Rethinking resilience in urbanizing river basins

BEJOY K. THOMAS, SHARACHCHANDRA LELE,
VEENA SRINIVASAN and PRIYANKA JAMWAL

URBAN resilience is no longer just an idea or a catchphrase. As the concept and practice have evolved, urban resilience now refers not just to the ability of cities to return to equilibrium after hazard-induced calamities, but also to adapt to and transform in the wake of multiple stressors that cities face, including climate change. Several intervention efforts now focus explicitly on building urban resilience. 100 Resilient Cities, a network of one hundred cities around the world established and supported by the Rockefeller Foundation, is one such initiative of which Bengaluru is a part, along with four other cities in India.

In outlining the Resilience Challenges for Bengaluru, the initiative states, 'Even with regular monsoonal rains, Bangalore struggles with water shortages. Officials have warned that a worsening of the water supply situation could lead to evacuations or even abandonment of parts of the city. Bangalore has already launched both regular desilting projects and public awareness campaigns, but the city needs to develop a comprehensive water supply and recovery strategy.'[1]

However, such a strategy is not merely a matter of urban planning, nor is it a matter of resilience thinking alone. In this article, we draw upon insights from research carried out in the Arkavathy sub-basin during 2012-16[2] to illustrate the interconnectedness of Bengaluru's water architecture, and the multiple actors and interests in it. We argue that resilience is just one of the concerns in approaching Bengaluru's water question, which also includes other normative concerns such as sustainability, equity, and justice. In addition, the 'comprehensiveness' mentioned in the Resilience Challenges also implies attention to multiple stressors: urbanization, industrialization, increasing water conflicts as well as climate change.

Roughly one-third of Bengaluru city falls in the Arkavathy sub-basin,[3] which is part of the Cauvery river basin (Figure 1). The Arkavathy sub-basin has a catchment area of 4169 sq km. Till the 1970s Bengaluru city received all its water from two reservoirs on the Arkavathy river, one at Hesaraghatta and another at Thippa-

* The research reported here was carried out with financial support from Sir Dorabji Tata Trust and the Allied Trusts, India and International Development Research Centre (IDRC), Canada.

1. http://www.100resilientcities.org/cities/entry/bengaluru#/-_/ (accessed on 7 February 2017).

2. http://www.atree.org/research/ced/lwl/ACCUWa (accessed on 7 February 2017).

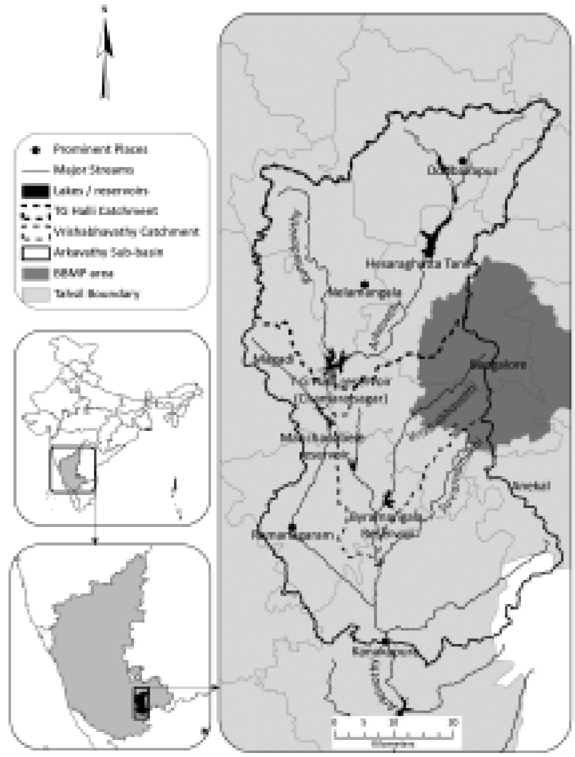
3. S. Lele, V. Srinivasan, P. Jamwal, B.K. Thomas, M. Eswar and T. Md. Zuhail, 'Water Management in Arkavathy basin: A situation Analysis', Environment and Development Discussion Paper No. 1, ATREE, Bengaluru, 2013. http://www.atree.org/sites/default/files/arkavathy2015_web_0.pdf

gondanahalli, or TG Halli. The TG Halli catchment has an area of 1447 sq km and comprises of a series of small water storage tanks built as a cascading system with overflows from the upstream tanks feeding the ones downstream, including Hesaraghatta. At present, the Hesaraghatta reservoir has become completely dry, water supply from TG Halli to Bengaluru is minimal or nil, and the irrigation water tanks in the TG Halli catchment are fully dry or only fill to part of their capacity.

Starting in 1974, Bengaluru began to receive water by pumping it from the Cauvery river, situated at around 90 kilometres from the city, to meet the growing demand from its increasing population. The Cauvery Water Supply Scheme was developed and expanded in stages; as of 2016 the total supply from the Cauvery had reached 1350 million litres per day (MLD).[4] The use of this water, along with locally pumped groundwater, generates an estimated 1400 MLD of wastewater return flow, part of which exits Bengaluru through the Vrishabhavathy river and eventually returns to the Cauvery. The Vrishabhavathy originates inside the city and carries not just the city's domestic waste, but also the industrial waste from Peenya and Bidadi industrial areas. A reservoir at Byramangala on the Vrishabhavathy, built as an irrigation structure, temporarily stores the wastewater, which is used by farmers downstream for irrigation through a canal system.

Thus, the changing links between Bengaluru city and its hinterland can be summarized as the decline in supplies from the Arkavathy, the increasing imports from the Cauvery, and the increased effluents being released via the Vrishabhavathy in the southwest (and other streams to the southeast) into farming areas. While devising a strategy for water in Bengaluru and building the city's resilience, it would be important that we look at these dependencies: What caused the drying of the Arkavathy river, what limits to imports from the Cauvery might exist, and how do current wastewater discharges affect downstream villages?

Various reasons have been attributed for the drying of the Arkavathy, including climate change. However, we undertook detailed climate and hydrological analysis as well as household surveys with farmers in the region, and our analysis of area-averaged monthly and annual rainfall in the region during 1934-2010 did not show any statistically significant trend. Further, rainfall intensities also did not show any significant change. While we found a statistically significant rise in temperature of around 0.6 to 1 degree celsius during the period 1901 to 2001, the estimated annual potential evapotranspiration did not show a statistically significant trend. This means that an increase in temperature could not have resulted in a decline in flows in the river.[5] Thus, historical climatic changes in temperature and rainfall alone cannot explain the disappearance of Bengaluru's original water supply source. This led us to look more closely into the impact of the city's expansion on the peri-urban areas and the villages in the TG Halli catchment.



Arkavathy sub-basin and Bengaluru. Map prepared by Ecoinformatics Lab, ATREE.

Our household survey and consultations with villagers showed that coinciding with the expansion of Bengaluru and the establishment of industrial areas in the periphery, agriculture has been experiencing a paucity of labour with the younger generation moving away from agriculture to take up industrial and service sector jobs in Bengaluru and small towns such as Doddaballapura. Labour scarcity in villages prompted many farmers to shift towards plantation crops, prominently eucalyptus. In 1973, the area under eucalyptus in the TG Halli catchment was 11 sq km, which increased dramatically to 104 sq km in 2001 and to 280 sq km in 2013. The government's social forestry programme also provided an impetus for adoption of eucalyptus in the area, but the massive uptake of the crop by the farmers has to do more with the difficulty in getting labour and the opening up of urban possibilities than anything else. The deep

4. https://bwssb.gov.in/content/about-bwssb-2 (accessed on 7 February 2017).

5. For details, see V. Srinivasan, S. Thompson, K. Madhyastha, G. Penny, K. Jeremiah and S. Lele, 'Why is the Arkavathy River Drying? A Multiple-Hypothesis Approach in a Data-Scarce Region', *Hydrology and Earth System Sciences* 19(4), 2015, pp. 1905-17. http://www.hydrol-earth-syst-sci.net/19/1905/2015/hess-19-1905-2015.pdf

roots of eucalyptus access water under the ground as it moves through the soil column. Replacing rainfed millets with eucalyptus has created and aggravated water stress.

Another key factor was the advent and spread of borewell technology in the 1980s that resulted in massive changes in the agrarian landscape leading to exploitation of groundwater.[6] While irrigation was earlier available just to farmers in the areas served by irrigation tanks, borewells meant that farmers in other areas could also have access to water. The government promoted and subsidized groundwater irrigation by reducing electricity rates and implementing schemes for uptake of borewell irrigation by lower caste farmers. While this led to a general increase in farmer welfare by enhancing productivity and incomes, indiscriminate drilling and unregulated pumping eventually resulted in a rapid decline in groundwater tables across the TG Halli catchment.

Our household survey revealed that while irrigated area as a proportion of net cultivated area did not change much during the 1993-2013 period, irrigation was maintained at the same level through increased use of groundwater, with no open well or canal water available in 2013. While in 1993 canal/river water irrigated 46% of the irrigated area in 11 randomly sampled villages, irrigation was completely borewell dependent by 2013. During the period, the average depth of borewells increased alarmingly from 195 ft to 938 ft and an increasing number of borewells failed to yield water. In the wake of severe water stress, farmers in the region have now begun to adopt more water efficient irrigation technologies such as drip and sprinkler, but that has done little to mitigate the ongoing groundwater decline.

The impact of eucalyptus plantations and borewell irrigation on the surface hydrology of the TG Halli catchment has been massive. There has been a steady decline in base flow since the 1980s and since 1992 there has not been a single month when there was base flow into the TG Halli reservoir.

While the Arkavathy sub-basin as a whole witnessed a shift away from agriculture, villages along the Vrishabhavathy river stood out as an exception to the rule. As Bengaluru expanded, and started drawing more water from the Cauvery, the river saw increasing flows, fed by urban domestic and industrial wastewater.[7] Our analysis of census data during the 1991-2011 period showed that people in villages along the Vrishabhavathy river and the Byramangala tank command continued to do agriculture, despite a general shift to non-agricultural activity across the sub-basin. Detailed farmer surveys in three villages in 2013 showed that 86% of cultivated area is irrigated, and of the irrigated area, 66% is irrigated with water from Vrishabhavathy river.

With the expansion of Bengaluru and the establishment of industrial areas upstream, water quality deteriorated in the river impacting both surface as well as groundwater. While this made cultivation of traditional crops such as ragi (finger millet) difficult, farmers adapted by experimenting with crops that could withstand and gain from the nutrient rich wastewater. Baby corn, a high value commercial crop, proved successful and brought in steady returns to the farmers. In 2013, baby corn occupied as much as 20% of the total cultivated area among farmers in the three villages. Fodder for cattle, the area under which was negligible in 1990, is being grown in substantial amounts at present, constituting 9% of the total cultivated area. In comparison, the area under ragi dropped from 55% to 16% during the 1990-2013 period.

While irrigation using treated wastewater has become an acceptable agricultural practice in these areas, inadequate treatment of domestic sewage and illegal discharge of industrial waste has led to increasing contamination of water in Byramangala reservoir and command area. Our assessment of the Vrishabhavathy Valley sewage treatment plant (STP) in Bengaluru showed that the plant does not operate to full capacity as there is a lack of an underground drainage network to take water to the STP. There was no positive impact of treated effluent discharge from the STP on river water quality.[8] Furthermore, water quality tests on another stream that flows through the Peenya industrial area showed consistently high levels of heavy metals and other chemical contaminants. Consequently, surface irrigation water, groundwater (used for drinking) and fodder, milk and

---

6. B.K. Thomas, M. Eswar, S.D. Kenchaigol, V. Srinivasan and S. Lele, 'Enhancing Resilience or Furthering Vulnerability? Responses to Water Stress in an Urbanising Basin in Southern India', presented at the ICARUS Fourth Global Meeting, University of Illinois at Urbana-Champaign, May 2015.http://www.icarus.info/wp-content/uploads/2015/05/Thomas-et-al.-Enhancing-resilience-or-furthering-vulnerability.pdf

7. P. Jamwal, B.K. Thomas, S. Lele and V. Srinivasan, 'Addressing Water Stress Through Wastewater Reuse: Complexities and Challenges in Bangalore, India', Proceedings of the Resilient Cities 2014 Congress, ICLEI, Bonn, 2014. http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Resilient_Cities_2014/RC2014_Congress_Proceedings/RC2014_congress_proceedings_Jamwal.pdf

8. P. Jamwal, T. Md. Zuhail, P.R. Urs, V. Srinivasan and S. Lele, 'Contribution of Sewage Treatment to Pollution Abatement of Urban Streams', *Current Science* 108(4), 2015, pp. 677-85. http://www.currentscience.ac.in/Volumes/108/04/0677.pdf

baby corn samples taken in the downstream villages were contaminated: 98% of irrigation water samples, 68% of drinking water samples, 77% of vegetable samples and 85% of milk samples exceeded heavy metal limits prescribed by existing standards.

Thus, a river which might otherwise have been seasonal has become perennial and nutrient rich with wastewater, providing 'free' irrigation water to farmers in villages downstream of Bengaluru. Farmers in the region, on their part, had to change the crops that they cultivated and adapt to changes in river water quality. While they have benefited economically by growing lucrative crops aimed at the urban market, irrigation using wastewater laden with toxic heavy metals poses long-term risks to their health and well-being. The story comes a full circle when vegetables grown using urban wastewater comes back to the city dwellers in the form of food, putting their health at risk as well.

With Bengaluru's growth showing no indication of slowing down and the available water sources being tapped to the limit, the city's water woes are only going to increase, and not because of climate change. In exploring ways forward, the multiple drivers and competing demands for water need to be taken into consideration. For instance, a strong case is being made for wastewater reuse, to limit the dependence on the Cauvery as well as to protect the groundwater buffer. However, this is not easy. There are competing interests around wastewater reuse, with urban residents on the one side and downstream farmers on the other.

Farmers in the Byramangala command have been using Bengaluru's wastewater for irrigation as we noted above. In the wake of changes in water quality, many have switched to baby corn, fodder and vegetables and have found this to be profitable. While it is nobody's case that wastewater should not be treated fully, especially to remove industrial contaminants, a policy towards large-scale reuse within the city will significantly reduce water available for agriculture. This raises questions on what to privilege – urban consumption or agrarian livelihoods?

The efforts at Arkavathy rejuvenation, a long-standing demand by many civil society groups in the region, and the idea of wastewater reuse, have evoked strong responses from Tamil Nadu, which shares the Cauvery river with Karnataka, giving the water question in the sub-basin and Bengaluru a trans-boundary dimension. In August 2013, the chief minister of Tamil Nadu wrote to the prime minister to intervene and advise the Government of Karnataka to not proceed with Arkavathy river rejuvenation and Hemavathy canal remodelling, arguing that Karnataka's measures will reduce the flow of the river and impact irrigation in Tamil Nadu.[9] Again in 2015, the Government of Tamil Nadu raised concerns that Karnataka is polluting the Cauvery by releasing untreated sewage and industrial waste into the tributaries of Cauvery, pointing fingers at Bengaluru city and Vrishabhavathy river.[10]

Thus, attempts at enhancing supply of water to Bengaluru and thereby building a resilient city have created problems elsewhere. What we have not discussed here, but adding to the complexities, are the inequities that exist within Bengaluru city in access to piped water, and the sustainability of groundwater in the context of unabated drilling of borewells.[11]

In conclusion, thinking about urban resilience and developing a 'water supply and recovery strategy' for Bengaluru as the 100 Resilient Cities initiative envisages is not an easy task. There are several challenges in the Arkavathy sub-basin. Groundwater decline and the drying of Bengaluru's traditional water sources raise questions of sustainability. Shortage of water in urban Bengaluru and water pollution in the lower Arkavathy (Vrishabhavathy) raise questions of rights and environmental justice, for both the people and the aquatic life dependent on the river.

The case of Bengaluru points to a high level of interconnectedness, both spatial and temporal, in the 'system', where the resilience of the city is highly dependent on the resources that it draws from elsewhere. There are diverse actors and overlapping interests, not merely within the city, and not everyone is affected equally, leading to questions of where is the equilibrium, whose adaptation, and how? A way forward would be to view such complex settings through an integrative lens, rather than focusing on the city and urban space in isolation, and look for alternatives that provide multiple and sustained benefits across scales. Such an approach will help anchor resilience thinking and practice in normative concerns such as equity, sustainability and justice and better explain and deal with ground realities.

---

9. http://www.tndipr.gov.in/DIPRImages/News_Attach/3896PDIPR-P.R.NO.471-HON_BLECMDOLETTERtoHON_BLEPMonArkavathyRiverPressRELEASE-DATE-04.09.2013.pdf (accessed on 7 February 2017).

10. http://www.thehindu.com/news/national/tamil-nadu/tn-moves-sc-against-karnataka-for-polluting-cauvery/article7286627.ece (accessed on 7 February 2017).

11. V.K. Mehta, R. Goswami, E. Kemp-Benedict, S. Muddu and D. Malghan, 'Metabolic Urbanism and Environmental Justice: The Water Conundrum in Bangalore, India', *Environmental Justice* 7(5), 2014, pp. 130-37.