# RECENT DEVELOPMENT

## DOMESTIC SOLUTIONS TO THE INTERNATIONAL PROBLEM OF WATER SCARCITY: SINGAPORE, A CASE STUDY

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## I. INTRODUCTION

Water scarcity is a critical international problem. The United Nations (UN) is calling 2005–2015 the International Decade for Action "Water for Life."[1] To address the water scarcity issue, the U.N. considers both resource-poor countries and countries with limited infrastructure capabilities to yield existing water resources from above- and below-ground sources.[2] Nations across the globe face severe water shortages, especially in Africa.[3] While the most severe shortages are in developing countries, water scarcity also occurs in developed nations. Besides providing for basic human necessities, access to water also has security and economic implications. In war time, water resources may be attacked, or if one side usually provides water to the other, water supplies may be cut off.[4] When one nation controls water access for another state, tension remains even in the absence of military conflict and creates an imbalance of power. That discrepancy in turn influences those nations' relations and any negotiations. Naturally, states wish to be independent of such pressure in political relations and to be in control of their own access to resources. As water scarcity increases, the drastic human suffering due to thirst and lack of sanitation will lead to discontent and possibly water wars.[5] In light of the water scarcity issue facing the international community, Singapore provides a valuable case study for methods Georgia could use to achieve water independence through domestic programs, particularly technological approaches.

Globally, nations have taken several different approaches to deal with the issue of water scarcity. First, international law addresses the duties riparian states owe each other based on their status of up or downstream state. Second, nations have also entered into trade treaties with their neighbors to supplement their water supply. Third, domestic conservation efforts decrease the demand for water, so the available local water can stretch further. Finally, nations have also used technical solutions such as desalinization plants or rain catchment methods to capture and treat obtainable water.

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[1] UNITED NATIONS, *International Decade for Action 'WATER FOR LIFE' 2005–2015: Water Scarcity*, http://www.un.org/waterforlifedecade/scarcity.shtml.

[2] *Id.*

[3] *Id.*

[4] Peter H. Gleick, *Water and Conflict: Fresh Water Resources and International Security*, 18 INT'L SEC. 79, 84–85 (1993), *available at* http://www.pacinst.org/reports/international_security_gleick_1993.pdf.

[5] *Id.* at 90.

In facing its own water scarcity, Singapore has chosen to focus on domestic and technological solutions to overcome its dependency on water imports. Singapore is a wealthy but water-resource-poor country. In the past, Singapore has relied primarily on its northern neighbor Malaysia for its water supply based on water agreements negotiated in 1961 and 1962. Strained relations and an expanding population stressed that relationship to the point that traditional trade agreements proved inadequate, so Singapore decided to try to become water independent.[6]

Because Singapore experiences heavy rainfall, its domestic efforts to achieve water independence were initially focused on developing a large system of rain catchment reservoirs. It is also a coastal state, and Singapore invested heavily in desalinization plants with an emphasis on clean energy. Additionally, Singapore created an extensive underground sewage treatment facility that produces non-potable water used in industrial settings, allowing potable water to be used solely for drinking. These methods have proved effective and Singapore is on track to become water independent by 2060.[7]

Part II will explore the international water scarcity issue. Water is necessary to human and animal life as well as agriculture, so nations strive to provide an adequate water supply. Geography and borders, however, do not always facilitate easy access to water, which can generate much conflict. As a consequence, many nations are water poor: because there is not enough water within their borders; because the present water is dirty, wasted, or unobtainable; or both. Part III will overview why Singapore decided to make changes aimed at achieving water independence. These reasons include political, geographical, and demographic factors. Next, Part IV will outline what efforts Singapore has made with a focus on its technological innovativeness and how much water those developments generate. Finally, Part V will argue which of these specific methods are most adoptable in Georgia.

## II. WATER SCARCITY: AN INTERNATIONAL PROBLEM

International law has created various ways to deal with issues of rights to access water. Often, countries share riparian rights to freshwater sources like rivers. In the territorial integrity model, downstream countries can demand that their upstream neighbors not only share their water but also limit their consumption to ensure that there is enough for those people relying on the

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[6] For a discussion of Singapore and its history of water scarcity, see *infra* Part III.*A*.

[7] PUBLIC UTILITIES BOARD OF SINGAPORE, *Local Catchment Water*, http://www.pub.gov.sg/water/Pages/LocalCatchment.aspx.

downstream water.[8] Under the territorial sovereignty doctrine, however, upstream states can decide what to do with their water without considering the needs of the downstream state.[9] International law prefers the former view over the latter, even though that essentially gives downstream states a veto power over their upstream neighbors.[10] In more recent years, a new approach—equitable utilization—has been put forward, which ensures that "all [s]tates in a watercourse share sovereignty over the resource, and their interests must be reasonably balanced."[11] This is the most favored approach and is endorsed by the 1997 UN Watercourses Convention.[12]

Even though the legal framework seems like it determines use, states and nations cannot always agree on water management. According to the UN, "there is enough freshwater on the planet for six billion people but it is distributed unevenly and too much of it is wasted, polluted and unsustainably managed."[13] Water inequity leads to disputes among nations; when those disputes arise, nations may try to renegotiate existing treaties, create new ones, or even consult the International Court of Justice to determine water rights.[14] If an agreement cannot be reached to satisfy water demand, or if access must be substantially limited in order to share water among surrounding nations, a nation or state may need to consider alternative ways to supplement water for its residents. Trade in water is one solution. Trade, though, is also subject to the political tensions present in negotiations. More recent methods include developments to catch and store rainwater in addition to desalinization. Through such systems, a state can focus its energies domestically to address this international problem.

The international problem of water scarcity can also be felt locally in Georgia. Increasing populations and drought have led to Georgia being

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[8] DAVID HUNTER, JAMES SALZMAN & DURWOOD ZAELKE, INTERNATIONAL ENVIRONMENTAL LAW AND POLICY 881 (4th ed. 2011).

[9] *Id.* at 879.

[10] *Id.* at 881.

[11] *Id.*

[12] *Id.* The UN Watercourses Convention is not yet in force and "unlikely to obtain the necessary 35 ratifications to enter into force." *Id.* at 874.

[13] *Id.* The UN also distinguishes between water scarcity and water stress: "an area is experiencing water stress when annual water supplies drop below 1,700 m3 per person. When annual water supplies drop below 1,000 m3 per person, the population faces water scarcity, and below 500 cubic metres 'absolute scarcity.' " *Id.* By this definition, the United States is experiencing water stress and Jordan faces absolute scarcity.

[14] *Id.* at 842–73.

embroiled in "water wars" with the surrounding states for over twenty years.[15]

These conflicts can be conceptualized comparatively with the water tensions between Singapore and Malaysia. Georgia has experienced various levels of drought and only recently has the northeastern part of the state emerged from prolonged drought.[16] In 2012, the Eleventh Circuit Court of Appeals overturned a ruling that Atlanta metro residents were using too much water from Lake Lanier.[17] Besides assuring a water supply for about three million Atlanta residents, this ruling also altered Georgia's negotiating position with Alabama and Florida.[18] Besides harming residential and agricultural interests, a lack of water also causes to be businesses reluctant to enter an without a certainty of water access.[19]

In Georgia, which has a riparian water rights system, property owners whose land touches surface water sources have a right to reasonable use of the natural flow of that water.[20] Groundwater is also a private ownership property right,[21] in which the government can interfere only in nuisance situations.[22] Georgia's water laws have been codified: "Running water belongs to the owner of the land on which it runs; but the landowner has no right to divert the water from its usual channel nor may he so use or adulterate it as to interfere with the enjoyment of it by the next owner."[23]

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[15] SOUTHERN ENVIRONMENTAL LAW CENTER, *Tri-State Water Wars (AL, GA, FL)*, *available at* http://www.southernenvironment.org/cases/tri_state_water_wars_al_ga_fl.

[16] Ellen Reinhardt, *Northeast Georgia Out of Drought*, Georgia Public Broadcasting News (Feb. 8, 2013), *available at* http://www.gpb.org/news/2013/02/08/northeast-georgia-out-of-drought. *See also* Drought Monitor Archives, UNIVERSITY OF NEBRASKA-LINCOLN, *available at* http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?GA (showing archives of Georgia's drought status).

[17] Greg Bluestein, Bill Rankin & Scott Trubey, *High Court Grants Georgia Water-Wars Victory*, ATLANTA J.-CONST., June 26, 2012, http://www.ajc.com/news/news/local/high-court-grants-georgia-water-wars-victory/nQWmm/.

[18] *Id.*

[19] *Id.*

[20] Allen H. Olson, *The Basics of Water Law, Part One*, GROWING GEORGIA: THE BUSINESS OF AGRICULTURE (May 14, 2013), *available at* http://growinggeorgia.com/features/2013/05/basics-water-law-part-one/. These uses include not only domestic uses but also agricultural and manufacturing uses.

[21] *See* Gregory W. Blount, Harvey A. Rosenzweig & David M. Moore, *The Role of Water Rights and Georgia Law in Comprehensive Water Planning for Georgia* (2002).

[22] Case law has developed slowly in this area. An unreasonable use includes limiting the flow of a stream so that a downstream mill could not operate. Price v. High Shoals Mfg. Co., 132 Ga. 246 (1909). Irrigation use is reasonable by a riparian owner, even for non-riparian land. Pyle v. Gilbert, 245 Ga. 403 (1980). One owner's leisure use for water was determined to be greater than his neighbor's irrigation use. Tunison v. Harper, 286 Ga. 687 (2010).

[23] O.C.G.A. § 44-8-1.

The Georgia Water Control Quality Act sets forth requirements to obtain a permit for surface water removals.[24] The policy states

> the water resources of the state shall be utilized prudently for the maximum benefit of the people, in order to restore and maintain a reasonable degree of purity in the waters of the state and an adequate supply of such waters, and to require where necessary reasonable usage of the waters of the state and reasonable treatment of sewage, industrial wastes, and other wastes prior to their discharge into such waters.[25]

To do so, the government takes the responsibility of assuring water quality through the Environmental Protection Division of the Department of Natural Resources.[26] State water permits are required to discharge pollutants into water sources[27] and other federal permit requirements may also be implicated by such actions.[28] Additionally, permits are necessary before removing surface water of generally more than 100,000 gallons monthly.[29]

But, like the international framework that cannot prevent the problems caused by water scarcity, Georgia's water scheme has been ineffective in avoiding conflict with its neighbors. As recently as August 2013, Florida governor Rick Scott declared his intention to seek an injunction with the United States Supreme Court over the amount of water Florida receives from Georgia in the Apalachicola Bay, where the Chattahoochee River and Flint River meet.[30] Specifically, the limited water flow is harming Florida's seafood industry, especially its oysters.[31] This has caused serious job loss

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[24] *Id.* § 12-5-31.

[25] *Id.* § 12-5-21(a).

[26] *Id.* The Act defines water as

> any and all rivers, streams, creeks, branches, lakes, reservoirs, ponds, drainage systems, springs, wells, and all other bodies of surface or subsurface water, natural or artificial, lying within or forming a part of the boundaries of the state which are not entirely confined and retained completely upon the property of a single individual, partnership, or corporation.

*Id.* § 12-5-22(13).

[27] *Id.* § 12-5-30.

[28] *See* Clean Water Act, 33 U.S.C. §§ 1251–1387 (1972).

[29] O.C.G.A. § 12-5-31.

[30] Karl Etters, *Florida Governor Says He'll Sue Georgia for Water*, USA TODAY, Aug. 14, 2013, http://www.usatoday.com/story/news/nation/2013/08/14/environment-florida-georgia-water-wars/2653075/.

[31] *Id.*

and dire predictions for the survival of the industry.[32] The region was recently declared a disaster area by the federal government.[33] Florida claims that Georgia's "withdrawal of 297 million gallons per day from Lake Lanier and 408 million per day from the Chattahoochee River" is excessive.[34] The Army Corps of Engineers is supposed to release a new water flow policy soon.[35]

Georgia has also disputed its border with Tennessee for almost 200 years[36] based on an 1818 survey.[37] Georgia has claimed since the survey was completed that the border was erroneously determined.[38] The land in question is only one mile, but 30,000 Tennessee citizens and a portion of the Tennessee River are located there.[39] Again, the catalyst for the continuing tension is the growth of Atlanta and the need to supply its citizens and businesses with enough water to sustain it and its growth.[40]

Part of the water scarcity issue may be perceived, rather than actual.[41] According to one of the attorneys who has represented the State of Georgia in some of these matters, there is plenty of water to share but there are economic competition and political factors causing the strain rather than real water scarcity.[42] Alabama and Florida are concerned about Atlanta growing too quickly, especially since it is located at the head of the shared water system, but Alabama and Florida have no lack of access to water.[43] Instead, they are worried about losing business to Georgia, and by claiming that there is not enough water, they hope to prevent such an outcome.[44] However, the types of Fortune 500 companies that headquarter in Atlanta do not really consider Alabama and Florida but instead look at cities like Atlanta with a large highway system and airport.[45] Manufacturers do not generally locate in

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[32] *Id.*

[33] Mary Ellen Klas, *Florida-Georgia Water Wars Go From Backroom to Courtroom*, TAMPA BAY TIMES, Aug. 13, 2013, http://www.tampabay.com/blogs/the-buzz-florida-politics/florida-georgia-water-wars-go-from-backroom-to-court-room/2136261.

[34] Etters, *supra* note 30.

[35] *Id.*

[36] Brad Carver, *Georgia-Tennessee Water Dispute*, ATLANTA J.-CONST., Apr. 18, 2013, http://blogs.ajc.com/atlanta-forward/2013/04/18/georgia-tennessee-water-dispute/.

[37] *Id.*

[38] *Id.*

[39] *Id.*

[40] *Id.*

[41] Telephone Interview with Todd Silliman, Partner, McKenna, Long & Aldridge (Sept. 25, 2013).

[42] *Id.*

[43] *Id.*

[44] *Id.*

[45] *Id.*

Atlanta, and those companies tend to use a lot of water.[46] Thus, this business competition based idea is inconsistent.[47] In fact, water used in metro Atlanta is mostly cleaned and returned to the water stream.[48] Agriculture uses much more water than residents and businesses in metro Atlanta, yet farmers irrigate when it is hot and dry because irrigation is expensive—they have no incentive to irrigate during rainy times.[49]

Perhaps there is enough water to share now, but if communities continue to grow exponentially, there will not always be enough. Instead, Georgia should begin now to decrease its dependence on these contentious water sources. The state should lead the forefront of water catchment, recycling, and perhaps desalinization technology so that not only would it have other sources of water but it could also export that knowledge to others in the future. At the same time, Georgia would diffuse the current tensions with its neighbors. Whether the anxiety is well-founded or not, it has persisted for years and continues firmly today. While hostility between neighboring states in the United States are not nearly as volatile as those between poor, developing nations in other parts of the world, water scarcity is still a growing problem. Georgia and its neighboring states can learn from Singapore's experience.

## III. SINGAPORE

### *A. A Water-Poor State*

In the past, Singapore has used traditional methods such as trade agreements and some technological innovations to conserve and supplement its water supply. Singapore is a small island of 697 square kilometers located south of Malaysia and north of Indonesia.[50] It is separated from Malaysia, its closest neighbor, by the Strait of Johore.[51] The border between

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[46] *Id.*
[47] *Id.*
[48] *Id.*
[49] *Id.*
[50] CIA, THE WORLD FACTBOOK, *Singapore*, https://www.cia.gov/library/publications/the-world-factbook/geos/sn.html (last visited Mar. 23, 2013).
[51] *Id.*

these nations runs in the middle of the Johore Straits.[52] This imaginary line was determined in 1994 to prevent boundary disputes.[53]

Singapore has had water troubles since its founding as a British colony in 1819.[54] Beginning in the late 1820s, the private sector supplied water for both private and commercial uses because the government could not keep up with demand.[55] In drought, though, this supply was not enough and private entities began to build reservoirs.[56] But these efforts proved inadequate, with harsh results like local governments being unable to put out fires.[57] In 1865, a municipal law created Commissioners in Singapore to build "tanks, reservoirs, or other works as such [are] necessary to provide in convenient parts of the said Town for the use of the inhabitants."[58] The water projects were consistently plagued with financial difficulties.[59]

After Singapore began to locally govern in 1867, legislation was enacted much more quickly by the Singapore Governor in response to provincial concerns.[60] In 1869, the Suez Canal opened, and as a result, the demand for fresh water from ships using Singapore's port drastically increased.[61] This demand resulted in water being piped to the port beginning in 1871.[62] In 1877, "the [m]unicipality started to charge for water supplied based on the value of the property that water was supplied to."[63] By the time of the now defunct 1927 water agreement between Singapore and Malaysia, political change meant that "the British, through their General Advisor in Johore and the City Council of Singapore dictated the water agreement on their own terms."[64] This and later water agreements provided that Singapore could

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[52] *Singapore Map – Singapore Satellite Image*, GEOLOGY.COM, http://geology.com/world/singapore-satellite-image.shtml (last visited Mar. 23, 2013).

[53] *Strait of Johore*, SINGAPORE INFOPEDIA, http://infopedia.nl.sg/articles/SIP_787_2005-01-24.html (last visited Mar. 25, 2013).

[54] Joel Teo, *Singapore Legal History of Water: The Municipal and the Singapore Story Past, Present and Future*, 24 SING. L. REV. 22, 22 (2004).

[55] *Id.* at 23.

[56] *Id.*

[57] *Id.* at 24.

[58] *Id.* at 25–26.

[59] *Id.* at 26.

[60] *Id.* at 27.

[61] *Id.* at 28.

[62] *Id.*

[63] *Id.*

[64] *Id.* at 32.

import water from Johore (through the Johore River) and Johore could purchase treated water from Singapore.[65]

In World War II, Japanese bombs badly damaged the pipe system that carried water.[66] After the war, the British military focused heavily on fixing the water utilities.[67] Extreme water shortages led to the 1961 and 1962 water trade agreements between Singapore and Malaysia.[68] In the 1961 Water Agreement, Johore allowed Singapore the use of certain lands for "an annual rent of $5 per acre" for fifty years.[69] Besides giving Singapore the right to enter and use the land, Johore once again gave Singapore the right to build water works.[70] In consideration, Singapore agreed to supply Johore "a daily amount of water not exceeding at any time 12% of the total quantity of water supplied to Singapore . . . and in no case less than 4 million gallons."[71] The 1961 water agreement ended in 2011[72] and the 1962 agreement will end in 2061.[73]

But these agreements did not resolve the tension between Singapore and Malaysia caused by the water shortage. After the Malaysian Federation expelled Singapore in 1965, "Malaysia's first post-independence prime minister[ ] threaten[ed] to turn off the taps if Singapore pursued a foreign

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[65] Cecilia Tortajada & Kimberly Pobre, *The Singapore–Malaysia Water Relationship: An Analysis of the Media Perspectives*, 56:4 HYDROLOGICAL SCI. J., 597, 598 (2011), *available at* http://www.thirdworldcentre.org/hsjsingmal.pdf. The 1927 Water Agreement

> allow[ed] Singapore to rent 2100 acres of land in Gunong Pulai at 30 cents per acre per year, and 'take, impound and use all the water which from time to time may be or be brought or stored in upon or under the said land' at no cost to [Singapore, and] . . . the Government of Johore could request the supply of 800,000 gallons of water per day, if necessary, at 25 cents per 1000 gallons.

*Id.* at 611. This trade agreement caused consternation later when Malaysia felt that it worked against its interests since the agreement did not specify a price per water unit (but rather was a flat land rental fee). Teo, *supra* note 54, at 33.

[66] Teo, *supra* note 54, at 35.

[67] *Id.* at 36.

[68] *Id.* at 38.

[69] Tortajada & Pobre, *supra* note 65, at 611.

[70] *Id.* at 611–12.

[71] *Id.* at 612. This time, the parties agreed that Singapore would pay Johore "3 cents for every 1000 gallons of water drawn from the State of Johore and delivered to Singapore, and the Government of Johore would pay to [Singapore] 50 cents for every 1000 gallons of pure water." *Id.* The language of the price terms is mandatory and the price can be reviewed after twenty-five years, according to clause 17 of the 1961 agreement. Teo, *supra* note 54, at 40–41.

[72] Teo, *supra* note 54, at 39.

[73] *Id.* at 40.

policy that was 'prejudicial' to Malaysia's interests."[74] In 1990, further water agreements were reached between Johore, Singapore, and the Public Utilities Board of Singapore (PUB), providing that PUB would build a dam and other related water work in exchange for the ability to purchase water from the dam in excess of 250 million gallons from the Johore government.[75] Singapore agreed to help Malaysia during its 1997–1998 financial crisis in exchange for more water access at a reasonable rate.[76] When Malaysia no longer needed this money, the countries agreed to continue to discuss the issue of water prices.[77] Malaysia offered several proposals, each subsequently increasing the price while Singapore subsidized the cost of treated water to Johore.[78]

More recently, Malaysia has challenged Singapore's reclamation projects, including that of a nearby island where construction caused a narrowing of the Johore River.[79] Both Malaysia and Singapore commissioned technical studies as part of a dispute settlement action under the UN Convention of the Law of the Sea, following claims by Malaysia's Chief Minister that the construction caused environmental damage.[80] Each study determined that the projects did not cause environmental damage like increased flooding, but the Chief Minister of Malaysia still blamed Singapore's reclamation works for disastrous flooding that killed seventeen Malaysians.[81]

Other political tensions persist, including a sovereignty dispute between Singapore and Malaysia that was partially resolved in 2008 by the International Court of Justice (ICJ).[82] Such continuous political disputes trickle over into the water negotiations.

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[74] *Singapore to Become Water-Sufficient*, ASIA SENTINEL (Nov 6, 2008), http://www.asiasentinel.com/politics/Singapore-to-become-water-sufficient/.

[75] *Id.* at 46. The price of the water would be

> either (i) the weighted average of Johor's water tariffs plus a premium which is fifty per cent of the surplus from the sale of this additional water by PUB to its consumers after deducting Johor's water price and PUB's cost of distribution and administration of this additional water or (ii) 115 per cent of the weighted average of Johor's water tariffs, whichever is higher.

[76] Simon S.C. Tay, *17th Singapore Law Review Lecture: The Singapore-Malaysia Relationship and the Future Roles of International Law*, 24 SING. L. REV. 78, 85 (2004).

[77] *Id.*

[78] Tortajada & Pobre, *supra* note 65, at 605.

[79] *Johor Minister Says Singapore Land Reclamation Cause of Recent Floods*, Environmental News Archive (Jan. 31, 2007), http://environmentalnews.blogspot.com/2007/02/johor-minister-says-singapore-land.html.

[80] *Id.*

[81] *Id.*

[82] WORLD FACTBOOK, *supra* note 50. The ICJ determined Singapore had sovereignty of Pedra Branca and Malaysia had sovereignty over Middle Rocks, small islands not particularly

*B. A Domestic Solution*

In light of these consistent political tensions and growing water needs, Singapore began to pursue water independence in order to insulate itself from potential Malaysian intimidation.[83] Because trade governance was unsuccessful, Singapore began to look to domestic conservation efforts and technological solutions.[84] The 1961 agreement expired in 2011, and Singapore moved quickly in the years preceding the expiration to establish enough water sources that it would not be forced to agree to a bad deal, or worse, have seriously decreased access to water if negotiations failed.[85]

This domestic development project to create water independence is called the "4 National Taps."[86] Two of the 'taps' come from traditional sources: imported Johore water and water caught from rainfall.[87] The other two, NEWater (recycled water) and desalinated water, have grown through extensive technology and infrastructure developments.[88] The goal of the 4 National Taps program is to provide Singapore with "a diversified and sustainable supply of water."[89] Besides increasing the water supply, Singapore also emphasizes conserving water to keep demand manageable and "calls on all Singaporeans to play their part to conserve water, keep the water catchments and waterways clean, and build a relationship with water so that everyone can enjoy a sustainable water supply for all uses."[90]

Singapore's rainwater and used water collection systems are extensive.[91] Its "[r]ainwater is collected through a comprehensive network of drains, canals, rivers and stormwater collection ponds before it is channelled to Singapore's 17 reservoirs for storage."[92] PUB's goal is to use the reservoirs and water treating technology to catch and treat water from other water bodies close to the shoreline.[93] PUB aims to meet its goal of water independence by 2060 by increasing the amount of water caught to ninety

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close to the coasts of Singapore and Malaysia. The ICJ did not decide issues surrounding the "maritime regimes, boundaries, or disposition of South Ledge."

[83] *Singapore to Become Water Sufficient*, *supra* note 74.

[84] *Id.*

[85] *Id.*

[86] PUBLIC UTILITIES BOARD OF SINGAPORE, *Teacher's Kit*, http://www.pub.gov.sg/events/School/Pages/TeacherKit2.aspx.

[87] *Id.*

[88] *Id.*

[89] *Id.*

[90] *Id.*

[91] *Local Catchment Water*, *supra* note 7.

[92] *Id.*

[93] *Id.*

percent.[94] In 2010, the Marina Barrage was constructed, and by 2011 it "increased Singapore's water catchment area from half to two-thirds of the country's land area."[95] It also functions to keep out seawater, manage storms and flooding, and offer recreational activities.[96] This reservoir is in the city itself and provides for ten percent of the water need.[97]

Singapore also uses NEWater, which is water that is treated and "further purified using advanced membrane technologies and ultra-violet disinfection."[98] The water purified by this technology exceeds standards set by the World Health Organization.[99] PUB's goal is for NEWater technology to provide for fifty-five percent of the nation's water needs by 2060.[100] NEWater is designated primarily for non-potable uses such as in commercial or industrial settings, but a small portion is used as drinking water.[101] By mainly being consumed in non-potable settings, NEWater frees up potable water to be used solely for drinking needs.[102]

To treat NEWater, Singapore built a Deep Tunnel Sewerage System (DTSS).[103] The DTSS "consists of two large, deep tunnels crisscrossing the island, two centralised water reclamation plants, deep sea outfall pipes and a link sewer network."[104] Water is filtered through two sedimentary tanks and treated water becomes NEWater.[105] Any extra treated water is discarded into the ocean.[106] The impure sludge is treated and dried, which causes a seventy percent decrease in size and makes it easier to remove.[107] The biggest NEWater plant was constructed on the roof of the Changi Water Reclamation

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[94] *Id.*

[95] PUBLIC UTILITIES BOARD OF SINGAPORE, *Marina Barrage/Reservoir*, http://www.pub.gov.sg/Marina/Pages/3-in-1-benefits.aspx.

[96] *Id.*

[97] *Id.*

[98] PUBLIC UTILITIES BOARD OF SINGAPORE, *Water For All: NEWater*, http://www.pub.gov.sg/water/newater/Pages/default.aspx.

[99] *Id.*

[100] *Id.*

[101] *Id.*

[102] PUBLIC UTILITIES BOARD OF SINGAPORE, *Water For All: Plans for NEWater*, http://www.pub.gov.sg/water/newater/plansfornewater/Pages/default.aspx.

[103] PUBLIC UTILITIES BOARD OF SINGAPORE, *Deep Tunnel Sewerage System*, http://www.pub.gov.sg/dtss/Pages/default.aspx.

[104] *Id.*

[105] PUB, SINGAPORE'S NATIONAL WATER AGENCY, *Used Water Superhighway*, http://www.pub.gov.sg/dtss/PublishingImages/DTSS_Animation.swf.

[106] *Id.*

[107] *Id.*

Plant.[108] Because of this design, the plant only takes up one third of the land a typical water reclamation plant would.[109]

In 2005, Singapore opened the SingSpring Desalination Plant, PUB'S first public-private partnership project.[110] The plant is capable of "produc[ing] 30 million gallons of water a day . . . and is one of the region's largest seawater reverse-osmosis plants."[111] Another desalinization plant is scheduled to be constructed by 2013 with the ability to produce seventy million gallons of water daily.[112] Desalinization plants are often criticized for their rather large carbon footprint, but Singapore has partnered with Siemens Industries to dramatically decrease the amount of energy required in the process of desalinization.[113] PUBs ultimate goal is to mimic the biological process of sea creatures and lower the amount of energy required as much as possible.[114] PUB plans to move from 15kWh/m3 of energy to less than .75kWh/m3 through technology using Biometri Membranes.[115]

Many of these projects, including the DTTS, Marina Barrage, NEWater facilities, and desalinization plants have been outsourced from Singapore's Public Utilities Board to the private sector.[116] These projects have generated more than $3 billion for the private sector.[117] In 2009, it was estimated that the "size of the market for water conservation and recycling systems

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[108] PUBLIC UTILITIES BOARD OF SINGAPORE, *Benefits of the DTTS*, http://www.pub.gov.sg/dtss/benefits/Pages/BenefitoftheDTSS.aspx.

[109] *Id.*

[110] PUBLIC UTILITIES BOARD OF SINGAPORE, *Water For All Desalinated Water*, http://www.pub.gov.sg/water/Pages/DesalinatedWater.aspx. PUB entered into an agreement with Hyflux Ltd. to build this plant. PUBLIC UTILITIES BOARD OF SINGAPORE, *Press Releases: PUB and Hyflux Sign Water Purchase Agreement for Singapore's Second and Largest Desalination Project*, http://www.pub.gov.sg/mpublications/Pages/PressReleases.aspx?ItemId=284.

[111] *Desalinated Water*, *supra* note 110 ("At the SingSpring desalination plant, sea water goes through a pre-treatment process where suspended particles are removed. In the second stage, the water undergoes reverse osmosis (RO). This is the same technology used in the production of NEWater. The water produced is very pure and is remineralised in the third stage. After treatment, desalinated water is blended with treated water before it is supplied to homes and industries in the western part of Singapore.").

[112] *Press Releases*, *supra* note 110.

[113] Peter Allen Mariano, *Singapore Facility to Desalinate Seawater with Minimum Energy Use*, ASIA-PAC. BUS. & TECH. REP. (Oct. 11, 2011), http://www.biztechreport.com/story/1624-singapore-facility-desalinate-seawater-minimum-energy-use.

[114] PUBLIC UTILITIES BOARD OF SINGAPORE, *Water for All: Lowering Energy Consumption in Desalination*, http://www.pub.gov.sg/LongTermWaterPlans/pipeline_LowerEgy.html.

[115] *Id.*

[116] ASIA-PACIFIC ECONOMIC COOPERATION, *Singapore: Water Treatment & Wastewater Recycling Systems* (July 21, 2009), http://egs.apec.org/more-articles/157-singapore-water-treatment-a-wastewater-recycling-systems.

[117] *Id.*

is . . . $950 million," and "trade sources reported that their sales of water conservation and recycling systems improved by as much as 50%."[118]

## IV. IS SINGAPORE'S SOLUTION EXPORTABLE TO GEORGIA?

By relying on technological solutions, Singapore has launched itself onto a track of water independence—from both Malaysia and annual rainfall amounts. Its efforts have released some tension with its neighbor Malaysia, while at the same time springing the nation into the forefront of renewable water research, technology, and development. But Singapore is a very small island nation. Can the state of Georgia, on its own, implement similar programs to achieve water independence? This Section will address the possibilities of exporting Singapore's model to Georgia.

Singapore's gross domestic product (GDP) per capita is $60,800,[119] and the United States' per capita GDP is $49,800.[120] Singapore has moved rapidly from a developing country to a wealthy nation with "a per capita GDP higher than that of most developed countries."[121] Clearly, Singapore's wealth is strikingly higher than other nations: in fact, Singapore's GDP is ranked seventh out of 229 nations.[122] Because of the sheer amount of money available in Singapore, building the infrastructure necessary for rain catchment, desalinization plants, and used water treatment is easier to accomplish than in nations where capital is not as readily available.

But Singapore did not construct everything with its own money. Rather, it partnered with foreign businesses for technology research and the building of desalinization plants.[123] Singapore's economy, however, had a strong foundation in the technology sector even before Singapore partnered with foreign business investors.[124] Because Singapore was known as a leader in the technology industry and had previously established contacts, it was likely easier for Singapore to attract these foreign investors. Singapore's efforts to build desalinization plants with a minimal carbon footprint also mark it as a leader in the link between clean energy and renewable resources. Besides

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[118] *Id.*
[119] WORLD FACTBOOK, *supra* note 50.
[120] CIA, THE WORLD FACTBOOK, *United States*, https://www.cia.gov/library/publications/the-world-factbook/geos/us.html (last visited Oct. 19, 2013).
[121] WORLD FACTBOOK, *supra* note 50.
[122] CIA, THE WORLD FACTBOOK, *Country Comparison: GDP – Per Capita (PPP)*, https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html (last visited Feb. 5, 2014).
[123] *See supra* notes 110–18 and accompanying text.
[124] WORLD FACTBOOK, *supra* note 50.

already having a foot in the door with these types of businesses because of its economy, the fact that Singaporeans had technological education and experience meant that the Singaporeans could be partners in research and development, which removed the need to import a workforce to build infrastructure and make Singapore even more attractive to foreign investment.

Developing technological solutions to the water crisis may be the most exportable solution to Georgia. Besides facing a water shortage, Georgia also has been hit hard by the 2008 financial crisis and resulting recession—but several factors weigh in favor of technological solutions in Georgia. First, Georgia, like Singapore, is located on the coast. This simple fact makes desalinization plans more feasible. Again, like Singapore, Georgia has connections to the technology sector by virtue of its location in the United States. Additionally, the presence of the Georgia Institute of Technology in Atlanta means that the state, or the capital at least, has access to premier engineers, researchers, and technicians. The city is also home to several innovative technology businesses.[125] While Georgia may not necessarily need to attract foreign investors, the state could bring in national businesses to both build and operate desalinization plants. Although all potential employees would not necessarily be Georgia citizens, the great likelihood is that the construction as well as the operation of the plant would require much labor and would increase the number of jobs in Georgia. Alternatively, the state itself, rather than businesses, could build such a plant. But given the current political and economic climate, a public-private partnership may be more feasible than the state funding the project single-handedly. Besides state funds, Georgia could apply for federal funds for this kind of project, but there is no guarantee that the state would receive them.

Even though Georgia may attract different kinds of business investors than did Singapore, this may not preclude businesses new to Georgia from financing developments. The state could even build a desalinization plant with low carbon emissions, as Singapore did. Georgia can benefit from Singapore's experience in a concrete way: once the technology has been invented, it is cheaper for businesses to export it. Because the research in Singapore has already produced the technology necessary to build a low carbon footprint desalinization plant, Georgia can simply import that

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[125] Jacques Couret, *TAG Names Top 40 Innovative Technology Companies*, ATLANTA BUS. CHRON. (Mar. 12, 2013), http://www.bizjournals.com/atlanta/news/2013/03/12/tag-names-top-40-innovative-technology.html.

knowledge at a lower cost.[126] But even using readily available technology, the construction of a desalinization plant would still be expensive. And given the increasing understanding of the effect of carbon output on climate change, a desalinization plant would more likely be built if it had the low-carbon design.

Potentially, a business could invest in the construction of a water reclamation project to stabilize water needs in Georgia. Existing pipelines could be adapted for recycling and water treatment programs, depending on the technology and current need. Again, learning from Singapore's experience, this solution would increase the availability of recycled water for commercial or non-potable uses, thereby freeing up potable water for drinking. As demand for water decreases—combined with increased production and conservation efforts—Georgia could eventually enjoy a surplus of water, which would then be available for trade. Given the current demands for water in the agricultural, residential, and business sectors, excess may take a long while to achieve, but it could eventually allow the investor and the state to profit from long-term water solutions.

As Singapore had difficulties with Malaysia that spurred these changes, so Georgia can use its water disputes as an impetus to capture, conserve, and recycle water. But because Georgia is not an island like Singapore, it will have to worry about potential ecological changes of programs like building reservoirs. Such projects may alter ecosystems—but the impact is unknown. Water programs may have only slight or primarily local impacts, but broader changes could potentially affect neighboring states. Florida and Alabama could actually appreciate Georgia investing in something like a desalinization plant or rain-catching reservoir, because most of Georgia's current tensions with its neighbor-states are premised on the consumption of river water.

But the realities of Georgia's political and geographical situation may cut against the direct application of Singapore's solutions. Singapore's small size may have contributed to its success in conceiving, planning, and implementing these projects. First of all, unlike Georgia, Singapore did not have to worry about coordinating with lower branches of local government to build the necessary infrastructure. Where small local governments can address water scarcity, water independence may be more likely and more

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[126] In exporting this low-carbon desalinization plant technology, international intellectual property issues are implicated. Depending on how the technology transfer was structured in light of international agreements, the technology could potentially be transferred in ways other than at commercial terms. This matter, however, is outside the scope of this Recent Development.

quickly achieved. Especially if trans-boundary issues are not implicated on a smaller scale, solutions can be pushed through local governance more quickly than at a higher level. As a small island, Singapore also did not have to worry about any latent environmental impacts its projects would have on its neighbors. While building reservoirs to catch rain altered Singapore's own topography, for example, its streams still go to the seas around the island, not to neighboring lands. Thus any modification of the streams could not affect anyone else—but these features are unique to Singapore.

On the other hand, larger government units are more capable of building economies of scale in terms of infrastructure. Georgia, like Singapore, can implement an overarching policy for the entire state. While Singapore had some existing pipe systems for its water recycling program, Georgia does not have infrastructure in place that would ease such a transition. But Georgia's geography—its natural infrastructure—may lend itself to the possibility of constructed wetlands, which could both catch rainwater and recycle the water.[127]

Singapore's social composition may have also contributed to its success. Singapore has initiated many efforts to achieve social harmony amongst its various ethnic and religious citizens.[128] As compared to developing nations with similar water scarcity issues, Singapore has much less religious and ethnic tension. Georgia, similarly, enjoys a relatively politically homogenous population, especially as compared to other states within the United States. Because Georgia is mostly politically conservative, if these types of projects were billed as creating jobs and independence, conservatives would likely support it. Additionally, more liberal minded citizens would be predisposed to support measures that would help the water scarcity problem with the caveat that programs like a desalinization plant be built with an eye towards low carbon emissions and other low-impact designs.

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[127] George M. Huddleston, III & John H. Rogers, Jr., *A Design Approach for Constructed Wetlands for Storm Water and Point-Source Wastewater Treatment*, *available at* http://www.rivercenter.uga.edu/education/practicum/documents/design_approach_huddleston_and_rodgers.pdf.

[128] Leonard Tan & Darryl Tang, *The Importance of Social Cohesion and Racial and Religious Harmony*, SINGAPORE UNITED (Mar. 21, 2011), http://www.singaporeunited.sg/cep/index.php/Our-News/The-Importance-of-Social-Cohesion-and-Racial-and-Religious-Harmony (Mar. 21, 2011); *see also Who Is Involved?*, SINGAPORE UNITED, http://www.singaporeunited.sg/cep/index.php/web/About-CEP/Who-is-involved (last visited Mar. 26, 2013) (outlining the community's efforts in conjunction with the government to promote social harmony in order to prevent terrorism or other crises from taking hold).

Singapore also receives 2,340 mm of rainfall per year.[129] Building reservoirs and other systems to capture all of that water therefore makes a lot of sense. Georgia also receives enough rainfall each year that a similar investment could capture a significant amount.[130] For example, Atlanta receives an average of forty-five inches or 1,143 mm, of rain a year.[131] While that is less than the amount of rainfall Singapore receives, that amount of rainfall is just in the city of Atlanta.[132] Depending on the expense, it may not make economic sense for Georgia to build rain catchment facilities. While it would be beneficial to capture the rainfall the state does receive, it may be politically easier to motivate support for a desalinization plant, since seawater is more dependable. But building reservoirs to capture rainfall would be much less expensive, than a desalinization plant and reservoirs can double as recreational areas. Because Georgia covers a large geographical area, rainfall reservoirs would need to be determined on a local level, probably city by city. Expense varies with size, and cities or counties may be able to start small and expand over time, depending on the consistency of their rainfall. But even small steps can be beneficial. Overall, drought from "water scarcity in some arid and semi-arid places will displace between 24 million and 700 million people."[133] In light of those statistics, capturing available rainwater would be beneficial.

Reservoirs could be useful to seize rainfall from storms for later use and to manage flooding. As flooding becomes more frequent and more intense due to climate change,[134] Georgia may wish to somehow appropriate at least some of that water for later use, or to treat it and use it as recycled water. Singapore's water treatment facilities can provide a useful study in association with this problem, but they will not be an exact parallel. More Georgia-specific research will need to be done to understand how to capture water from a flood without the system becoming overwhelmed.

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[129] WORLD TRAVEL GUIDE, *Singapore Weather, Climate, and Geography*, http://www.worldtravelguide.net/singapore/weather-climate-geography (last visited Feb. 5, 2014).

[130] *Rain and Precipitation*, U.S. GEOLOGICAL SURVEY WATER SCIENCE SCHOOL, http://ga.water.usgs.gov/edu/earthrain.html (last visited Aug. 16, 2013).

[131] *Id.*

[132] These statistics focus on Atlanta since that is the site of the main water scarcity issue in the state. For more information on annual rainfall in other Georgia cities, see *Rainfall Scorecard*, NAT'L OCEANIC & ATMOSPHERIC ADMINISTRATION, http://www.srh.noaa.gov/ffc/?n=rainfall_scorecard (last visited Sept. 9, 2013).

[133] *International Decade for Action 'WATER FOR LIFE,' supra* note 1.

[134] U.N. Secretary-General, *As Floods, Earthquakes Increase in Frequency, Intensity, Secretary-General Urges Long-Term Engagement on Climate Change, Investment in Disaster Risk Reduction*, U.N. Doc. SG/SM/13203 (Oct. 26, 2010).

Applying Singapore's solutions in Georgia would relieve some of the water stress presently felt. Were Georgia to use some of these methods, it would eventually and perhaps even quickly harness more than enough water to meet its needs. It could then trade water to its water-poor neighbors, like Alabama or Tennessee. Of course, the concern would remain that those states would become increasingly dependent on the new water source. But hopefully Alabama and Florida would be able to meet their own needs and perhaps decide to invest in similar technology. Then, Georgia could benefit from exporting some of its technology and expertise as well.

## V. CONCLUSION

Ultimately, some of Singapore's programs are more exportable to Georgia than others. A desalinization plant would be useful since Georgia borders the Atlantic Ocean, but it would also be expensive. Rain catchment programs will be most effective in those cities with persistent rainfall. Otherwise, the investment would probably not be economically worthwhile.

Any project or construction of infrastructure will carry a large price tag. Recycling water programs would allow non-potable needs to be met more easily—for example, the extraordinary amount of water needed to operate Georgia's air conditioning units in the summer. But such programs would require an infrastructure of something like the pipe system in Singapore. While existing pipes could be adapted for the purpose, the actual recycling facility would still need to be built. If funding could be procured, water treatment and recycling would allow Georgia to reuse its own water and not have to find as much *new* water. Water from treatment facilities that cannot make the water potable can be used in various other ways, so the available potable water may be dedicated solely to consumption. Thus, it would still be a reliable source.

Although Singapore's extensive technological NEWater facilities may be too expensive for many water-poor nations or states like Georgia to start in the near future, other options include an above ground (or less deep) model of Singapore's system or constructed wetlands, depending on the area's climate. A desalinization plant could also work in Georgia and develop jobs in the coastal region. Depending on the project, funding could come from the state itself, counties or cities (for something like a reservoir), business investors, or the federal government.

Before implementing any of these models, Georgia should look closely at its own economy and geography as well as political and social situation to determine which of Singapore's solutions could work in Georgia. If the state

implemented even just one or two of these strategies, Georgia could potentially meet its own demand and even become an exporter of water. Hopefully, this would create a regime that would ultimately decrease the water scarcity issue throughout the Southeast and allow water to reach other water-poor states.

Although long-term ecological consequences are unclear, constructed wetlands or other recycling programs, reservoirs, or desalinization plants would help to alleviate the water scarcity issue in Georgia and its impact in the surrounding areas. Singapore's innovativeness and commitment to achieve water independence should be a model in Georgia's efforts to combat water scarcity.