

APN-TERI Workshop on Systems Thinking and Adaptive Governance: The Context of Urban Flooding and Water Stress in Bangalore **24-25 April 2014**

TERI SRC Bangalore

Overview

TERI organized a workshop on “Systems Thinking and Adaptive Governance: The Context of Urban Flooding and Water Stress in Bangalore” during 24-25 April 2014. This workshop was supported by the Asia Pacific Network for Global Change Research (APN) under its CAPABLE capacity building programme.

The aim of this workshop was to create a greater appreciation of the principles of systems thinking and adaptive governance among government and non-government practitioners, and to discuss how these principles can be operationalized in the context of Bangalore. The thematic focus was on the issues of urban flooding and water stress. In Bangalore, high intensity rainfall causes urban flooding due to inadequate drainage and unplanned development in lake beds and low-lying areas.

This two-day workshop had an interesting mix of expert presentations and group activities to introduce participants to systems thinking and adaptive governance in the Bangalore context. Participants used simple conceptual modeling techniques in groups to understand issues such as urban flooding, water stress, and ecological degradation from different perspectives, factor in the challenges posed by uncertainty due to climate change, and strategize accordingly.

Participants included representatives of the Bangalore Metropolitan Region Development Authority (BMRDA), Bangalore Water Supply and Sewerage Board (BWSSB), Central Ground Water Board (CGWB), Environmental Management and Policy Research Institute (EMPRI), Lake Development Authority (LDA), Administrative Training Institute (ATI) and State Institute for Urban Development (SIUD), Mysore, in addition to research and academic institutions like Ashoka Trust for Research in Ecology and the Environment (ATREE), Indian Institute of Science (IISc), Indian Institute for Human Settlements (IIHS), and AzimPremji University; and civil society organizations like Environment Support Group (ESG).

In his welcome remarks Mr P R Dasgupta, Director, TERI Southern Regional Centre gave an insight into existing issues of water scarcity, lake encroachment, ground water depletion, and urban flooding in Bangalore and climate change related environmental issues in the state as a whole. Talking about the relevance of this workshop he believe that the results of this workshop will certainly lead to a certain amount of coordinated thinking at the state level and at the city level. He also expressed concern for existing lot of uncoordinated spasmodic reactions to a certain symptoms in the governance. In his final remark he thanked APN for supporting these series of workshop and hoped this workshop will be able to address the issues and come out with concrete solutions of water scarcity and flood problem in a collective manner.

Mr Navarun Varma Research Associate, Earth Science and Climate Change Division, TERI

He presented the objective of this workshop along with the approach and methodology for participatory modelling exercise on system thinking and adaptive governance.

Ms Ritu Kakkar Director-General, Environmental Management and Policy Research Institute (EMPRI)

Ms RituKakkar's talk focussed on the challenges and responses for Bangalore city in terms of water management. According to the projects EMPRI has done on water management issues in Bangalore, the key challenges what the city is facing right now are critical like any other fast growing city in India. Water management is a biggest challenge in the city at all level and rapid population growth, unplanned city development, damages to natural resources, increase in waste; climate change related issues and pollution further worsening the situation.

As for as the water sector is concern there are many challenges in supply of safe drinking water. The water availability and water quality are big issue as the available water is not sufficient to full fill the demand side. Surface and ground water pollution, encroachment of the lakes, mixing of sewage into drinking water supply and water losses from supply distribution system (around 45% as the water brought to the city from great distance from Cauvery River) are main reasons for poor water quality and quantity.

Talking about the Flooding problem in Bangalore she discussed the causes and associate risk of flooding in urban environment. Flooding in Bangalore is a result of cumulative impact of Urban Development. With growing population, city needs to expand itself to accommodate and cope up the pressure. For the development of the city it needs resources in terms of construction materials, Land, food etc this aggravates impervious surface, over cultivation, soil erosion, deforestation as the large areas of forests near the rivers/catchment of cities are being cleared to make room for settlements, roads and farmlands due to which soil is quickly lost to drains and reducing the carrying capacity of the drains causing over flowing. The areas which were essentially created by the storm water drains to let their flood waters pass freely being trespassed for developmental purposes resulting in obstruction of water flow and thus contribute immensely to the fury of floods. Areas near and around the city and the lakes in Bangalore which used to serve as the storage of rainwater are being taken by the development authorities and private players for the construction purposes in unplanned manner. Due to these unplanned developments natural drains are filled up and the lakes are no more interconnected to facilitate storm water flow. Giving the example of 2005 and 2013 flood incidents in Bangalore she explained the severity of the incident and related damages to infrastructure and commerce. The main reason identified was the choking of storm water drains and excess rainfall.

Talking about the EMPRI's work for the development of Karnataka State Action Plan for Climate Change, they have mentioned the problem associated with water resources management for the Bangalore. The city is facing the sever problem of water scarcity. Supply and demand side gap is 135 mld and expected to grow more if the adaptive measure are not implemented in priority basis. Karnataka experienced a decline in net annual ground water availability by 3.2% between 2004 and 2009. Notably Bangalore, Kolar, Tumkur and Chitradurga draw much more water than is naturally recharged. For the management of ground water ground water EMPRI has recommended monitoring and mapping of ground water for quality and quantity as well as Establishment of a state level policy body to review the possibility of prohibiting the use of groundwater for non-drinking and non-emergency uses. The city has a great potential of Rainwater harvesting which can be used for irrigation, drinking water supply and ground water recharge, extension of BWSSB rule on rainwater harvesting to other urban local bodies will help in managing ground water. There is need of awareness for the acceptance to use the treated water in industrial and urban local bodies. In agriculture sector as it is the largest consumer of water and demands 84% of utilisable water of the state, low priced irrigation water is a substantial barrier for investment in water infrastructure and sustainable resource utilisation and management. To overcome this problem Water resource

department has to lead a cost benefit analysis in order to assess the financial burden of irrigation water and to formulate a pricing policy rationalising irrigation in view of long-term sustainability and the need for adequate finance. EMPRI's research on Bangalore's lakes applies a holistic approach to lake conservation along with drainage and protection of surface water quality, under which **lake health report cards** have been prepared. EMPRI also conducts rainwater harvesting training programmes, bio medical waste management programmes, and solid waste management programmes. **Water safety plan for Bangalore** is a modern approach to improve the quality of drinking water, prevent water loss, and upgrade the existing system.

Dr VeenaSrinivasanFellow, Centre for Environment and Development, Ashoka Trust for Research on Ecology and the Environment (ATREE)

Dr VeenaSrinivasanpresented a quantitative system dynamics analysis of water availability for Bangalore city. She pointed out the inequities in water supply within the city, which are not usually captured in systems models that focus on aggregates. Her presentation attempted to address questions such as how future levels of water consumption can be sustained and how resilient the city is to multi-year droughts. The study investigates the reasons for 80% reduction in flows to the TG Halli reservoir since the 1980s. There are different hypotheses for this little understood phenomenon. Dr Srinivasan explained it in terms of blockages as the city urbanized, which she termed the "million puddles theory". The presentation also pointed out downstream issues in wastewater treatment related to inequity, lack of **compliance**, and lack of **capacity to treat river water with industrial effluent**.

Citing the study ATREE has done on Bangalore's water situation; the key concerns raised in the study was the sufficient water availability to meet the demand as the supply demand gap is huge, Equitable distribution of water which is not there; big variations in supply from 25 to 330 LPCDraising the concern of system approach and management of water resources. Groundwater extraction is correspondingly higher in wards with fewer water supplies even at current extraction rates; GW Levels have been declining in peri-urban areas but are rising/stable in central Bangalore. With the rising demand of water and with limited and almost constant supply of water from surface water sources from Cauvery river and Arkavathi (TG Halli) basin Ground water supply is rising leading to depletion of ground water and declining of GW table; raising the issue of sustainable supply of water in future. The fourth concern and question arises about the city's resilience towards multiyear droughts. Bangalore is largely dependent on Cauvery water supply and in case of multiyear drought a major source of vulnerability came up in the form of inter-state conflict between Karnataka and Tamil Nadu and in recent years with the Mandya farmers as they believe their water is diverted to Bangalore. These are the main question arises when we talk about the modelling of water supply problem in Bangalore.

For the solution point of view she discussed the BWSSB plan of Cauvery Stage IV Phase 2 and Netravati (Yettinahole) project which is in pipeline. But there are the possibility of applying lots of soft options for the management of water supply in Bangalore which includes proper wastewater management, rejuvenating the existing water bodies, rainwater harvesting and ground water recharge and efficiency improvement of existing water supply system.

Talking about the learning and thinking from system perspectives on Bangalore's water situation; issues and solutions, her main concern was focussed on two issues. One is the rejuvenating the Arkavathy and second is wastewater recycling. Giving the example of the study conducted on Arkavathy Catchment which partly covers Bangalore city though but the issues are similar irrespective of geographical coverage. She divided the catchment into upstream and downstream and discussed the issues separately for each part.

The upstream catchment is 1400 km² TG halli reservoir which receive annual rainfall of 800 mm and used to be the major source for water in Bangalore with design capacity of 148 mld but now it is only supplying 30 mld of water to the city. So there is almost 80 % decrease in incoming water in the reservoir. There is a sharp decline of Inflows into the TG Halli reservoir, which supplies Bengaluru, although there are no new upstream dams constructed. So to investigate the decrease of flow over time there is need to understand the soci- hydrologic linkage. They have taken into consideration these five hypotheses which could be the reason for this decline

1. Decreasing Rainfall
2. Increasing temperature
3. Loss of deep aquifer due to Ground water pumping
4. Increase ET due to Land Use change and
5. Million puddles due to urbanization

But these hypothesis are partly explains the reasons for decline in flow as per there analysis but not convincingly.

Downstream catchments are facing problem of waste water. The downstream catchment Vrishabhavathy receives all the sewage and wastewater from Bangalore which contain more than 64 % untreated water, causing the threat of serious health impacts. Wastewater is used for irrigation in peri urban areas because it is nutrient rich and has economic benefits. It is also a promoted solution towards sustainability. But increased toxicity level in wastewater may have impacts on waste water reuse. More over waste water recycling and treatment facility is inefficient and insufficient. Most water is treated directly from River not in Sewerage system. Only 20% of river water is being treated and that not to effectively. As per the Gov. Notification large apartment and housing complexes have to have their own decentralized wastewater treatment system but many break down in few months due to lack of enforcement and lack of incentives and capacity from the Gov.

Prof. Vishal Narain Associate Professor, Public Policy and Governance, Management Development Institute (MDI), Gurgaon

Prof. Vishal Narain investigated how a periurban conceptual lens can be applied to environmental issues to help to take a system approach in understanding urbanization and its consequences. He defined the peri-urban concept as where the rural and urban co-exist and where the ecological footprint of the city falls. Land loss and land acquisition processes accompany urban expansion, but the impacts on water access and security are not well known. Increase in waste water due to urbanization affects both food producers and consumers. Yet there is a fragmentation or dichotomy between urban planning and rural development. Current institutions do not allow planning for both together e.g. urban water supply may be expanded at the cost of rural water supply. Peri-urban locations have to face both urban and rural stressors. While the peri-urban elite are able to gain from both new urban and existing rural opportunities, peri-urban tenants and sharecroppers are hurt the most. Hence there is a need to create dialogues or forums for agencies and actors along the urban-periurban-rural spectrum to interact and work together. (One of the comments following this presentation highlighted the roles played by sub-urban aspirations and the real estate mafia.)

Dr Kala Sridhar Head, Public Policy Research Group, Public Affairs Centre (PAC)

Dr Kala Sridhar, presented the challenges of Urban services and governance in Bangalore in context of Urban flooding and water stress. She presented the causes and consequences of urban flooding and the solutions and recommendations for the future. She compared demography of different cities in India in terms of Density which is relevant as it encroaches the flood plain of the cities which is one of primary cause of urban flooding. In this context Bangalore stands 6th with population density of 10600/km² compare to the other municipal cities in India and its much beyond the average density compare to the other cities in Karnataka. She also compared the services in Bangalore against benchmarks which showed its poor performance in the services related to drainage infrastructure, solid waste management and water quality. Comparing the Bangalore solid waste management practice with Surat it is evident that the Surat has improved its urban services after the plague but Bangalore is on the brink of a solid waste management crisis. There is a multiplicity of institutional arrangements which acts as a hindrance to effective urban governance. Pricing is a very important issue: since the city first uses the cheapest sources of water, and then as it grows, goes to more distant and costlier water sources, the marginal cost, not the average cost, should be used to price water in a growing city. (But one of the questions that arose in reaction to this recommendation was whether evidence from around the world shows an impact of pricing on behavioural change.)

Mr Prasoon Singh Research Associate, Earth Science and Climate Change Division, TERI

Mr Prasoon Singh presented the Decadal Trend of Land Use changes in Bangalore using remote sensing data. It was seen in Bangalore since 1973 to 2013 there was sharp increase in built-up area more than 100 percent, there was sharp decline in number of water bodies, vegetation cover and increase in fallow land.

Mr Saurabh Bhardwaj Associate Fellow, Earth Science and Climate Change Division, TERI

The topic of Mr. Saurabh Bhardwaj's presentation was "Climate change and associated uncertainty". He started his presentation by explaining the basics of climate, its difference with weather processes and emphasized on the complex interactions between each climate component. The components within the climate system interact non-linearly amongst each other that lead to climate variability at spatial as well as temporal scales. Any change or forcing in one the component induces change or responses in all the other components in a non-linear way which makes the scientific problem of assessing the change highly complex. He showed how these non-linear interactions are numerically quantified by using various models which are a set of mathematical equations explaining the various dynamical processes that govern the climate system. The framework of a climate model along with the flow chart of climate modelling process was explained wherein the importance of observations was established. Mr. Bhardwaj stated that observations not only help in model development and help in model simulation by providing boundary forcing and initial conditions, it also helps in validation process for any model.

He then pointed out on the uncertainty aspect in the climate science and modelling which arises due to lack of observations, type of observations and resolution of model utilized. Hence to overcome these uncertainties, it was mentioned that IPCC have brought out various scenarios and ensemble approach which the modelling community uses to present their results to the research community and stakeholders. The climate exposure and risk over the Karnataka state was also explained by him. Referring to the existing literature he mentioned that mean annual temperature, rainfall and

intensity are projected to increase over the state for the future time periods of 2020-2080. Long term historical district wise climatological trends and future projections for the state were also illustrated by him in his talk.

He ended his presentation by showing national coverage on climate change impacts on Bangalore and emphasized on the awareness which should be an important part of any climate change action plan.

Mr D Kiran Kumar *Research Associate, Sustainable Habitat Division, TERI*

Mr D KiranKumar, presented data on the urban heat island effect and increase in imperviousness factor in Bangalore.

Dr ArchanaPatankar *Senior Research Fellow, Regional Centre for Urban and Environmental Studies, All India Institute of Local Self Government*

Ms ArchanaPatankar, discussed the findings of an APN-funded research study on urban flooding in Mumbai, Manila and Bangkok and the resulting costs to households and city economies. In the context of flooding the profile of these cities are similar. These 3 cities are coastal consist of huge industrial, residential and commercial establishment along with large population lives in improper settlement. So the vulnerability in the context of flooding is similar. They have conducted a loss and damage methodology to assess the economic impact of flooding in these cities. She also emphasized to use the framework for the loss and damage assessment because unless we have an impact assessment done for flooding wecan't really inform a better adaptive interventions and nor we can identify who is vulnerable and at what extent they are vulnerable and how to address the vulnerability and adaptation at the same time.

Dr H S Sudhira *Gubbi Labs*

Dr H S Sudhira, used geospatial analysis and agent-based models to assessing headwater streams and flooding in the urban watershed of Bangalore. Highlighting the burial of **first and second order streams** and the construction of **covered drains**, he showed that urban flooding in Bangalore is a unintended consequence of several unintended consequences of urbanization and urban governance.

Prof. S Ravi Rajan *Asia Research Institute, National University of Singapore and University of California, Santa Cruz*

Prof Ravi Rajan, spoke about systems thinking and adaptive governance concepts in the context of issues discussed in the workshop. He pointed out the need for education and raising awareness among elected representatives at the municipal level. Multistakeholder dialogues are more difficult when stakeholders do not share a common literacy or language about concepts and are unable to discuss issues of mutual interest on a common footing. This shared language has to be created.

Group activities

1. Issues with systems thinking

The land use group found it difficult to add social and institutional aspects to the model. The physical linkages in the system were complex enough.

One of the participants asked whether the three models would be linked, to which the TERI expert replied that the systems thinking process followed in the workshop was more about how a negotiated solution could be achieved.

How do we prioritize within systems thinking? If there are competing priorities, which stakeholders should be given priority?

2. Problem context

A government participant said that despite government notifications, illegal land use is still happening (e.g. large apartment complexes are being built on major storm water drains or rajakluves). Policies are not enough to ensure compliance. There is political pressure. Agricultural or common land is declared as barren and hence eligible for conversion. Eucalyptus is planted to drain the lake bed and then convert it for real estate developments. As one government participant put it, poor people are encroaching illegally but bureaucrats are encroaching legally. Another participant also pointed out that even illegal constructions built over a storm water drain can be regularized by paying a fine under the akrama-sakrama rules.

A government participant also said that there is a limit to how much the government can spend on remedial measures, e.g. lake restoration (flattening, garbage removal, desilting and plantation) is expensive to do repeatedly. Awareness raising and enforcement are required.

The blockage of first and second order streams was added to the model as a key problem after Dr Sudhira's presentation.

3. Solutions

The **community should contribute to and access data** on natural resources (e.g. surface water or ground water) and on land use (e.g. property developments). A **common database or reporting system** could be created which allowed contributions from anybody – with weights or rating to indicate data quality. A common data platform is a concrete solution beyond creating forums for different actors to come together. The state has never before been more open to data sharing.

The **websites of urban local bodies could make available information to citizens** that would facilitate transparent governance. For example, in planning layouts, the BDA does not use the BBMP's drainage map. People should know about whether the plot they are planning to purchase is built on a lake bed or storm water drain otherwise they may legally acquire a property without realising its implications.

A government participant said that **raising awareness of individuals** is very important for ensuring compliance with existing laws e.g. waste segregation at source, rainwater harvesting.

Storm water drains should be separated from sewage lines in the older established parts of the city.

In newer areas of the growing city, there is a need to **understand the topography and the presence of first and second order streams** to prevent encroachment of lakebeds or drainage channels.

Price incentives are important but for rainwater harvesting to work, top-down subsidies are needed.

Urban planning is not new but there are gaps in incorporating trends in socioeconomic drivers and in physical and ecological hazards into coding. **Ecologically based zoning** is required as urban

development and sprawl cannot be ad hoc and cannot be left to developers and their powerful lobbies. But such zoning requires inter-disciplinary expertise in municipal planning agencies. Perhaps there is need for a distinct government agency on adaptation and resilience, which is staffed by people with knowledge of ecological complexity and the necessary technological expertise.

Norms are easy to formulate but implementation is difficult. However, the **RTI** (right to implementation) has made governance reforms possible. If **people are held accountable under law**, the agency will transform itself.

Multiagency coordination is a characteristic of large firms and is not a new issue. Management science has explored interesting ways of addressing this issue by applying basic principles of organizational behaviour.

**Workshop on Systems Thinking and Adaptive Governance:
The Context of Urban Flooding and Water Stress in Bangalore**

24-25 April 2014, Bangalore

Participants list

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24-25 April 2014

**First floor conference room, TERI (The Energy and Resources Institute)
4th Main, 2nd Cross, Domlur 2nd Stage, Bangalore 560071**

AGENDA

Thursday, 24 April 2014		
Registration starts at 9.30 AM		
10 – 10.15 AM	Welcome remarks	Mr P R Dasgupta Director and Distinguished Fellow, TERI Southern Regional Centre
10.15 – 10.45 AM	Overview of workshop approach and goals	Mr Navarun Varma Research Associate, Earth Science and Climate Change Division, TERI
10.45 – 11.15 AM	Urban flooding, water stress, and lake ecology: challenges and responses for Bangalore city	Dr Ritu Kakkar Director-General, Environmental Management and Policy Research Institute (EMPRI)
11.15 - 11.30 AM	<i>Tea / Coffee</i>	
11.30 AM – 12 PM	Water stress, systems thinking and adaptive governance in an urbanizing basin: focus on Bangalore	Dr Veena Srinivasan Fellow, Centre for Environment and Development, Ashoka Trust for Research on Ecology and the Environment (ATREE)
12 – 12.30 PM	Urbanization and peri-urban water insecurity	Prof. Vishal Narain Associate Professor, Public Policy and Governance, Management Development Institute (MDI), Gurgaon
12.30 – 1 PM	Challenges of urban services and governance in Bangalore	Dr Kala Sridhar Head, Public Policy Research Group, Public Affairs Centre (PAC)
1 – 2 PM	<i>Lunch</i>	
2– 4 PM	Group activity: Discuss preliminary models, develop them further, and identify possible interventions	Facilitated by Navarun Varma, Saurabh Bhardwaj, and Prasoon Singh, TERI
4 – 5 PM	Plenary: Groups present interventions to each other	Facilitated by Navarun Varma, Saurabh Bhardwaj, and Prasoon Singh, TERI

Friday, 25 April 2014		
10 – 10.15 AM	Trends in land use change for Bangalore	MrPrasoon Singh Research Associate, Earth Science and Climate Change Division, TERI
10.15 – 10.30 AM	Climate change and associated uncertainty	MrSaurabhBhardwaj Associate Fellow, Earth Science and Climate Change Division, TERI
10.30 – 11 AM	Minimizing urban heat island effect and imperviousness factor in Bangalore	Mr D Kiran Kumar Research Associate, Sustainable Habitat Division, TERI
11 – 11.30 AM	Tea / Coffee	
11.30 AM – 12 PM	Urban flooding in Mumbai, Manila and Bangkok	DrArchanaPatankar Senior Research Fellow, Regional Centre for Urban and Environmental Studies, All India Institute of Local Self Government
12 – 12.30 PM	Assessing headwater streams and flooding in the urban watershed of Bangalore using geospatial analysis and agent-based models	Dr H S Sudhira Gubbi Labs
12.30 – 1 PM	Systems thinking and adaptive governance concepts in the context of issues discussed in the workshop	Prof. S Ravi Rajan Asia Research Institute, National University of Singapore and University of California, Santa Cruz
1 – 2 PM	Lunch	
2 – 3.30 PM	Group activity: Consider modifying models and interventions	Facilitated by NavarunVarma, SaurabhBhardwaj, and Prasoon Singh, TERI
3.30 – 4.15 PM	Plenary: Groups present models, solutions, and rationale	Facilitated by NavarunVarma, SaurabhBhardwaj, and Prasoon Singh, TERI
4.15 – 5 PM	Operationalizing techniques and principles learnt in the workshop and ways to sustain network	Comments by Prof. Ravi Rajan Discussion with participants
5 – 5.05 PM	Vote of thanks	NavarunVarma, TERI