds this kind of annual maintenance is provided by the building management after the responsibilities of the installers and construction teams has ended. Maintenance and repair may not be formally organised. The maintenance of systems is negotiated by the residents or managers of the building. The removal of rubbish and the washing of filtration screens may be necessary and repair is also required at times of breakdown or blockage. Even systems that start as effective may become ineffective 'eye-wash' over time due to lack of maintenance and updating.

5. Water Justice in Smart Places

Digitally enhanced smart places must not over-look the provision of water, particularly in places like Mumbai, where water supplies are far from guaranteed. As India refines its smart cities programme, water security should be a key area with rainwater harvesting and greywater recycling included as smart technologies. It is a misconception that smart means digital, and what should be prioritised are solutions that respond to the specific needs of specific places. Smart places can be designed using appropriate technology, not just digital systems.

Moreover, the narrow focus of India's Smart Cities Mission further increases urban inequalities. Digital technologies are expensive to install and to maintain, and they usually augment existing infrastructure, infrastructure which is already unevenly distributed. The privatisation and digitising of implementation exacerbates this. Only the wealthy can afford to live in the smart places, or projects are initiated only in wealthy areas. Smart city programmes must acknowledge and address the issues of justice and power in who gets to inform, create and access smart places. Rather than pushing certain technological fixes, there should be a pull based upon needs and technology should respond to this. Smart place-making must consider community needs.

Innovations in water provision can be combined with smart metering and monitoring to further improve the efficiency of service delivery to improve both the quantity and quality of the water and help demand to be predicted. Digital systems could monitor and regulate water provision, usage and drainage, but more equitable access to clean water supplies must come be the starting point.

The designing and creation of smart places is exciting, but what happens afterwards leaves a legacy for shaping future places. Mumbai has seen the problems of straightforward technology not being maintained, leading to blocked rainwater harvesting systems that are then abandoned and to poorly maintained buildings collapsing in the monsoon rains. Smart places must take into consideration the regulations and maintenance requirements, as well as the cultural attitudes and the local climate. A place isn't smart if it doesn't stay smart. So, updating and maintenance should be central to a lasting vision of smart places in India, without relying upon expensive fees from residents, as this will continue to exclude the urban poor from smart places.

Many smart city initiatives are set to become 'eye wash'. There is a danger that promises to make Indian cities into smarter places will lead to mere illusions of smart systems and the new utopias will turn out to be mirages. Adequate water supplies and the green spaces that improve the water supply and drainage should not be the preserve of the wealthy. The problems with rainwater harvesting systems serve as analogies for smart cities as a whole.

Images for inclusion in the text:

*** Insert Figure 16.1 ***

Caption: Figure 16.1 Rainwater harvesting pathways schematic diagram

Credit: Cat Button

*** Insert Figure 16.2 ***

Caption: Figure 16.2. Rainwater harvesting often both needs and creates green spaces, and so smart places become green spaces.

Credit: Cat Button

*** Insert Figure 16.3 ***

Figure 16.3a: Clearing leaves form the system

Figure 16.3b: The gravel filters must be cleaned annually

Caption: Figure 16.3 Maintenance of retrofitted rainwater harvesting system in Mumbai

Credit: Cat Button

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