

UCLA

UCLA Journal of Environmental Law and Policy

Title

The Law and Policy of Rainwater harvesting: A Comparative Analysis of Australia, India, and the United States

Permalink

<https://escholarship.org/uc/item/19121940>

Journal

UCLA Journal of Environmental Law and Policy, 36(1)

Author

Holland-Stergar, Brianne

Publication Date

2018

DOI

10.5070/L5361039903

Copyright Information

Copyright 2018 by the author(s). All rights reserved unless otherwise indicated. Contact the author(s) for any necessary permissions. Learn more at <https://escholarship.org/terms>

The Law and Policy of Rainwater Harvesting: A Comparative Analysis of Australia, India, and the United States

*Brianne Holland-Stergar**

ABSTRACT

Rainwater harvesting is increasingly being turned to as a viable water conservation measure in the face of increasing water shortages. Legislatures at local, state, and national levels have begun implementing legislation that regulates rainwater harvesting; in some cases, governments choose to make the practice mandatory. This article examines four mandatory rainwater harvesting policies implemented in Australia, India, and the United States. The article summarizes the relative success of each policy's adoption, and then moves on to discuss the impact of the policy on overall water conservation. In comparing the relative success of the policies, one finds that while financial investment plays an important role in determining the impact of the programs, other factors, such as the leniency of the mandate, cost to consumer, and support from non-governmental organizations play an important role in determining whether the policies are adopted. Furthermore, policymakers can encourage greater water conservation by incentivizing behavioral change and creating more robust financial incentives.

* UCLA School of Law, J.D. Candidate, 2018; Harvard University, B.A., 2013; Arizona State University, M.Ed., 2015.

TABLE OF CONTENTS

INTRODUCTION	128
I. Rainwater Harvesting Techniques	132
II. Case Studies	133
A. Tucson	133
1. Adoption	135
2. Conservation	136
B. Bangalore	138
1. Adoption	140
2. Conservation	142
C. Queensland	144
1. Adoption	146
2. Conservation	147
D. Tamil Nadu and Chennai.....	150
1. Adoption	152
2. Conservation	154
III. Policy Analysis and Suggestions.....	156
A. Socioeconomic and Cultural Impacts.....	156
B. Adoption	158
1. Severe vs. Lenient Mandates	158
2. Minimize Cost to Consumer	159
3. Non-Governmental Support	160
C. Conservation	160
1. Encouraging Behavioral Changes.....	161
2. Financial Incentives	162
CONCLUSION	164

INTRODUCTION

By 2025, two-thirds of the world's population may face water shortages.¹ Numerous factors contribute to this projection; global climate change, expansion of business activity and urbanization, and increased population are stressing the world's supply of freshwater.² Rainwater harvesting (RWH) is one means of

1 *Water Scarcity*, WORLD WILDLIFE FUND, <http://www.worldwildlife.org/threats/water-scarcity> [https://perma.cc/V9M3-CQ58].

2 AL FRY, WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT, WATER FACTS AND TRENDS 11 (2014).

mitigating this impending water scarcity. Research demonstrates that a single rain barrel can provide up to 25 to 30 percent of indoor, non-potable water demand for the average household in water-scarce cities.³ Moreover, with extreme weather events like intense flooding and extended drought becoming increasingly common, RWH offers the benefits of catching excess rain during heavy downpours and storing it for use during prolonged drought.⁴ Urban areas can benefit by trapping the vast amount of water that evaporates or runs off of impervious surfaces, like pavement or concrete, after a storm.⁵ Rural areas can similarly reap the benefits of collecting water for later use by storing water in an above-ground tank or directing storm water to water-catchment areas.

The potential for increased conservation through RWH is beginning to be recognized. Worldwide, city and state governments have started to implement RWH policies to encourage water conservation.⁶ Policymakers comment that

3 See Katie M. Meehan & Anna W. Moore, *Downspout Politics, Upstream Conflict: Formalizing Rainwater Harvesting in the United States*, 39 WATER INT'L 417, 418 (2014).

4 I.M. Voskamp & F.H.M. Van de Ven, *Planning Support System for Climate Adaptation: Composing Effective Sets of Blue-Green Measures to Reduce Urban Vulnerability to Extreme Weather Events*, 83 BUILDING AND ENV'T 159, 162–65 (2015); see also J. Mwenge Kahinda et al., *Domestic Rainwater Harvesting as an Adaptation Measure to Climate Change in South Africa*, 35 PHYSICS & CHEMISTRY OF THE EARTH 742, 743 (2010).

5 Currently, in urban areas, “only 15 percent of stormwater reenters the ground The rest runs off or evaporates.” Additionally, RWH equipment manufacturers are seeing increased business. See Luke Whelan, *How to Beat the Drought by Hoarding Water (If it Ever Rains Again)*, MOTHER JONES (Aug. 17, 2015), <http://www.motherjones.com/environment/2015/08/rainwater-harvesting-drought-california> [https://perma.cc/24DR-YRT7].

6 See Meehan & Moore, *supra* note 3, at 418 (“In recent years, governments in the United states have promoted RWH as ‘sustainable’ and ‘green’ . . .”). For instance, in 2013 the California Office of Administrative Law approved amendments to the Recycled Water Policy by the State Water Resources Control Board that call for increased usage of storm water, encouraging “all water purveyors to provide financial incentives” for usage of rainwater and other recycled water. Amend. to Recycled Water Policy, Resol. 2013-003, State Water Res. Control Board (Ca. 2013); see also discussion *infra* Part II, Tucson; Meehan & Moore, *supra* note 3, at 418 (“Worldwide, rain catchment is increasingly considered a vital strategy in adaption to climate change: harvesting is

RWH can be a “vital strategy in adaptation to climate change” and have taken steps to formalize, codify, and establish comprehensive RWH policies and programs.⁷ These programs employ a variety of mechanisms to promote conservation through RWH, including statutory and regulatory codification, market-based incentive systems (e.g., rebates or subsidies), and combinations of the two.⁸

A comparative analysis of the successes and failures of existing RWH programs can help to increase the efficacy of the growing number of government-led RWH policies.⁹ This article assumes that an RWH program should achieve two objectives. First, it must encourage adoption and use of RWH technologies; and second, it should result in decreased reliance on more traditional water sources, such as municipal water supplies, so as to positively impact overall water conservation. This article uses four case studies of policies in Tucson, Arizona; Bangalore, India; Queensland, Australia; and Tamil Nadu and Chennai, India to offer insight into how market-driven and codified RWH policies achieve these outcomes. I first outline how each of the geographic locales employed varying levels of mandated use and market-based incentives to encourage adoption of RWH, then move on to discuss how these programs have impacted overall conservation.

widespread in Australia, India, Japan and Mexico, and has the potential to meet between 48% and 100% of residential water demand in Brazil.”)

7 See Meehan & Moore, *supra* note 3, at 418.

8 *Id.* (discussing the different policies currently in use for RWH).

9 There is some scholarship related to comparisons of RWH. For instance, Jennifer Steffan and her co-authors present an “analysis of the projected performance of urban rainwater harvesting systems in the United States.” Jennifer Steffen et al., *Water Supply and Stormwater Management Benefits of Residential Rainwater Harvesting in U.S. Cities*, 49 J. AM. WATER RES. ASS'N., 810, 810 (2013). However, much of the research currently focuses on analysis of programs in specific geographic locations, rather than comparative analysis. See, e.g., Despins et al., *Assessment of Rainwater Quality from Rainwater Harvesting Systems in Ontario, Canada*, 58 J. WATER SUPPLY: RES. AND TECH. 117 (2009) (discussing the rainwater quality harvested in Ontario, California); S. Ward et al., *Performance of a Large Building Rainwater Harvesting System*, 46 WATER RES. 5127 (2012) (analyzing one RWH system in a singular building in the UK).

This article focuses on each policy's ability to drive RWH adoption and water conservation; however, it does not provide substantial analysis of the cultural and socioeconomic factors operating in the background of these policies. Thus, one should not consider it to be a wholly comprehensive analysis of the programs' operations in each of the areas. Moreover, this article does not discuss numerous other RWH programs that have been implemented around the world.¹⁰ Although this article does not provide a complete picture of RWH, by identifying patterns in the successes and failures across the four locations discussed herein, it offers insights for policymakers intending to implement a RWH program and provides foundational knowledge to guide future research.

Part I of this article briefly discusses common methods for harvesting rainwater to provide necessary background knowledge. Part II offers four case studies: Tucson, Arizona, where the local municipal government implemented a hybrid system of market-based incentives and mandated RWH installation; Bangalore, India, where the local government mandated RWH installation for all buildings of a certain size; Queensland, Australia, where the state first mandated the installation of RWH tanks for new construction and provided incentives for installation of RWH tanks on existing structures; and Tamil Nadu, India, where the state mandated RWH structures on all buildings. Information is provided for each case study regarding the demographics of the location, its water governance structure, the RWH program, and the policy's ability to drive RWH adoption and overall water conservation. Part III goes on to discuss the successes and failures of the programs. Subpart III.B outlines considerations related to driving adoption of RWH technologies, suggesting that policymakers carefully

10 The United Nations Environmental Programme provides a summary of RWH utilization, providing information about policies that have been implemented in Singapore, Berlin, Zimbabwe, and various other locations. *Examples of Rainwater Harvesting and Utilisation Around the World*, U.N. ENVIRONMENTAL PROGRAMME, <http://www.unep.or.jp/ietc/publications/urban/urbanenv-2/9.asp> [https://perma.cc/Q5QK-VLK6].

consider the severity of any mandates to be implemented, minimize the cost of implementation to the consumer, and look to grassroots organizers to provide support in the community. Subpart III.C moves on to discuss how policymakers can ensure that RWH, once adopted, results in higher levels of water conserved. Barriers to conservation are then highlighted, such as attitudinal apathy toward RWH and a lack of strong financial incentives to conserve harvested water. The article concludes by providing suggestions for policymakers hoping to drive conservation.

I. RAINWATER HARVESTING TECHNIQUES

Numerous techniques are available to practice RWH. Two of the most common are passive (external) harvesting and active (domestic) harvesting.¹¹ In passive harvesting, rainwater runoff is directed to sub-surface, underground catchment areas, where the water seeps into the soil and recharges the groundwater supply.¹² Methods for passive collection include water harvesting infiltration areas, as well as systems that direct water from a rooftop or other location to areas where it can be stored for future use.¹³ In active harvesting, rainwater is collected from surface areas and stored in above-ground rainwater tanks or cisterns.¹⁴ Typically, active systems are more costly than passive systems.¹⁵

Passive RWH systems may be especially beneficial in low-income areas, as many low-income families still rely on

11 See B. Helmreich & H. Horn, *Opportunities in Rainwater Harvesting*, 248 DESALINATION 118, 119–20 (2009).

12 *Id.*

13 Cado Daily & Cindy Wilkins, *Passive Water Harvesting*, UNIV. OF ARIZ. COLL. OF AGRIC. AND LIFE SCI. 1 (2012), <https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1564.pdf> [<https://perma.cc/3RK9-Z9VX>].

14 TUCSON, ARIZ., DEV. STANDARD no. 10.03.0, § 3.2 (2009).

15 See, e.g., *Rain Harvesting Cost*, COSTHELPER HOME & GARDEN, <http://home.costhelper.com/rain-harvesting.html> [<https://perma.cc/5N54-VUDJ>] (reporting the cost for a residential rain garden at up to \$3000, and the cost of a cistern at up to \$20,000).

municipal sources for their water and do not have the space or financial resources to install an active RWH system. As M. Dinesh Kumar of the International Water Management Institute notes, in low rainfall areas, often the only people who benefit from active RWH are the wealthy or those who have a large roof area and room for storage that can handle high volumes of rainfall.¹⁶ Thus, by installing passive rainwater harvesting systems, even low-income households can contribute to greater underground recharge across the geographic area.

II. CASE STUDIES

A. Tucson

The desert city of Tucson is nestled in the southern portion of Arizona near the U.S./Mexico border. The income per capita is approximately \$20,437.¹⁷ As the city receives only twelve inches of rainfall each year,¹⁸ Tucson Water (the municipal water authority that provides water to the majority of Tucson and the surrounding areas)¹⁹ looks to a number of sources to obtain a municipal water supply for its 530,000 residents.²⁰ Sources include mined groundwater, aquifers in the area, and allocations from the Colorado River.²¹ In this desert city, studies show that

16 M. Dinesh Kumar., *Roof Water Harvesting for Domestic Water Security: Who Gains and Who Loses?*, 29 WATER INTERNATIONAL 43, 51 (2009) (“In low rainfall areas, [rooftop rainwater harvesting is] suited to only those classes that has access to large roofs and storage space.”).

17 *Tucson Arizona*, SPERLING’S BEST PLACES, <http://www.bestplaces.net/economy/city/arizona/tucson> [https://perma.cc/J2NZ-GVYT].

18 *Climate Tucson – Arizona*, U.S. CLIMATE DATA, <http://www.usclimatedata.com/climate/tucson/arizona/united-states/usaz0247> [https://perma.cc/8SUT-H34N].

19 CITY OF TUCSON WATER DEP’T, WATER PLAN: 2000–2050, ch. 2 at 9 fig.2–3 (2004), <https://www.tucsonaz.gov/files/water/docs/waterplan.pdf> [https://perma.cc/GAS2-45R2].

20 *QuickFacts Selected: Tucson City, Arizona*, U.S. CENSUS BUREAU, <https://www.census.gov/quickfacts/fact/table/tucsoncityarizona/PST045216> [https://perma.cc/7RQP-HGF8].

21 See CITY OF TUCSON WATER DEP’T, *supra* note 19, at 2–5.

harvested rainwater usage could reduce residential water usage by 30 to 40 percent.²²

In October 2008, Tucson became the first city in the United States to mandate RWH installation in commercial buildings when it amended the city's municipal code and development standards.²³ Passed unanimously by the city council,²⁴ the amendments mandated that 1) commercial development and site plans include an RWH plan, and 2) 50 percent of landscaping water demand be met using the harvested water collected through either active or passive harvesting.²⁵ At the same time the mandates were implemented, the city also created a rebate system for residential users.²⁶ Under the system, qualifying users became eligible for rebates of up to \$2,000 for installing rainwater harvesting cisterns, and up to \$500 for installing passive RWH systems.²⁷ Those applying for the rebate had to attend a mandatory workshop that focused on passive and active rainwater catchment systems for residential ownership.²⁸ Tucson funded the rebate program, as well as other conservation programs, by charging municipal users a \$0.25 fee on their

22 NOAH GARRISON ET AL., NAT. RESOURCES DEF. COUNCIL, CAPTURING RAINWATER FROM ROOFTOPS: AN EFFICIENT WATER RESOURCE MANAGEMENT STRATEGY THAT INCREASES SUPPLY AND REDUCES POLLUTION 12 (2011), <https://www.nrdc.org/sites/default/files/rooftoprainwatercapture.pdf> [<https://perma.cc/M78S-F5PA>].

23 Rob O'Dell, *City Mandates Rainwater-Harvesting for Commercial Developments in 2010*, ARIZ. DAILY STAR (Oct. 15, 2008), http://tucson.com/news/local/govt-and-politics/city-mandates-rainwater-harvesting-for-commercial-developments-in/article_a9469a4e-f97f-596a-949f-0d420f9bc90f.html [<https://perma.cc/5ZPQ-35R6>].

24 *Id.*

25 TUCSON ARIZ., CODE ch. 6, art. VIII § 6-182-183 (2008); *see also* TUCSON DEV. STANDARD, *supra* note 14.

26 Tony Davis, *Tucson's Rain-Catching Revolution*, HIGH COUNTRY NEWS (April 27, 2015), <http://www.hcn.org/issues/47.7/tucson-s-rain-catching-revolution> [<https://perma.cc/67WY-7VWQ>].

27 *Rainwater Harvesting Rebate Application*, TUCSON WATER (2016), https://www.tucsonaz.gov/files/water/docs/RWH_application.pdf [<https://perma.cc/ZFT3-NTRY>].

28 FY 2014–15 CITY OF TUCSON, WATER CONSERVATION PROGRAM ANN. REP., at 23 (2015).

monthly water bills.²⁹

Local grassroots activists played an integral role in passing the amendments. A group of local stakeholders, including development groups, drafted the ordinance and negotiated the details of the mandates.³⁰ Similarly, the fee to fund the rebate program passed in large part due to residential and grassroots support; only after numerous residents attended a public hearing and told the council that they would pay higher rates to support conservation did the city council begin to seriously consider adopting the program.³¹

1. Adoption

Tucson could not provide any information regarding the permitting compliance rates in regards to the mandates for commercial RWH.³² The city could, however, simply deny a permit to anyone proposing a building that failed to meet the RWH standards, leading one to believe that compliance rates are virtually 100 percent.³³ Regarding the rebate program, Tucson Water did not receive any applications for RWH rebates until fiscal year 2012 to 2013, after which point it received approximately 275 each of the following three years.³⁴ Tucson Water approved 837 applications for rebates in that time period.

35

29 See Davis, *supra* note 26.

30 Yvonne Gonzalez, *Tucson Set to Require New Commercial Developments to Harvest Rainwater*, ARIZ. CAPITOL TIMES (March 1, 2010), <http://azcapitoltimes.com/news/2010/03/01/tucson-set-to-require-new-commercial-developments-to-harvest-rainwater> [https://perma.cc/SSD2-G6QE].

31 See Davis, *supra* note 26 (activists organized “a public hearing packed with residents” in support of paying higher rates).

32 E-mail from Daniel Ransom, Water Conservation Program Manager, Tucson Water, to author (Nov. 8, 2016, 7:36 PST) (on file with the author).

33 *Frequently Asked Questions*, CITY OF TUCSON (2017), <https://www.tucsonaz.gov/pdsd/faq> [https://perma.cc/Y5U5-W2VK].

34 See FY 2014–15 CITY OF TUCSON, *supra* note 28, at 9 tbl.6.

35 *Id.*

2. Conservation

Although over 800 households installed RWH systems, a Tucson Water study showed that recipients of the RWH rebates were not conserving more water than a control group of homeowners.³⁶ Officials found that rebate recipients were simply adding additional, new landscaping to be watered with harvested rainwater, rather than reducing their overall consumption.³⁷ Moreover, Tucson Water reports that the RWH rebate program is the least cost-effective of the city's conservation programs; indeed, the program did not result in any overall conservation, but cost the city \$327,145.³⁸ Thus, the RWH program has not contributed to Tucson's water conservation efforts in terms of reductions in consumption.

The lack of water conserved may be due in part to the rebate program's focus on installation of RWH systems, instead of on the uses for the harvested water. Rebate applicants are required to attend an educational workshop and complete an application before receiving the rebate. Yet, neither the workshop nor the application provide any disclaimer suggesting that applicants curb their municipal water use.³⁹ Instead, the application materials are focused on the installation of the system. For example, the workshop covers topics including "selecting the most appropriate passive and active rainwater harvesting system strategies" and asks users how they plan to channel

³⁶ *Id.* at 24.

³⁷ Tony Davis, *Tucson's Rain-Catching Revolution*, HIGH COUNTRY NEWS (April 27, 2015), <http://www.hcn.org/issues/47.7/tucson-s-rain-catching-revolution> [<https://perma.cc/67WY-7VWQ>].

³⁸ *See id.* at 5 tbl.3. In comparison, the high efficiency toilet rebate program cost the city \$645,690, but saved 65,812 Ccfs, leading to a cost per Ccf of \$9.81 dollars. *See id.*; *see also* Tony Davis, *Tucson May Expand Rainwater Harvesting Rebates*, ARIZ. DAILY STAR (Nov. 1, 2014), http://tucson.com/news/local/govt-and-politics/tucson-may-expand-rainwater-harvesting-rebates/article_e7c73e50-2dc3-5a9a-b717-e91caa17de47.html [<https://perma.cc/C6A9-QCDP>].

³⁹ *See* TUCSON WATER, *supra* note 27; Workshops and Project Plans, CITY OF TUCSON, <https://www.tucsonaz.gov/water/rainwater-harvesting-workshop-and-project-plans> [<https://perma.cc/7XST-YXWT>].

water from their roofs to catchment areas or cisterns.⁴⁰ Additionally, there is no indication that the city inspects the property and RWH system before issuing the rebate, leaving residents free to use the retained rainwater for any purpose.⁴¹ Thus, there is little incentive for users to use the rainwater to reduce their municipal water consumption.

Tucson officials suggest that the power of the RWH program may not lie in the reduction of consumption, but instead in increased awareness of the need for water conservation. For instance, a Tucson Water official noted, “If the goal of Tucson’s rainwater harvesting program is customer outreach and education it is probably ok as such. If the goal is to reduce residential per capita water use, it is a dubious effort.”⁴²

Despite the lack of conservation through the RWH program, the city offers numerous other, non-RWH water conservation programs that have been linked to direct decreases in consumption. These include rebates for water-conserving-appliance installation and rebates for gray water use.⁴³ These other programs appear to be working: currently, the city uses less water per capita than other major metropolitan areas in the southwestern United States with similar rainfall patterns,⁴⁴ and reported significant reductions in gallons per capita per day from 1996 to 2015.⁴⁵ Overall, reports show that the groundwater table in Tucson’s urban core has risen more than fifty feet in recent

40 *See id.*

41 *See generally How to Apply*, CITY OF TUCSON, <https://www.tucsonaz.gov/water/how-to-apply-for-rainwater-harvesting-rebate> [<https://perma.cc/G7QE-H7X6>] (providing FAQs and program specifics, neither of which demonstrate that the city will be inspecting properties). Notably, the city reserves the right to verify and inspect rainwater harvesting systems at its discretion.

42 *Tucson May Expand Rainwater Harvesting Rebates*, *supra* note 38.

43 *See* FY 2014–15 CITY OF TUCSON, *supra* note 28, at 5, tbl.3.

44 *See* CITY OF TUCSON WATER DEP’T, *supra* note 19, app. B at 12.

45 Making Action Possible for Southern Arizona, Residential Water Use: Summary, <https://mapazdashboard.arizona.edu/infrastructure/residential-water-use> (last visited Nov. 16, 2017) (noting that per capita use fell from 121 gallons per day in 1996 to 80 in 2015).

years.⁴⁶ Thus, though the RWH program itself may not contribute to overall conservation, Tucson remains a leader in water conservation in the southwestern United States.

B. Bangalore

The city of Bangalore sits in the middle of the Indian peninsula.⁴⁷ One of India's wealthiest cities, Bangalore is experiencing a period of rapid economic and population growth and is often referred to as the Silicon Valley of India, with a reported per capita income of approximately \$4,000 a year.⁴⁸ Despite this economic expansion, however, approximately one-quarter of its ten million residents live in slums and only half the residents have private access to municipal water sources.⁴⁹ Those without private access often obtain groundwater from wells, public taps, unregulated street vendors, open wells, or to supply their needs.⁵⁰ On average, the city receives thirty-four

46 Tony Davis, *Gains Seen on Area's Water Goals*, ARIZ. DAILY STAR (Jan. 20, 2012), http://tucson.com/news/science/environment/gains-seen-on-area-s-water-goals/article_80fd8805-ca1e-5217-aecc-549c77450d4d.html [<https://perma.cc/W4ML-LG6M>].

47 In 2014, Bangalore was renamed Bengaluru. *Bengaluru: India's Bangalore City Changes Name*, BBC NEWS (Oct. 31, 2014), <http://www.bbc.com/news/world-asia-india-29845215> [<https://perma.cc/5EP2-WU7V>]. However, many still use the name "Bangalore." The term "Bangalore" will be used for the purposes of this article.

48 *Id.*; see also Nagesh Prabhhu, *Bengaluru Urban Tops State in Per Capita Income, Kalaburagi last*, THE HINDU (Mar. 20, 2016), <http://www.thehindu.com/news/cities/bangalore/bengaluru-urban-tops-state-in-per-capita-income-kalaburagi-last/article8376124.ece> [<https://perma.cc/HQY6-J5P7>] (converted rupees to USD using exchange rate on Nov. 11, 2016).

49 VICKY WALTERS, *WATER DEMOCRACY AND NEOLIBERALISM IN INDIA: THE POWER TO REFORM* 112 (2013) (Noting that citizens in Bangalore's slums "access water from better-off households, unregulated street vendors, open wells or the thousands of public taps that are scattered throughout the city"); Siri Bulusu, *Bangalore Leads the Way in Water Harvesting*, DEUTSCHE WELLE: ENV'T (May 9, 2013), <http://www.dw.com/en/bangalore-leads-the-way-in-water-harvesting/a-17069995> [<https://perma.cc/UKP4-Z9R9>]; Bangalore Population 2017, WORLD POPULATION REVIEW, <http://worldpopulationreview.com/world-cities/bangalore-population> [<https://perma.cc/3B28-FBFQ>].

50 See WALTERS, *supra* note 49; See Bulusu, *supra* note 49.

inches of rainfall each year.⁵¹ Studies show that rainwater could be used for approximately 53 percent of Bangalore's annual water needs.⁵²

The municipal water supply in Bangalore is managed by the Bangalore Water Supply and Sewerage Board (BWSSB). The BWSSB is self-funded through tariffs and fees imposed on its customers, in addition to assistance from non-governmental funding agencies.⁵³ The city's primary source of municipal water is the Cauvery River, which is located approximately 100 kilometers away from the city.⁵⁴ Current allotments provide only 60 percent of the city's per capita water requirements.⁵⁵

In 2004, the BWSSB "experimented" with making RWH mandatory for new construction.⁵⁶ However, the regulation was loosely enforced and did not significantly impact the water levels.⁵⁷ Then, in 2009, the BWSSB took a stronger position and passed the Bangalore Water Supply and Sewerage Amendment Act, which required "every owner or occupier of a building and

51 *Bangalore Facts*, KARNATAKA, <http://www.karnataka.com/bangalore/facts> [<https://perma.cc/N3H9-NF2L>] (converted millimeters to inches).

52 S. Vishwanath, *Domestic Rainwater Harvesting: Some Applications in Bangalore, India*, RWH CONFERENCE, IITD H-2 (Apr. 2001) (unpublished manuscript),

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.575.5149&rep=rep1&type=pdf> [<https://perma.cc/2Z7A-7YF4>] (stating that 77600 liters could be captured annually and that a family of four typically consumes 100 liters per day).

53 See K.C. Smitha, *Urban Governance and Bangalore Water Supply and Sewerage Board (BWSSB)* 1, 9–10 (2006), https://www.researchgate.net/publication/228465980_Urban_Governance_and_Bangalore_Water_Supply_Sewerage_Board_BWSSB; see also *About BWSSB, BANGALORE WATER SUPPLY & SEWERAGE BOARD*, <http://bwssb.gov.in/bwssbuat/content/about-bwssb-2> [<https://perma.cc/Y7WD-DSZB>].

54 K. S. Umamani & S. Manasi, *Rainwater Harvesting Initiative in Bangalore City: Problems and Prospects* 6 (The Inst. for Soc. and Econ. Change, Bangalore, Working Paper 302, 2013), <http://203.200.22.249:8080/jspui/bitstream/123456789/7319/1/ISEC-WP-302.pdf> [<https://perma.cc/4TJR-VH3K>].

55 See Umamani & Manasi, *supra* note 54, at 6.

56 See Bulusu, *supra* note 49.

57 *Id.*

having a[n] . . . area of 2400 square feet” to install an RWH system (active or passive) within nine months of implementation.⁵⁸ It also required RWH system installations for buildings being constructed on lots measuring 1200 square feet or greater.⁵⁹ Those who failed to implement RWH as mandated would face their municipal water supply being disconnected.⁶⁰ The BWSSB did not provide funding to retrofit buildings, though the cost to build or retrofit each structure ranged from about \$200 to \$725 USD.⁶¹

1. Adoption

BSWWB officials acknowledge problems with compliance with the mandate, noting that violators could be in the “thousands.”⁶² In 2013, BWSSB identified only 25,000 homes that had installed RWH out of the approximately 55,000 that were required to implement the systems.⁶³ In other words, out of the buildings

58 The Bangalore Water Supply and Sewerage (Amendment) Act § 72A (2011), <https://bwssb.gov.in/sites/default/files/RWH%20GAZATTE%20%20NOTIFICATI%20ONS.pdf> [<https://perma.cc/BG8K-W382>] (hereinafter Bangalore Act); see also *Rainwater Harvesting Becomes Mandatory in Bangalore*, CENTRE FOR SCI. & ENV'T, <http://www.rainwaterharvesting.org/newsletter/bangalore.htm> [<https://perma.cc/94BC-P2RU>].

59 See Bangalore Act, *supra* note 59; see also *Rainwater Harvesting Becomes Mandatory in Bangalore*, *supra* note 59.

60 Bangalore Act, *supra* note 59.

61 Deepthi MR, *Catching Rain Where it Drops with Rain Water Harvesting*, DAILY NEWS & ANALYSIS (Mar. 22, 2012, 1:41 PM), <http://www.dnaindia.com/bangalore/report-catching-rain-where-it-drops-with-rain-water-harvesting-1665815> [<https://perma.cc/JK5E-74N5>]; see also Nilofer D'Souza, *Bangalore's Rain-Catcher: The Man Who Never Paid for Water*, FORBES INDIA (June 4, 2013), <http://www.forbesindia.com/blog/technology/bangalores-rain-catcher-the-man-who-never-payd-for-water> [<https://perma.cc/VU7C-3DA3>] (“[I]t can cost about Rs 30000-50000” to retrofit houses on 40x60 ft. plots); see also Umamani & Manasi, *supra* note 54, at 14.

62 Rohith B.R., *No Rainwater-harvesting unit? Pay 25% Fine on Bill*, TIMES OF INDIA (Nov. 3, 2015), <https://timesofindia.indiatimes.com/city/bengaluru/No-rainwater-harvesting-unit-Pay-25-fine-on-bill/articleshow/49638811.cms> [<https://perma.cc/2EXR-X7F6?type=image>].

63 K. V. Aditya Bharadwaj, *Harvest Rain Water or Pay Penalty*, THE HINDU, (Oct. 10, 2015, 7:49 AM),

with the requisite square footage, only 45 percent complied with the mandate.⁶⁴

This low compliance was likely due to a lack of enforcement; in 2013, the BWSSB commented that the officials charged with overseeing the program did not “seem to be serious about it.”⁶⁵ Indeed, in 2013, the BSWWB had not penalized a single home for violations, although the entity acknowledged that compliance with the mandate was low.⁶⁶ Notably, the BSWWB has been cited for poor governance in the past,⁶⁷ and critics of the BSWWB suggest that the entity only pushes its RWH as a form of “sloganeering” without intending to devote significant resources to its implementation.⁶⁸

Furthermore, a large majority of participants cited the up-front cost of installing RWH system as having been prohibitively expensive and technically challenging. Indeed, one survey in Bangalore found that financial cost of implementation was a primary reason why individuals chose not to adopt RWH.⁶⁹ Citizens also cited the burdensome nature of retrofitting a

<http://www.thehindu.com/news/cities/bangalore/harvest-rain-water-or-pay-penalty/article7743860.ece> [<https://perma.cc/Z5XW-MKB3>].

64 *Id.*

65 *Despite Threat, Rainwater Harvesting a Flop in City*, THE HINDU, (Feb. 27, 2013, 11:01 PM), <http://www.thehindu.com/news/cities/bangalore/despite-threat-rainwater-harvesting-a-flop-in-city/article4456297.ece> [<https://perma.cc/W9V5-KLYD>].

66 JENNY GRÖNWALL, UNDP-SIWI WATER GOVERNANCE FACILITY, GROUNDWATER GOVERNANCE IN INDIA: STUMBLING BLOCKS FOR LAW AND COMPLIANCE, WGF REP. NO. 3, at 19 n.9 (Marianne Kjellén et al. eds., 2013).

67 Critics of the BSWWB note that many of its policies favor the utility but hurt the poor. For instance, in a program designed to provide water to the urban poor, the utility began installing water hook-ups in certain households in the city’s slums. However, two months after the program began, citizens reported that their water hookups were not working, but they were still receiving erroneous bills that charged them for up to eighteen times their monthly income. See WALTERS, *supra* note 49, at 200–201.

68 V Balasubramanian, *Bangalore Water Crisis, The Big Hoodwink*, DAILY NEWS & ANALYSIS (March 3, 2013, 2:00 PM), <http://www.dnaindia.com/analysis/report-bangalore-water-crisis-the-big-hoodwink-1807556> [<https://perma.cc/E4A4-QBLD>].

69 See Umamani & Manasi, *supra* note 54, at 17 (finding that “financial difficulty” was the third most cited reason for failing to install a system).

structure with RWH equipment, commenting that the mandate should have been implemented only during new construction.⁷⁰

Faultfinders also note that municipal water is highly subsidized, while the capital cost of installing a rainwater system is high, thus discouraging adoption of RWH.⁷¹ Indeed, policymaker S. Vishwanath notes that the main issue behind the lack of RWH use in Bangalore is that “there is no incentive to harvest rain water. BWSSB provides highly subsidized water at Rs. [Rupees] 8 a [kiloliter] while the capital cost of RWH is high.”⁷² Moreover, some residents felt as though water scarcity was not a pressing enough issue to warrant RWH installation; the majority of respondents in one survey stated that they did not personally experience water shortages and felt that using the RWH systems was unnecessary.⁷³ Thus, even though installing a passive RWH system could contribute to groundwater recharge and increase municipal water supplies, the low cost of existing municipal water stores coupled with attitudinal apathy toward RWH leaves users with little personal incentive to adopt RWH.

2. Conservation

Study results further show that households with RWH systems may not have substantially contributed to overall conservation. First, many of the buildings that implemented RWH did so poorly; news commentators reported leaking tanks and contaminated rainwater supplies.⁷⁴ Then, residents remained apathetic regarding the use of the conserved water; one survey found that 93 percent of RWH users (including active users) still used municipal water for all purposes.⁷⁵ The survey

⁷⁰ *Id.* at 11.

⁷¹ See Bharadwaj, *supra* note 63.

⁷² *Id.*

⁷³ See Umamani & Manasi, *supra* note 54, at 18.

⁷⁴ Shree Padree, *Where Suvarna Jala Fails, Schools Leap Ahead*, INDIA TOGETHER (Nov. 14, 2009), <http://www.indiatogether.org/schoolrwh-environment> [https://perma.cc/8THK-U2BT] (lamenting the poor implementation of rainwater harvesting in schools).

⁷⁵ See Umamani & Manasi, *supra* note 54, at 11.

also reported that some individuals that had installed active RWH systems still relied on municipal water sources, rather than the harvested rainwater.⁷⁶

This lack of conservation is reflected in the fact that the groundwater table has not risen significantly since the implementation of the mandate.⁷⁷ Instead, between 2014 and 2015 levels decreased by up to five meters in some urban districts.⁷⁸ In response to the lack of water, in 2016 the BWSSB began to penalize residents more harshly for failing to comply with RWH guidelines. As part of the new program, residents will pay a penalty equal to 25 percent of their water bill for the first three months until they adopt harvesting. After that, the penalty will double.⁷⁹ The utility also recently reduced the size of newly built structures that must install a system from 60 by 40 square feet to 30 by 40 square feet.⁸⁰ However, there is no indication that the city will provide more funding to individuals that are required to install the systems.

76 *Id.*

77 *30x40 Site? Rainwater Harvesting Mandatory*, BANGALORE MIRROR (Apr. 20, 2016, 11:34 PM), <http://bangaloremirror.indiatimes.com/bangalore/others/30x40-site-Rainwater-harvesting-mandatory/articleshow/51916567.cms> [<https://perma.cc/G79C-BRBG>] (“[T]he underground water table has not risen significantly.”).

78 Niranjan Kaggere, *Falling Water Table Worries State Govt*, BANGALORE MIRROR (July 9, 2015, 4:00 AM), <http://bangaloremirror.indiatimes.com/bangalore/others/water-table/articleshow/47993564.cms?> [<https://perma.cc/G5TW-DH4K>]. However, there is evidence that groundwater is sufficiently recharged during monsoons season in some parts of the city. See G.V. Hedge & K.C. Subhash Chandra, *Piezometric Water-Level Conditions in Bangalore City, Karnataka, India*, 106 CURRENT SCI. 156, 159 (2014); see also Sridhar Vivan, *After Decades, Groundwater Level is Getting Recharged*, BANGALORE MIRROR (Nov. 18, 2015, 4:00 AM), <http://bangaloremirror.indiatimes.com/bangalore/cover-story/articleshow/49822490.cms> [<https://perma.cc/235S-84EP>] (discussing the benefits of high rainfall in raising the water level in some Bangalore areas).

79 Afshan Yasmeen, *Harvest Rainwater or Pay Fine from May 1*, THE HINDU (April 22, 2016, 5:46 PM), <http://www.thehindu.com/news/cities/bangalore/harvest-rainwater-or-pay-fine-from-may-1/article8506756.ece> [<https://perma.cc/AH8A-Z2UQ>].

80 See *30x40 Site?*, *supra* note 77; see also *Rain Water Harvesting*, BANGALORE WATER SUPPLY & SEWERAGE BOARD, <http://bwssb.gov.in/bwssbuat/content/rain-water-harvesting-0> [<https://perma.cc/AH2T-JHQ4>].

Bangalore provides an example of a city with an ambitious goal, but one that appears to have failed to provide resources necessary for efficacious implementation. First, the city failed to inspect and penalize buildings that failed to comply with the mandate, leaving little incentive for individuals to adopt RWH or conserve water. Then, the city's mandate required significant personal expenditures for individual homeowners who qualified under the mandate, which discouraged adoption. Thus, without more significant oversight or educational support, it is unlikely that the newly instituted penalties will result in a more effective RWH program.

C. Queensland

Queensland, the second-largest and third-most populous state in Australia, occupies the northeastern corner of the country. The state's largest city is Brisbane, where the 2011 median per capita income was \$22,905 USD in 2011.⁸¹ Historically, the region receives annual rainfall of about twenty-three inches, but drought has led to the state receiving significantly less in the most recent decades.⁸²

The Queensland government practices a decentralized management system for water usage.⁸³ Today, seventy-seven local governments provide water services to their residents. Each local council turns to a council-owned "water distribution retailer," which is in turn governed by various state entities (including the primary urban and rural bulk supplier Southeast

81 *Median Total Personal Income (a)(b) by Statistical Area Level 4 (SA4) (c), Queensland, 2006, 2011 and 2016*, QUEENSL. GOV'T, <http://www.qgso.qld.gov.au/products/tables/median-personal-income-sa4/index.php> [<https://perma.cc/QU6G-7LG7>] (converted to USD using exchange rate on Nov. 11, 2016).

82 *Queensland in 2015: Third Warmest Year on Record Dry Across Much of the State*, AUSTL. GOV'T, BUREAU OF METEOROLOGY, <http://www.bom.gov.au/climate/current/annual/qld/summary.shtml> [<https://perma.cc/5SFX-3M9P>] ("The statewide rainfall during 2015 was 487/5 mm, 22% below the historical average.").

83 SARAH HENDRY, FRAMEWORKS FOR WATER LAW REFORM 82 (2014).

Queensland Water [SEQwater], to obtain their water supply.⁸⁴ Prior to 2013, however, the long-term water policy was overseen by the Queensland Water Commission, a body formed in response to a severe drought Queensland experienced in the first decade of the 2000s.⁸⁵ In 2013, the Queensland Water Commission was replaced by the governmental water authority SEQwater.⁸⁶

In 2007, the Queensland government implemented a water conservation program in response to Australia's worst drought in one hundred years.⁸⁷ As part of the scheme, the government began mandating active RWH on "new construction" for the entirety of the state⁸⁸ and implemented the "Home Waterwise Rebate Scheme" to provide rebates for water saving measures like RWH tank installation.⁸⁹ Through the program, individual

84 *Who We Are*, QUEENSL. URB. UTILITIES (2014), <https://www.urbanutilities.com.au/about-us/who-we-are> [<https://perma.cc/4DL3-P7FL>].

85 *Id.*; Peter Spearritt, *The Water Crisis in Southeast Queensland: How Desalination Turned the Region into Carbon Emission Heaven* in Patrick Toy, *TROUBLED WATERS: CONFRONTING THE WATER CRISIS IN AUSTRALIA'S CITIES* 28 (2008) (discussing the motivations behind the formation of the Queensland Water Commission).

86 SEQWATER, SEQ WATER GRID MANAGER ANN. REP. 2012–2013, at 4 (2013); *See also* Seqwater, *About us*, <http://www.seqwater.com.au/about> (last visited Nov. 16, 2017) ("We are also responsible for the long term planning of the region's future water needs, a function that was formerly undertaken by the Queensland Water Commission.").

87 Hope Hamashige, *Worst Drought in a Century Hurting Australian Farmers*, NAT'L GEOGRAPHIC NEWS (Nov. 8, 2007), <https://news.nationalgeographic.com/news/2007/11/071108-australia-drought.html> [<https://perma.cc/TY25-WZ2E>].

88 QUEENSLAND BUILDING SERVICES AUTHORITY, *DOMESTIC RAINWATER HARVESTING IN QUEENSLAND: A GUIDE TO POSITIONING, INSTALLATION, CONNECTION AND MAINTENANCE OF DOMESTIC RAINWATER TANKS AND THEIR ASSOCIATED ROOF WATER COLLECTION SYSTEMS 2* (available at <http://qbis.com.au/wp-content/uploads/2015/08/Domestic-Rainwater-Qld.pdf>) (Noting that "any new building or structure constructed in Queensland" must be built in compliance with RWH regulations).

89 Julie Cart, *Brisbane Writes a Case Study on Saving Water*, L.A. TIMES (Nov. 24, 2009), <http://articles.latimes.com/2009/nov/24/local/la-me-conserve-brisbane24-2009nov24> [<https://perma.cc/A6H2-DAYD>]; *See also* Renovate.com.au, *Home Waterwise Rebate Scheme Reaches \$100 Million Mark* (Aug. 2007) (available at

homeowners could obtain a rebate between \$681–\$871, enough to cover the cost of a small RWH system.⁹⁰ In all, the Queensland government devoted \$9 billion AUS to these and other water conservation efforts,⁹¹ which included setting a goal for residents to use only thirty-five to forty gallons of water per day.⁹²

1. Adoption

Research does not reveal any reported compliance problems with the mandates. More importantly, from 2004 to 2008 the number of residential households implementing RWH systems increased from 8 to 40 percent.⁹³ Indeed, in 2008, the government had received 462,845 rebate applications and spent over \$250 million on the program.⁹⁴ However, a survey of Queensland residents reported that the rebates were important—but not necessarily determinative—factors in their decisions to adopt RWH.⁹⁵ Aside from the availability of rebates, research revealed that users' decisions to implement an RWH system stemmed from feeling as though their household would

<http://staging.renovate.com.au/docs/index.cfm?page=print&record=854>) (discussing features of the Home Waterwise Rebate Scheme).

90 Vivian W.Y. Tam et al., *Cost Effectiveness and Tradeoff on the Use of Rainwater Tanks: An Empirical Study in Australian Residential Decision-Making*, 54 RES., CONSERVATION & RECYCLING 178, 182–83 (2010). These figures were calculated using the exchange rate from Australian Dollars to USD on November 11, 2017.

91 Cart, *supra* note 89.

92 Susan Carpenter, *Australian Water Crisis Offers Clues for California [Updated]*, L.A. TIMES: GREENSPACE (Jan. 15, 2010) (available at <http://latimesblogs.latimes.com/greenspace/2010/01/australian-water-crisis-provides-clues-for-california-at-gday-usa.html>) (noting that water usage was reduced to 35–40 gallons per day).

93 I. White, *Rainwater Harvesting: Theorizing and Modelling Issues that Influence Household Adoption*, 62 WATER SCI. & TECH. 370, 371 (2010).

94 The Honorable Craig Wallace, Minister for Natural Resources and Water and Minister Assisting the premier in North Queensland, *Home Waterwise Rebate Scheme Pays Over \$250 Million in Rebates* (May 13, 2008) (available at <http://statements.qld.gov.au/Statement/Id/58020>).

95 See White, *supra* note 93, at 374 tbl.2.

be subject to an individual water shortage.⁹⁶ Here, a key factor in implementing RWH appears to be a fear of experiencing water shortage, rather than the incentivizing nature of a rebate.

2. Conservation

Studies demonstrate that RWH proved a cost-effective and efficient means of conserving water in Queensland. A 2012 study showed that rainwater tanks fulfilled 30 to 35 percent of average household water use and that the overall water savings were greater than predicted at the outset of the program.⁹⁷

These increases may be due in part to the government's targeted water reduction campaign, "Target 140," which attempted to "personalise the problem" of the drought and encouraged users to limit their consumption to 140 liters a day.⁹⁸ The program focused on "voluntary residential indoor water saving practices, behaviours and attitudes" and used extensive mass media advertising, direct mailings, and partnerships with news agencies and local water providers to communicate with users.⁹⁹ Residents were informed of practical tools, such as reduced shower times, to self-assess consumption, and the government also provided "weekly feedback to residents of performance against the 140 target."¹⁰⁰ The program succeeded in reducing consumption, with 76 percent of residents making water saving changes within their home by the end of the campaign.¹⁰¹ Impressively, 100 percent of residents achieved the personal goal of 140 liters per day.¹⁰² In short, the combination of

96 URB. WATER SECURITY RES. ALLIANCE, FACT SHEET: RAINWATER TANKS IN SEQ 3 (2012), http://www.urbanwateralliance.org.au/publications/factsheets/UWSRA_Fact_Sheet_1.pdf [<https://perma.cc/6XPE-UDYU>].

97 *Id.* at 2.

98 *Target 140*, PUB. REL. INST. OF AUSTL., <http://www.pria.com.au/resources/target-140> [<https://perma.cc/RUM9-Q4PA>].

99 *Target 140*, UTS LIBRARY, <http://www.lib.uts.edu.au/gta/14246/target-140> [<https://perma.cc/LN9R-874W>].

100 *Id.*

101 *Id.*

102 *Id.*

rebates coupled with the Target 140 plan contributed to positive impacts in overall conservation due to RWH.

Despite these successes, the rebate plan was discontinued in 2008 when the drought alleviated and the Water Commission was replaced by SEQwater.¹⁰³ Additionally, the “Target 140” plan was increased to “Target 170.”¹⁰⁴ Five years later, the government relaxed the rainwater tank mandate for new construction. The change stipulated that only new construction, in areas where the local government chooses to “opt-in” to the Queensland Development Code, would be required to install RWH systems.¹⁰⁵ Accordingly, there was a decrease in the number of households that used RWH after the rebate program ended, with the number of tanks decreasing from 36.5 to 33.9 percent from 2010 to 2013.¹⁰⁶ Housing officials claimed that the repealed regulations “place[d] an unwanted drag on the construction industry.”¹⁰⁷ They posited that homeowners had come to self-regulate their water use, making the RWH program unnecessary.¹⁰⁸

103 See HENDRY, *supra* note 83, at 83.

104 MCCANN ERICKSON, THE AUSTRALIAN EFFIE AWARDS 2009 3 (2009) (available at <http://www.effies.com.au/attachments/b6feef08-6239-40df-a691-576aca0c56a6.pdf>).

105 *Rainwater Tanks: Installation Requirements Under the Queensland Development Code*, DEP'T OF HOUS. & PUBLIC WORKS (2014), <http://www.hpw.qld.gov.au/SiteCollectionDocuments/InstallationRequirementsForRainwaterTanksFactSheet.pdf>, [<https://perma.cc/KHF3-ABBR>].

106 *Sources of Water and its Uses*, AUSTR. BUREAU OF STATISTICS (last updated Oct. 29, 2013), <http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/4602.0.55.003Main%20Features3Mar%202013?opendocument&tabname=Summary&prodno=4602.0.55.003&issue=Mar%202013&num=&view=> [<https://perma.cc/5WTM-WVXW>].

107 *Queensland Government to Scrap ‘Green’ Home Laws*, THE AGE (Dec. 14, 2012), <http://www.theage.com.au/queensland/queensland-government-to-scrap-green-home-laws-20121214-2bedx.html> [<https://perma.cc/6WS7-8A55>].

108 Koren Helbig, *Newman Government Drops Mandate for Water Tanks and Energy-Saving Measures on New Homes Built in Queensland*, THE COURIER MAIL (Dec. 12, 2012, 6:20 PM), <http://www.couriermail.com.au/news/queensland/newman-government-drops-mandate-for-water-tanks-and-energy-saving-measures-on-new-homes-built-in-queensland/news->

Today, although much of the drought has been alleviated throughout the rest of Australia due to increased rainfall, Queensland is not likely to receive the amounts of rainfall necessary to bring about water security if other water sources are not found.¹⁰⁹ SEQwater acknowledged that population growth will force the entity to find new water sources; its strategic thirty-year plan notes that “by about 2030, based on most likely demand, a new water supply source will be required to meet the needs” of the Queensland population.¹¹⁰ The SEQwater plan centers on obtaining water from dams and weirs, but does not mention individual household rainwater collection as an alternative water source.¹¹¹ Commentators critique this omission, noting that this SEQwater program would be “five to eighteen times” less cost-effective than RWH rebate programs.¹¹²

In sum, Queensland provides an example of the power of strong government action coupled with the incentivizing nature of drought to drive strong RWH programs. The drought conditions created a natural incentive to conserve water, which the government supplemented through funding and the creation of policies. Notably, though, the governmental action dried up as the drought alleviated.

story/604970be8f17f7bdf7031bad53544b8d?sv=ddd4a7a1ba67fe705d1ccf5a141294d2 [https://perma.cc/T2ZF-JUVX?type=image].

109 *Recent Rainfall, Drought and Southern Australia's Long-Term Rainfall Decline*, AUSTL. GOV'T, BUREAU OF METEOROLOGY, (Apr. 2015), <http://www.bom.gov.au/climate/updates/articles/a010-southern-rainfall-decline.shtml> [https://perma.cc/CWQ7-ATBW].

110 SEQWATER, WATER FOR LIFE: YOUR SAY ON SOUTH EAST QUEENSLAND'S WATER FUTURE 2015–2045, at 22 (2015), http://www.seqwater.com.au/sites/default/files/PDF%20Documents/Water%20for%20life_SEQs%2030%20year%20water%20security%20plan_0.pdf [https://perma.cc/YV4M-ZULN].

111 *Id.* at 12.

112 White, *supra* note 93, at 394; *but see* Akhok K. Sharma et al., *Rainwater Harvesting Systems for Urban Developments*, in RAINWATER TANK SYSTEMS FOR URBAN WATER SUPPLY 1, 11 (Akhok K. Sharma et al. eds., 2015) (reporting that Queensland stopped the rebate program because the costs had begun to exceed the benefits).

D. Tamil Nadu and Chennai

The state of Tamil Nadu covers approximately 50,000 square miles of the southeastern portion of the Indian subcontinent.¹¹³ The population was approximately seventy-two million in 2011, and the per capita income of Tamil Nadu in 2012 to 2013 was \$854 USD.¹¹⁴ The state receives approximately 970 mm (thirty-eight inches) of rainfall per year, most of which is accumulated in the monsoon season.¹¹⁵ Some studies estimate that rainwater usage could account for anywhere from 37.5 to 66 percent of Tamil Nadu's annual water needs.¹¹⁶

Water in Tamil Nadu is governed by the Water Supply and Drainage Board, which develops water and sewer systems throughout this Indian state.¹¹⁷ Most of the state's water comes from reservoirs, as well as the Cauvery River, through numerous distributional systems.¹¹⁸ The demand for water outpaces supply by approximately 16 percent.¹¹⁹

113 *What is Total Area of Tamil Nadu ?*, CENSUS 2011 (2015), <http://www.census2011.co.in/questions/7/state-area/total-area-of-tamil-nadu-census-2011.html> [https://perma.cc/X6SV-6G4E].

114 *Tamil Nadu Population Census Data 2011*, CENSUS 2011, <http://www.census2011.co.in/census/state/tamil+nadu.html> [https://perma.cc/S6RM-G3H6]; TAMIL NADU GOV'T, STATE INCOME 21, <http://www.tn.gov.in/dear/State%20Income.pdf> [https://perma.cc/GH3T-LFED] (converted rupees to USD using the exchange rate on Nov. 12, 2016).

115 *Salient Details of Tamil Nadu State*, Tamil Nadu Water Supply & Drainage Board, <http://www.twadboard.gov.in/twad/tamilnadu.aspx> [https://perma.cc/5DE8-GPSX].

116 PEEYUSH SEKHSARIA & VAIBHAV KALEY, ARCH. & DEV., INDIVIDUAL TANK BASED RAINWATER HARVESTING SYSTEM FOR COASTAL TAMIL NADU 20, <http://www.arvindguptatoys.com/arvindgupta/rainwaterharvest-eng.pdf> [https://perma.cc/6THW-9NW4].

117 *About Us*, TAMILNADU WATER SUPPLY & DRAINAGE BOARD, <http://www.twadboard.gov.in/twad/AboutUs.aspx> [https://perma.cc/U82Z-8SC8].

118 *Combined Water Supply Scheme Launched by CM*, THE HINDU (Aug. 27, 2016), <http://www.thehindu.com/news/national/tamil-nadu/combined-water-supply-scheme-launched-by-cm/article8039633.ece> [https://perma.cc/Y268-NS8R].

119 See M. Rajshekar, *The Story of How Karnataka and Tamil Nadu Mismanaged Their Water and Then Blamed Each Other*, SCROLL.IN (Sept. 14, 2016), <https://scroll.in/article/816445/the-story-of-how-karnataka-and-tamil>

The capital of Tamil Nadu, Chennai, has a population of approximately 8.5 million.¹²⁰ The per capita income in the city was \$1398 USD in 2016.¹²¹

In response to an acute drought, the state launched the Rainwater Harvesting Scheme in 2001.¹²² This resulted in a 2004 amendment to section 215-A of the Tamil Nadu District Municipalities Act, which effectively mandated rainwater installation in all buildings, residential and commercial, that fell under the government's jurisdiction.¹²³ The water supply would be disconnected if the building did not comply.¹²⁴ The Act did not specify the types of RWH that could be implemented,¹²⁵ but the state's RWH information website promotes active and passive harvesting.¹²⁶ The government did not provide subsidies to individuals who needed to retrofit their homes, but relied on banks to provide loans to those unable to afford the cost of implementing a system.¹²⁷

nadu-mismanaged-their-water-and-then-blamed-each-other
[<https://perma.cc/92M7-34EM>].

120 *Chennai Population*, POPULATION. CITY,
<http://population.city/india/chennai/#1> [<https://perma.cc/KB33-DHUH>].

121 See Live Chennai.com, *Per Capita Income Rises to Rs 93293* (June 2, 2016) (available at <http://www.livechennai.com/detailnews.asp?newsid=26873>). (used exchange rate of 1 USD to 67.19 INR, source <https://www.poundsterlinglive.com/best-exchange-rates/us-dollar-to-indian-rupee-exchange-rate-on-2016-11-12>).

122 *TN's Success Story: Rain Water Harvesting*, HINDUSTAN TIMES, (June 5, 2015) (available at <http://www.hindustantimes.com/india/tn-s-success-story-rain-water-harvesting/story-u2LJmSHM4O4vA155wEtmOK.html>).

123 Tamil Nadu District Municipalities Act, 1920 § 215-A(1), <http://cma.tn.gov.in/cma/en-in/Downloads/The%20Tamil%20Nadu%20District%20Municipalities%20Act,%201920.pdf> [<https://perma.cc/HP5Q-3QBT>].

124 *Id.* § 215-A(4).

125 *Id.* § 215-A(1).

126 *Rain water harvesting*, TAMIL NADU DIRECTORATE OF TOWN PANCHAYATS, http://www.tn.gov.in/virtual_directory/dtp/rainwater.htm [<https://perma.cc/73D9-QXEK>].

127 Balaji L. Narain, *Water Scarcity in Chennai, India* 10 (July 6, 2005) (unpublished manuscript), http://ccs.in/internship_papers/2005/7.%20Water%20scarcity%20in%20Chennai.pdf.

1. Adoption

Statewide, the program was problematic. Out of the 260,000 buildings required to implement the RWH structures, less than 60,000 (approximately 23 percent) had implemented RWH structures in October of 2014 (twelve years after the program was implemented), and the state saw many large, public institutions fail to implement the mandated RWH technologies.¹²⁸ Indeed, some estimates report that government-run schools and other buildings have the poorest RWH implementation, and state, “the adoption rate among private citizens would probably be higher than the government.”¹²⁹ Officials cited a lack of enforcement for the low compliance rate.¹³⁰ They note, “several thousand structures have managed to escape the monitoring mechanism entirely.”¹³¹

In 2002, Chennai’s municipal water board also mandated RWH in new construction and existing buildings.¹³² The program was more successful in the city than the state’s rural areas. “In Tamil Nadu, urban harvesting is better when compared to the rural ones,” said Shekhar Raghavan, the director of a local RWH organization.¹³³ Indeed, 90 percent of the buildings in the city

128 Ajai Sreevatsan, *One Lakh Government Buildings have no RWH Structures*, THE HINDU, <http://www.thehindu.com/news/national/tamil-nadu/one-lakh-government-buildings-have-no-rwh-structures/article6482672.ece> [<https://perma.cc/Z5KS-T8MK>] (last updated May 23, 2016).

129 *Id.*

130 *Id.*

131 Julie Mariappani, *Parched Tamil Nadu Lets Rainwater Go Down the Drain*, TIMES OF INDIA (July 15, 2013, 4:54 AM IST), <https://timesofindia.indiatimes.com/city/chennai/Parched-Tamil-Nadu-lets-rainwater-go-down-the-drain/articleshow/21077598.cms> [<https://perma.cc/944D-R55R>].

132 Center for Science and Environment, *Legislation on Rainwater Harvesting*, <http://www.cseindia.org/content/legislation-rainwater-harvesting> (describing the Tamil Nadu regulations).

133 *TN’s Success Story: Rain Water Harvesting*, HINDUSTAN TIMES (June 5, 2015), <http://www.hindustantimes.com/india/tn-s-success-story-rain-water-harvesting/story-u2LJmSHM4O4vA155wEtmOK.html> [<http://perma.cc/R9SS-LWDG>].

installed RWH systems after the mandate.¹³⁴ Furthermore, some neighborhoods went beyond the requirements of the mandate and installed public harvesting structures (e.g., recharge wells along public roads) to supplement the private implementation of RWH.¹³⁵

The success was likely due in part to the strong grassroots RWH movement in Chennai; indeed, NGOs and private citizens began promoting RWH in the city long before the mandates were implemented¹³⁶ and increased their efforts when the mandate was released in 2002.¹³⁷ For instance, in 2002, a local citizen's action group opened The Rain Centre, a local educational center that offered educational programming to residents and school children, hosted seminars, and provided on-site RWH education.¹³⁸ NGOs and private institutions further promoted RWH in the city by organizing public meetings, door-to-door campaigns, and various other events to promote RWH.¹³⁹ These efforts were integral to the success of the program; researchers note that the government implementation was rushed, and without the intervention of the grassroots community, the mandates would have been a complete failure.¹⁴⁰

134 Julie Mariappani, *Parch Tamil Nadu lets Rainwater go Down the Drain*, TIMES OF INDIA (July 15, 2013), <https://timesofindia.indiatimes.com/city/chennai/Parched-Tamil-Nadu-lets-rainwater-go-down-the-drain/articleshow/21077598.cms> [http://perma.cc/MEA5-FHTX].

135 Liffy Thomas, *Rainwater Harvesting Structures Come up Around Mylapore*, THE HINDU (May 24, 2014) (available at <http://www.thehindu.com/features/downtown/rainwater-harvesting-structures-come-up-around-mylapore/article6043826.ece>) (describing the efforts of residents to build and maintain rainwater harvesting structures in Kalakshetra Colony and First Avenue).

136 Vivek Vivek, *Rainwater Harvesting in Chennai: What Made it Work?*, 5 IIM KOZHIKODE SOC'Y & MGMT. REV. 91, 99, 102 (2016).

137 *Id.* at 103.

138 *Activities*, AKASH GANGA TRUST RAIN CENTRE, CHENNAI, <http://raincentre.net/activities.php> [http://perma.cc/FQ9U-LD7V].

139 Vivek, *supra* note 136, at 99.

140 *See* Vivek, *supra* note 136, at 103 (“If a large number of non-governmental actors were missing, the rushed timeline would have led to a complete failure instead of a reasonable level of success that was achieved.”).

2. Conservation

Overall, research does not reveal substantial records of the impact of RWH in the state of Tamil Nadu. However, some studies show that the effects of the mandate were short-lived, with tank usage in rural areas declining and installed tanks falling into a state of disrepair shortly after implementation.¹⁴¹ Indeed, ten years after the mandates were implemented, groundwater levels reportedly fell in thirty out of thirty-two districts, receding to more than ten meters below ground level in some areas.¹⁴²

In Chennai, however, some studies show that RWH raised the city's ground water level.¹⁴³ According to qualitative data pre-and-post-RWH implementation, well levels increased by 30 percent and groundwater levels increased an average of four meters across the city.¹⁴⁴ Some attribute these raised to RWH, but may instead be due to increased rainfall.¹⁴⁵

Regardless of any increases, it is likely that the city is not optimizing usage of RWH due to poor installation and maintenance. A 2003 survey demonstrated that while 99 percent of buildings were compliant, only 50 percent were "technically sound."¹⁴⁶ Accordingly, reports note that residents did not maintain the structures installed during the early days of the mandate.¹⁴⁷

141 Kimberley J. Van Meter et al., *The Socioecohydrology of Rainwater Harvesting in India: Understanding Water Storage and Release Dynamics Across Spatial Scales*, 20 HYDROLOGY & EARTH SYS. SCI., 2629, 2630 (2016) (discussing RWH tanks in rural Tamil Nadu).

142 See Sreevatsan, *supra* note 128.

143 Abraham Jebmalar et al., *Groundwater Storage through Rain Water Harvesting (RWH)* 40 CLEAN SOIL AIR WATER 624 (2012).

144 See Vivek, *supra* note 136, at 101, 102.

145 *Id.*

146 *Id.* at 97, tbl.1.

147 See *Rainwater Harvest Tech Outdated, Chennai in Crisis*, TIMES OF INDIA (Sept. 21, 2015, 5:36 AM IST), <https://timesofindia.indiatimes.com/city/chennai/Rainwater-harvest-tech-outdated-Chennai-in-crisis/articleshow/49039080.cms> [http://perma.cc/HWN5-HQTH].

Nevertheless, Chennai is expanding its RWH programming on a public level. In 2015, the city had plans to set up 50,000 RWH structures near storm water drains in the city, spending three million dollars on the project.¹⁴⁸ The city is also implementing more RWH structures in offices and school buildings.¹⁴⁹

	Tucson	Bangalore	Queensland	Tamil Nadu
RWH Program	Mandated passive or active system installation for new, commercial construction. 50 percent of water for landscaping through RWH. \$2,000 rebates for household installation.	Mandated passive or active system installation for all buildings 2400 square feet and above.	Mandated active system installation for all new construction; rebates available for installation on previously constructed structures.	Mandated active or passive system installation for all buildings.

148 *50,000 Rain Water Harvesting Structures to Come Up in Chennai*, TIMES OF INDIA (May 30, 2014, 9:26 PM IST), <https://timesofindia.indiatimes.com/city/chennai/50000-rain-water-harvesting-structures-to-come-up-in-Chennai/articleshow/35794531.cms> [<http://perma.cc/8Z3X-SXX6>].

149 *Id.*; see also Aloysius Xavier Lopez, *Rainwater Harvesting in Chennai to Get Fillip*, THE HINDU, <http://www.thehindu.com/news/cities/chennai/rainwater-harvesting-in-chennai-to-get-fillip/article5394640.ece> [<http://perma.cc/EWQ6-NJ6Q>] (updated Nov. 27, 2013, 8:29 IST).

Adoption	~100 percent compliance with mandates; 837 obtain rebates.	~ 45 percent compliance.	~100 percent compliance with mandates; 20,000 apply for rebates.	Statewide: ~23 percent compliance. Chennai: ~90 percent compliance (50 percent not technically sound).
Conservation	No direct impact from RWH.	Poor implementation, little impact and little adoption other than mandates.	30–35 percent of home water use fulfilled by RWH at program height, but program discontinued when drought alleviated.	Statewide: Poor implementation. Chennai: Higher groundwater levels reported.

To summarize, in Chennai, NGOs and grassroots organizers provided important support to the government's RWH program implementation—a program that continues to expand. Moreover, if one contrasts the efficacy of RWH policies in Tamil Nadu and Chennai, these grassroots and centralized efforts in Chennai appear to have proved more successful than the efforts in more rural areas and will have proven integral to the success of the program in the capital city.

III. POLICY ANALYSIS AND SUGGESTIONS

Each of the governments outlined above experienced different levels of relative success and failure in implementing RWH policies and programs. The following chart summarizes the policies and their results in Tucson, Bangalore, Queensland, Tamil Nadu, and Chennai.

A. Socioeconomic and Cultural Impacts

Socioeconomic and cultural forces inevitably played a role in the relative impacts of the programs. For instance, Queensland

spent a full nine billion exclusively on water conservation,¹⁵⁰ while BWSSB's 2011–2012 operational budget was 324 million dollars,¹⁵¹ and the entire 2003–2004 operational budget for the Tamil Nadu Water Supply and Drainage Board was approximately 104 million dollars.¹⁵² The relative ability to expend resources undoubtedly contributed to the success of Queensland's program.

Furthermore, cultural attitudes and bureaucratic organizations likely play an important role in the structure and ultimate success of a program. Simply put, certain types of RWH policies are not as feasible in some areas as in others due to structural forces. In India, for example, bureaucratic hurdles may prevent rebate programs from being easily implemented.¹⁵³

However, financial resources and cultural attitudes are not wholly determinative of the success or failure of an RWH program. Though Tucson offered a significantly higher rebate to RWH users than did Queensland, Queensland's program still resulted in greater amounts of conserved water. Additionally, though rebate programs in India have repeatedly been introduced only to fail to receive governmental support,¹⁵⁴ a

150 Cart, *supra* note 89.

151 *Annual Financial Statement for 2011–12 & Revised Estimates for 2010–11*, BANGALORE WATER SUPPLY & SEWERAGE BOARD, [http://bwssb.gov.in/bwssbuat/sites/default/files/rti/4\(1\)\(b\)/4\(1\)\(b\)x.pdf](http://bwssb.gov.in/bwssbuat/sites/default/files/rti/4(1)(b)/4(1)(b)x.pdf) [<http://perma.cc/B92U-UHA6>] (Rupees converted to USD using exchange rate on Nov. 11, 2016).

152 *Demand 33*, TAMIL NADU MUN. ADMIN. & WATER SUPPLY DEPT 0, 48 (2003–2004), http://cms.tn.gov.in/sites/default/files/documents/maws_1_0.pdf [<https://perma.cc/B4PB-L4L4>] (Rupees converted to USD using exchange rate on Nov. 11, 2016).

153 Ipshita Chaturvedi, *Why Tax Incentives for Efficiency Are a Step Forward for India's Energy Security*, THE WIRE (Nov. 11, 2016), <https://thewire.in/81234/energy-efficiency-tax-marrakech> [<https://perma.cc/3ZV8-ASWW>] (“In 2014, there was a talk of giving a 5% property tax rebate to buildings with rainwater harvesting in Mumbai. . . . At the time, a former municipal commissioner said providing a rebate on property tax for eligible buildings would not be possible because the Municipal Corporation of Greater Mumbai has not received clear directives on the issue from the state government.”).

154 *See, e.g., 5% Rebate in Property Tax for Buildings Having Rainwater Harvesting Fails to take off*, DAILY NEWS & ANALYSIS (May 3, 2015),

rebate program was successfully approved in the northern part of the country early last year, demonstrating that governments may be willing to implement new policy mechanisms given the appropriate circumstances.¹⁵⁵ Thus, governments attempting to implement RWH programs can focus on specific policy mechanics that are likely to incentivize adoption of RWH given each region's specific socioeconomic and cultural constraints. The remainder of this article analyzes some of these policy mechanisms in the context of the four cases discussed above to provide guidance and insights for RWH policy design.

B. Adoption

1. Severe vs. Lenient Mandates

Policymakers may face a choice between implementing harsh mandates that require substantial resources for oversight or less severe mandates that are more easily enforceable. If deciding on the former, governments should ensure that they can provide the oversight required for successful implementation. To illustrate this point, both Bangalore and Tamil Nadu had difficulty enforcing harsh mandates that required retrofitting and/or installation of RWH technologies in private residences, as neither location achieved compliance rates above 50 percent. Commentators in Bangalore specifically noted the lack of penalties when discussing the program's compliance problems.¹⁵⁶ Therefore, if a government chooses to adopt harsh mandates, it should also have a plan in place to penalize those who do not comply, thereby driving individuals to obey those regulations.

However, governments may find that adopting less severe

<http://www.dnaindia.com/mumbai/report-5-rebate-in-property-tax-for-buildings-having-rainwater-harvesting-fails-to-take-off-2082643> [<https://perma.cc/GV9H-7P8D>].

¹⁵⁵ Rashmi Verma, *Tax Rebate to Promote Rainwater Harvesting*, DOWN TO EARTH (Feb. 11, 2016), <http://www.downtoearth.org.in/news/tax-rebate-to-promote-rainwater-harvesting-52792> [<https://perma.cc/3CZL-EKZ2>].

¹⁵⁶ See discussion *supra* Part II.B (discussing the lack of enforcement in Bangalore).

mandates can also offer significant benefits. Queensland implemented relatively lenient mandates that only required RWH system installation for new construction despite the relatively higher resources at its disposal. By implementing less arduous mandates—limited just to new construction that could be monitored through the building permitting process—the government ensured that it would be able to oversee the program, leaving it freer to devote significant resources to its overarching conservation program. Indeed, the region saw groundwater levels rise substantially due to these efforts. Though Queensland’s vast expenditure on conservation undoubtedly played a role in the relative success of the policy, the results support the hypothesis that harsh mandates may not be required to drive conservation (especially when a government has significant resources to devote).

2. Minimize Cost to Consumer

Second, regardless of whether they implement lax or harsh mandates, governments should consider providing some sort of financial assistance to individuals who implement RWH. Aside from resources for oversight, Tamil Nadu and Bangalore provided no funding to assist individuals who wanted to install RWH even though the systems carried substantial costs (between \$200 and \$725).¹⁵⁷ This cost could prove prohibitively expensive in low-resource communities; in Bangalore, one of the primary reasons for noncompliance was the expense required to install the system. Compliance rates may have increased if the financial barriers associated with RWH installation were lessened.

One method to minimize cost to the consumer is the provision of loans or government subsidies to cover the up-front cost of RWH implementation, especially in areas with substantial low-income populations. This system could even prove preferable to the rebate systems currently in use. While rebate programs help

¹⁵⁷ See *id.*; discussion *supra* Part II.D.

to mitigate the cost to the consumer, they are often only accessible to the wealthy, who can afford to invest in the upfront cost of the system. Tucson is exploring this type of alternate financing solution, as the city recently unanimously passed a pilot RWH program for low-income families. Through the program, low-income households will be provided with grants and loans to offset the up-front cost of an RWH system.¹⁵⁸ Though the results of this effort have not yet been studied, it could reduce the burden on individuals hoping to install RWH and thereby increase overall adoption.

3. Non-Governmental Support

Finally, governments should also look to NGOs and grassroots organizers for support during the implementation period. For instance, the grassroots RWH community in Tucson drove support for the municipal adoption of the program, and the network of NGOs and private citizens who raised RWH awareness in Chennai provided needed support for government programs.¹⁵⁹ Thus, governments should forge strong partnerships with NGOs and private citizens to develop sustainable policies, especially if a state's financial ability to invest heavily in a program is lacking. Once the programs are implemented, governments can then use the structures created by these agencies, like Chennai's Rain Centre, to help drive awareness of the plan and encourage adoption.

C. Conservation

Notably, while designed to encourage adoption of RWH, many of the policy mechanisms in the four case studies above did not directly incentivize water conservation. The policies in Tamil

158 Press Release, City of Tucson, Mayor and Council to Help Low-Income Families Harvest Rainwater (Sept. 8, 2016), <https://www.tucsonaz.gov/newsnet/mayor-and-council-help-low-income-families-harvest-rainwater> [<https://perma.cc/GYR5-8AWH>].

159 See discussions *supra* Part II.A.

Nadu and Bangalore, for example, mandated RWH system installation but did not address the use of the water that was conserved post-installation. Many households that integrated RWH still depended heavily on municipal water sources. As a result, groundwater levels did not improve after program implementation.¹⁶⁰ Similarly, in Tucson, those applying for rebates simply had to demonstrate that they had installed a system, without having to provide proof that water was being conserved through its use.¹⁶¹ Individuals used the extra water merely to supplement pre-existing uses, which resulted in no net gains in water conservation. Policymakers therefore may be more successful if they integrate mechanisms that are targeted at promoting conservation into their RWH policies. In doing so, policymakers will need to confront the current lack of incentives for conservation.

1. Encouraging Behavioral Changes

One means of encouraging conservation could be governmental action aimed at changing individual attitudes and behaviors regarding RWH. One current barrier is a belief that water scarcity is not a severe enough problem to warrant action. In Bangalore, for instance, a majority of respondents to one survey stated that they did not install RWH because they felt they had not experienced scarcity and “hence it was not necessary.”¹⁶²

A severe drought can be a strong environmental factor prompting this behavioral and attitudinal change. As discussed above, the severe drought in Queensland highlighted the necessity of adopting RWH to conserve water and avoid shortages on an individual level—when residents felt as though they would be personally affected by the drought, they were more likely to conserve water.¹⁶³ Moreover, the government was

160 See discussions *supra* Part II.B and II.D.

161 See discussion *supra* Part II.A.

162 See Umamani & Manasi, *supra* note 54, at 18.

163 See discussion *supra* Part II.C.

prompted to spend a significant amount of resources and created the “Target 140” plan to combat the drought.¹⁶⁴ Thus, governments in areas faced with a severe drought may be uniquely poised to implement successful RWH programs.

Unfortunately, this observation does not provide much guidance for governments hoping to implement RWH systems in the absence of drought, or for those that lack the resources to implement costly programs. Thus, cities with average rainfall or those lacking resources may need to develop creative means for incentivizing the adoption of RWH policies.

One option for policymakers hoping to encourage behavioral change could be the use of behavioral modification techniques such as Queensland’s “Target 140” plan¹⁶⁵ to encourage consumers to reduce municipal water consumption but increase their use of harvested rainwater. Governments could create goals for users to utilize a certain amount of harvested rainwater in lieu of municipal water every day. Alternatively, they could create a community-wide groundwater recharge goal to incentivize individual decreases in water consumption. Notably, however, Queensland implemented the “Target 140” plan during a severe drought, and more research would be required to determine whether this type of goal-setting would have a similar effect in absence of drought. However, if the principle proves as effective in times of adequate water supply, the use of behavioral goals could prove an important aspect of an RWH policy.

2. Financial Incentives

Other barriers standing in the way of conservation include faulty pricing schemes. In Tamil Nadu, cheap access to existing groundwater creates pricing mechanisms that do not encourage RWH conservation; though individuals may install a RWH

¹⁶⁴ *Id.*

¹⁶⁵ QUEENSLAND WATER COMMISSION, PRIA STATE AWARDS FOR EXCELLENCE, GOVERNMENT SPONSORED CAMPAIGNS, TARGET 140 8–10 (available at <https://www.pria.com.au/documents/item/728>) (describing the behavioral strategies underpinning the Target 140 plan).

system to avoid a penalty, they do not have any financial incentive to use the water conserved.¹⁶⁶ In Bangalore, meanwhile, the capital cost of harvested rainwater is high, while subsidized municipal water sources remain inexpensive.”¹⁶⁷

To introduce incentive-based conservation policies, governments could make rebate or subsidy plans contingent on a demonstrated reduction in reliance on municipal water. For instance, provision of rebates could be made contingent on proving that the harvested water was used in lieu of, rather than in addition to, municipal water. In Tucson, such a program would help prevent individuals who install RWH systems from using the harvested water to install additional landscaping.

Another option is for governments to provide financial incentives to those who decrease their use of municipal water after installing a RWH system. There are a variety of means by which cities could do so. Local municipalities or NGOs could provide cash rewards to those who prove that they have used a RWH program to reduce municipal water usage,¹⁶⁸ or governments could provide tax breaks for individuals who prove they have reduced consumption. Moreover, cities that use tiered-rate water pricing schemes and charge higher rates for consuming more water could offer reduced rates to individuals who use RWH systems to conserve. In addition, cities could allow individuals who reduce their water consumption to direct their monetary savings to environmental restoration programs, thus incentivizing conservation as a means to provide more resources

166 Van Meter et al., *supra* note 141, at 2630 (discussing easy access to groundwater and pumping that has led to decreased use of RWH technologies).

167 See Bharadwaj, *supra* note 63 (discussing skepticism regarding penalties that would probably fail to motivate individuals).

168 Though this program may sound radical, “payments for environmental services” (PES) programs are an “increasingly popular conservation and resource management tool” primarily used in developing countries. In these programs, individuals in countries like Uganda and Costa Rica have already received payments for conserving natural resources. With some alterations, a similar program may benefit RWH policies. *Markets and Payment for Environmental Services*, Int’l Inst. for Env’t & Dev., <http://www.iied.org/markets-payments-for-environmental-services> [<https://perma.cc/LL9T-PCVK>].

to a worthy cause; a similar program in Tucson resulted in savings of more than 855,000 gallons in two years.¹⁶⁹ Though funding these programs would inevitably require substantial resources, policymakers should explore such ideas as viable means of incentivizing conservation.

The above suggestions are by no means an exhaustive list, and more research is needed to evaluate whether these policy mechanisms would indeed prove effective.¹⁷⁰ However, by being mindful of the need for policies aimed not only at driving adoption of RWH technology, but also at the overall conservation of water, policymakers can plan more effective overall policies.

CONCLUSION

RWH is gaining traction as a favorable practice for increased water conservation. However, as the examples of Tucson, Bangalore, Queensland, Tamil Nadu, and Chennai demonstrate, policymakers must make calculated decisions as they develop RWH programs. Implementation can certainly be made more effective if governments consider their areas' "physical and [] socio-economic attributes, . . . the quality of the rainwater[,] and the alternative water sources."¹⁷¹ Policymakers should focus on the specific elements of a policy and how they work to drive both adoption of RWH technologies as well as post-implementation

169 See Davis, *supra* note 26.

170 Notably, research has already been conducted on the most efficacious manner by which to encourage conservation-behavior. See, e.g., Samuel R. Staley, *Institutional Considerations for Sustainable Development Policy Implementation: A US Case Study*, 24 PROP. MGMT. 232, 246 (2006) ("[R]esources may be better and more effectively focused on enabling sustainable development practices to emerge spontaneously thorough market mechanism than prescribing specific outcomes."); see, e.g., Carl J. Circo, *Using Mandates and Incentives to Promote Sustainable Construction and Green Building Projects in the Private Sector: A Call for More State Land Use Policy Initiatives*, 112 PENN STATE L. REV. 732, 732 (2008) (acknowledging the power of state action and mandates to drive implementation of green building measures). However, little research has been conducted in the context of a RWH program.

171 J. Mwenge Kahinda et al., *Domestic Rainwater Harvesting to Improve Water Supply in Rural South Africa*, 32 PHYSICS & CHEMISTRY OF THE EARTH 1050, 1055 (2007).

water conservation. For instance, governments should consider the ramifications of implementing harsh or lenient mandates, as well as whether to employ rebate or subsidy programs. Furthermore, policymakers should consider how their policy will incentivize increased water conservation.

As the world population grows and water resources become increasingly depleted, the importance of RWH as a viable alternative water source will continue to grow. By learning from the successes and failures of previously implemented programs, policymakers can ensure that the RWH policies of the future positively contribute to overall water conservation.