SHERWOOD INSTITUTE

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February 10, 2014

Shri. T. Sham Bhatt
Commissioner
Bangalore Development Authority
T. Chowdaiah Road, Kumara Park West
Bangalore 560 020

Dear Commissioner,

Per the Memorandum of Agreement dated November 6th, 2012, between the Bangalore Development Authority (BDA) and Invicus Engineering in collaboration with the Sherwood Institute and Carollo Engineering, please find attached the Vision Plan for the restoration of the lakes of Bangalore and a framework for their regeneration.

The intent of this Vision Plan is to increase the understanding of what steps need to be taken to allow the City of Bangalore to regenerate its lakes, the importance of their role in a City-wide sustainable water supply system, and to start a conversation about how such steps can and should be financed.

We would like to thank you for signing the MOA and acknowledge the contribution of Mr. Chickarayappa, Mr. Nayak and Mr. Manjappa of the BDA and Mr. Akash with Sky Group for providing the GIS data used in our preparation of this Vision Plan.

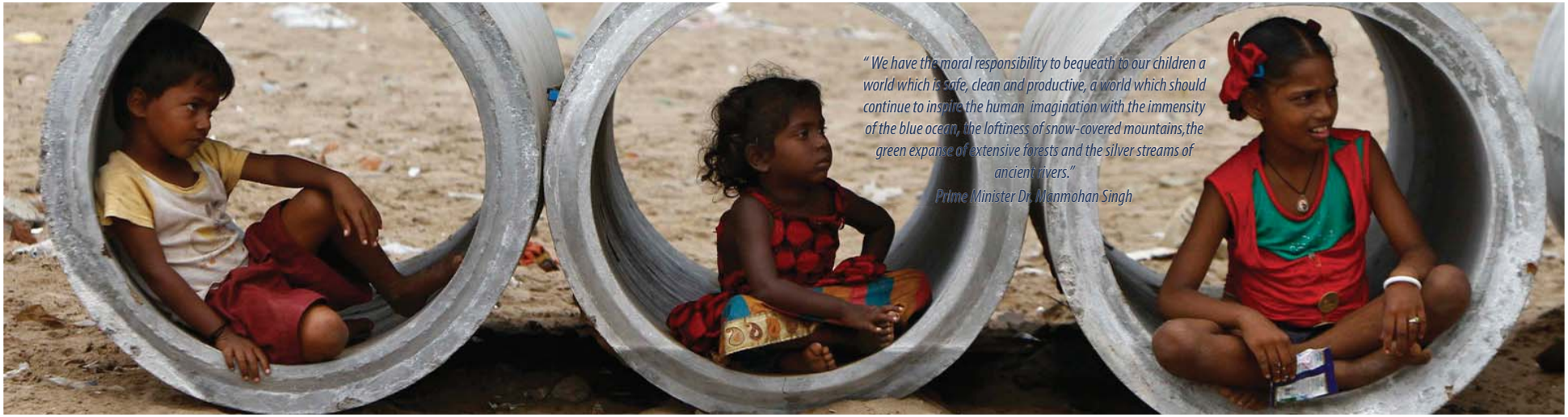
We look forward to reviewing this plan with the BDA and receiving the BDA's feedback.

Best Regards,

John Leys
Associate Director
Sherwood Institute


Better Lakes,
Better Bangalore

Introduction: *Purpose Of The Vision Plan*



The lakes of Bangalore, some which date as far back as the sixteenth century, were created by damming streams in the four natural valley systems in Bangalore. They were built as a public utility to provide water for drinking, irrigation, fishing and other uses. However, during the past 30 years the lakes have undergone significant degradation due to urbanization. This degradation, in the form of infill, pollution and the alteration of drainage patterns, has turned the lakes into a public health and environmental justice offender. Out of the over 280 original lakes and tanks in the city, only a fraction remain, and of those, only a handful have been restored, protected and are in good condition. The lakes and streams that remain are a resource for many of the half million poverty stricken city dwellers who continue to use the polluted water—spreading disease and sickness. In addition, the city has lost an important connection to its history and faces dire water shortages with nearly one third of projected water demand unlikely to be met. During this rapid period of urbanization the City has stressed water supplies to the point of near disaster while unable to meet the growing demand.

The Sherwood Institute, in collaboration with Invicus Engineering and Carollo Engineers, signed a memorandum of agreement with the Bangalore Development Authority in 2012 with the primary purpose of developing a vision for the lakes of Bangalore and a framework for their regeneration. This Vision Plan defines goals and guiding principles for lake regeneration; covers approaches to combating the primary water resource challenges; and proposes a process for the implementation of a comprehensive plan. The regeneration of the lakes of Bangalore is an undertaking that is bigger than one agency can handle and more complex than a single plan can detail. The process will involve collaboration among agencies both at the state and local level with input and support from private and non-governmental stakeholders. This Vision Plan recognizes this challenge and as such proposes a dynamic solution that revolves around the preparation of a Sustainable Water Supply Plan for the City of Bangalore. Internationally, as the current global water crisis has intensified, Water Supply Plans have proven to be an effective tool to combat rapid growth and the challenges that come with an unpredictable climate. Implementation of such a plan will allow the City of Bangalore to realize its potential, regenerate its lakes, and move through the 21st Century in a sustainable manner.

Introduction: *Stakeholder Outreach Process*

The creation and successful implementation of a comprehensive restoration plan for the lakes of Bangalore must involve the participation of a variety of actors in the public, private and non-governmental sectors. Several agencies have undertaken efforts to clean up individual lakes. However, successful planning for Bangalore's water resources and lake restoration falls across the jurisdiction of various government departments, and requires their cooperation for long-term success.

Maintaining longterm health of the lakes of Bangalore will succeed if both local citizens and corporate tenants, have a stake in their success. This includes engaging them in the restoration efforts, and/or giving them a perceived benefit, such as access to open space or increased property values, after restoration is complete.

Local Stakeholders

Public	Private	Academic / NGO
• *Lake Development Authority (LDA)*	• *CREDAI*	• *India Water Portal*
• *Bangalore Water and Sewage Board (BWSSB)*	• *Nicole Faria*	• *ATREE*
• *Karnataka Pollution Control Baord (KPCB)*	• *Various Multi-national Corporations*	• *The Centre of Ecological Sciences at IISc Bangalore*
• *Bruhat Bangalore Mahangara Palike (BBMP)*	• *Various developers*	• *The Centre for Science and Environment*
• *Bangalore Development Authority (BDA)*		• *Environment Support Group*
• *Environmental Management and Policy Reasearch Institute (EMPRI)*		• *Save Our Lakes groups*

Several other actors in each of these sectors are undertaking significant efforts toward the rejuvenation of Bangalore's lakes. Sherwood Institute's process has harnessed the energy and awareness raised by the efforts of these stakeholders to date. The Sherwood Institute has had an ongoing collaboration with representatives of the BDA for two years including a memorandum of agreement signed in a 2012 and participation in a workshop in July, 2013.

Key Stakeholder Outreach:

• In February, 2013 stakeholder interviews were held to solicit feedback from public, private, and NGO stakeholders.

• A digital campaign was run in May and June of 2013 which targeted feedback from grass roots organizations and the general public.

• Stakeholder Workshops in July 2013 included a multi-agency discussion on major issues and key aspects of plan implementation.

The Challenge: *Background*




Bangalore is known as the Garden City. Termperate climate, numerous lakes and significant gardens have driven Bangalore's reputation as a living environment that is more moderate than most major Indian cities. Its attraction as a destination for International Technology and Industry is, in part, driven by these factors and contributed to its growth. However, this growth in turn threatens the very elements that makes Bangalore an attractive location for businesses and residents.

The lakes and nalas of Bangalore were originally built as a public utility, available to all, providing water to the citizens of Bangalore. They captured rainwater and allowed it to infiltrate into aquifers, provided habitat for various species of birds, and contributed to the livelihoods of fishermen, farmers, and brickmakers. The lakes of Bangalore continue to play a critical role in the city, in providing moderation of urban climate, home for wildlife, economic resources for surrounding residents and as a major urban amenity that is key to making Bangalore a global destination to attract businesses and talent.

Since 1970, Bangalore has grown by 632%. During this period, the Metropolitan area has lost almost 80% of its water bodies and more than 75% of its vegetative cover. The result is a major increase in ambient temperature, poorer air quality, reduced aquifer recharge, and a falling groundwater table. Currently , only 30% of Bangalore's 282 lakes remain and it is estimated that 60% of remaining lakes in Bangalore are partially fed by sewage. Bangalore's success can be easily undermined if the water systems are not protected and restored appropriately. They will continue to degrade the physical and environmental quality of the city.

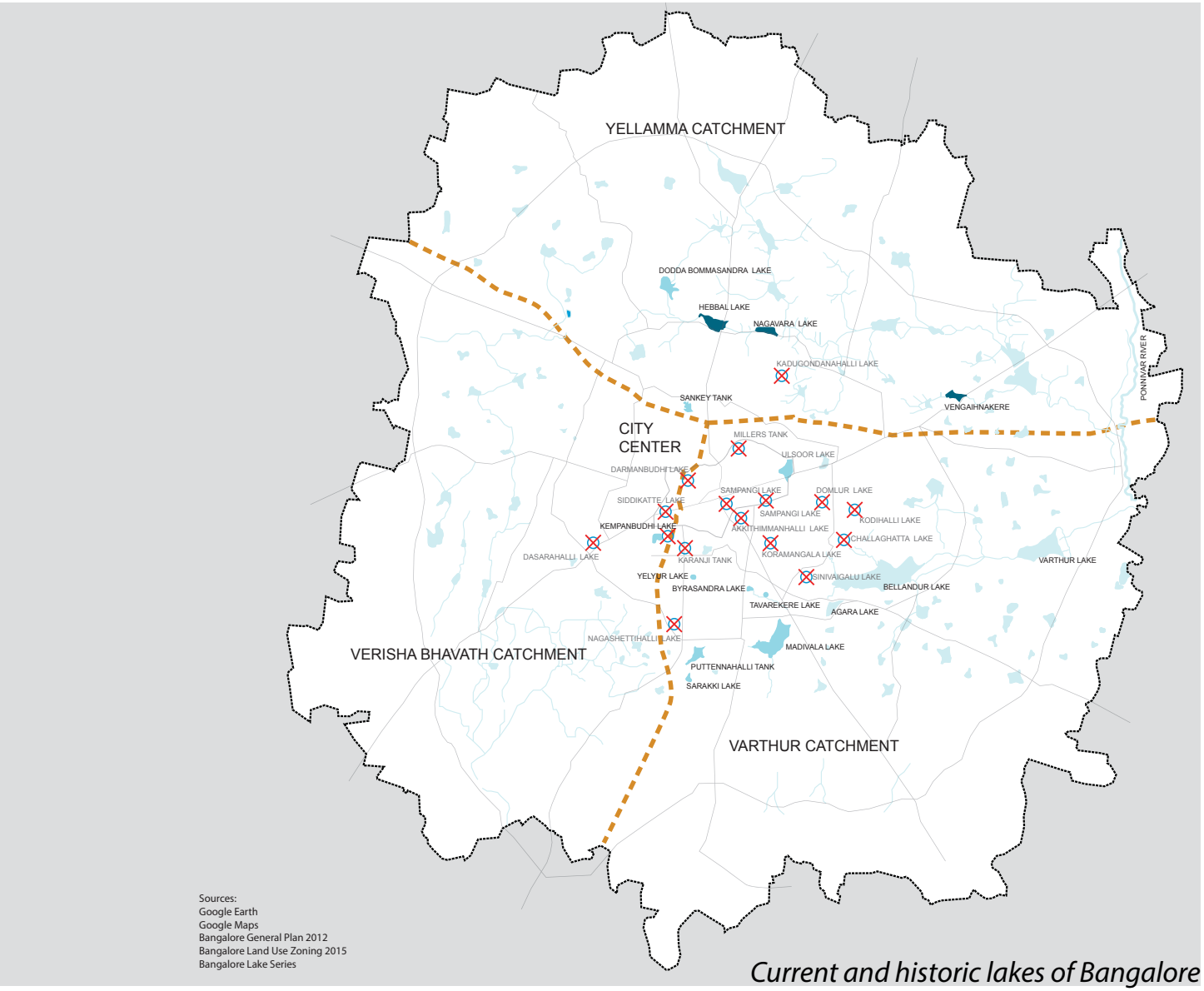


The Challenge: *Land Use*

Currently the lakes are used in a variety of ways, though seldom as a water resource. The lakes have lost their historic importance as a source of water for drinking and washing and of clay for brickmaking. Most of Bangalore's drinking water is derived from the Cauvery River, almost 100 kilometers away.

While the nalas that feed the lakes enjoy some legal protection, in reality, oftentimes their source of water has been clogged or cut off. Therefore the nalas, if they flow at all, convey human waste and trash to the lakes. Many years of such input, and possibly also the lack of the removal of the build-up of clay for bricks from the lake bottom, have severely decreased the ability of the water that does reach the lakes to infiltrate into the aquifer.

As the inflow of water to the lakes is cut off, many lakes have dried up or significantly decreased in size. Population pressure has led to an increase in the value of land, and the need for additional land for housing. These combined influences



Sources:
Google Earth
Google Maps
Bangalore General Plan 2012
Bangalore Land Use Zoning 2015
Bangalore Lake Series

Current and historic lakes of Bangalore

The Challenge: *Land Use*

Historic lakes have been lost to development, either with government sanctions or without, for a variety of reasons and uses: for sports facilities, for private development, and for public uses such as bus terminals and shopping complexes.

Kempegowda Bus Station

The Challenge: *Land Use*

Informal settlements and unauthorized dumping have impacted the lakes specifically and the watershed in general, turning the remaining system of nalas and lakes into an open sewer.

Illegal dumping in Hebbal Lake

The Challenge: *Land Use*

Of the remaining lakes, some, like Hebbal and Nagavara Lakes, have been restored and privatized, resulting in a great deal of public dissatisfaction and distrust.

Privatized Nagavara Lake

The Challenge: *Land Use*

A few lakes, like Sankey Tank, have been cleaned up and restored and their surroundings are available to the public as open space.
Restored Sankey Tank

The Challenge: *Water Resources & Infrastructure*

The Bangalore lakes were originally built as a base for the city's water supply infrastructure. Pollution of lakes and nalas has led to a decline in their ability to serve this critical purpose. Due to the scarcity of freshwater resources available, many of the city's demands are met using borewells, which has led to unsustainable rates of groundwater withdrawal.

Meanwhile, the City's demand for water is growing at an alarming rate. Population pressures and urban growth are making the water crisis in Bangalore even more acute. It is estimated that the water demand in the City surpasses the supply by over 36%. Future development hinges on the City's ability to tackle this challenge and create a comprehensive Water Supply Plan. There is an opportunity for the lakes of Bangalore to play a key role in this plan, both as a supply source and part of the storage and treatment process.

Women line up for water from a truck

The Challenge: *Case Study - Sankey Tank Restoration*

Sankey Tank, covering 37.5 acres in western Bangalore on the site of a 500-year-old perennial water body, was constructed in 1882 as a reservoir to protect against water shortages. Despite poor water quality it had always been popular as a spot for boating and picnicking, and in 2000 was developed into a park with the initiative of Bruhat Bengaluru Mahanagara Palike (BBMP), as well as the Bangalore Water Supply and Sewerage Board and the Sankey Park Walkers' Association.

A popular attraction that is well-maintained and generally used responsibly by visitors, the park is developed on land created with silt removed from the lake bottom. It has a 1.5-km system of paved and landscaped walkways (with shelters and seating areas), and a nursery operated by the Forest Department. Additional elements include a restored island, rainwater harvesting facilities, a tank for idol immersion, a rebuilt boat jetty, a children's play area, sports fields, and a restored swimming pool.

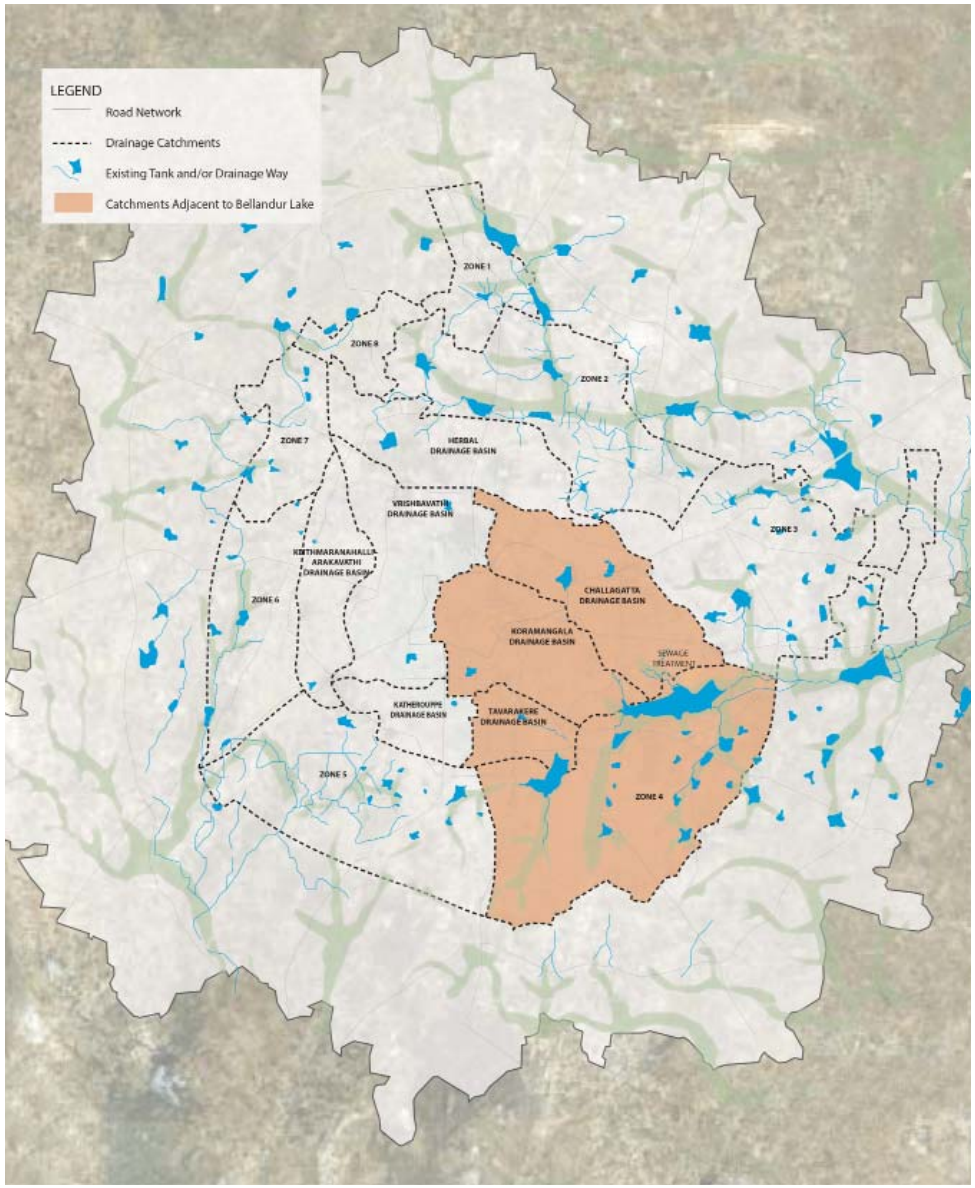
At the time of the park's creation, the drainage of all industrial effluent and domestic sewage into the lake ceased. Yet despite water treatment and a 2004 recommendation that no new construction take place close to the lake edge, environmental quality appears to have fluctuated over the past few decades. The lake is once again contaminated by sewage, threatening plant life along its margins as well as populations of fish, ducks, and migratory birds. This case study illustrates an important point regarding the severity of the issue: even a very public and popular lake, with a management plan in place, will slowly degrade without larger citywide programs to keep polluted water from entering the lake.

The Challenge: *Bellandur Lake*

Bellandur Lake is located approximately halfway between the Bangalore City Center and the new technology driven business districts of Whitefield and Electronics City, and is therefore a very attractive location for residential and commercial development. The lake's watershed is a critical component of the city's southern and southeastern storm drainage system, as a receptor from three chains of lakes upstream, with a catchment area of about 37,000 acres.

Given its catchment size, proximity to Bangalore's key industry, and prominence with the city, Bellandur is one of the lakes that is the most important to showcase. But with its importance comes challenges around the density of its watershed and complexity of sewage treatment, urban stormwater management, and enviornmental restoration.

Currently, most of the City Center's sewage drains, treated or not into Bellandur Lake. The result of the mismanagement of Bellandur Lake watershed is that much of the Bellandur Lake has been filled by excessive sediments and sewage loading. The presence of such a water body poses a hazard to public heath, and is a detractor for prospective residents. Restoration of this lake and the chains within its watershed would not only restore key hydrological functions, but also make the area more attractive to business tenants and future residents by providing a public amenity.



Vision 2035: *Bangalore's Potential as a Global City*

Indian cities are critical to the overall economic success of India. A recent McKinsey Global Institute research report indicates that Indian cities could generate 70% net new jobs created by 2030, produce around 70% of Indian GDP and drive a near four fold increase in per capita income across India. The potential for Indian cities is tremendous. India has become a powerful engine driving and shaping the world's economies, culture, technology and development. Now an established global force in telecommunications, manufacturing, information technology, agriculture and entertainment—the prosperity of India's economy affords the amenities that will allow its people to live, work, and play in ways that are special and unique to them.

The urban expansion of Bangalore is happening at a speed quite unlike anything the world has seen before. If handled well, Bangalore can reap significant benefits from urbanization. India and especially Bangalore have the potential to unlock many new growth markets, including infrastructure, transportation, healthcare, and education. Cities like Bangalore can also deliver a higher quality of life for Indian citizens.

The Bangalore urban metro region faces the challenge of preserving vital and increasingly scarce resources, such as land, water and air, while at the same time, growing and providing adequate housing, transportation, food, open space, and economic opportunity for all its residents. To succeed, Bangalore must come up with novel solutions to the challenges this rate of development poses and address these critical development issues, creating a balance between population growth, infrastructure requirements and the carrying capacity of the environment. These challenges are also an opportunity for Bangalore to create a new paradigm for Indian cities.

Bangalore skyline

Vision 2035: *Global City-Making Principles*

Why does it matter to address water security and quality of life?

Overall , cities compete on the global marketplace to attract people (talent) and businesses. Several metric systems have been developed to rate and rank cities world wide as they compete in the global marketplace to attract businesses and investment. For instance, the Global Cities Index promoted by the Foreign Policy , AT Kearney and the Chicago Council on Global Affairs highlights some of the metrics that have been developed to date. The "Global City" indicators are organized into two broad categories: City Services and Quality of Life.

Governmental agencies can have a major impact to affect the global appeal of a city to attract talent and businesses. A key reading from the various analyses highlight that the overall livability of a city benefits from density, affordability and diversity of public transit system; and quality and extent of its cultural facilities and open space system. The index aims to measure how much sway a global city has over what happens beyond its own borders -- its influence on and integration with global markets, culture, and innovation.

The potential for a city like Bangalore to beomce a center of excellence in the Technology sector has a direct relationship with its ability to attract smart young people that can transform the economy from a service industry to a knowledge based economy. This requires a total commitment from the elected officials and government agencies to invest in and improve the overall infrastructure of the city. Bangalore water problems need to be addressed immediately in order to not lose the positive momentum the city is benefiting from to date.

"Cities compete on the Global Marketplace to attract people (talent) & businesses. Unless it steps up investment in its cities, India could well lose the productivity dividend of urban living. Today, in per capita terms, India's annual capital spending of $17 is only 14 percent of China's $116 and less than 6 percent of New York's $292 (McKinsey Global Institute)

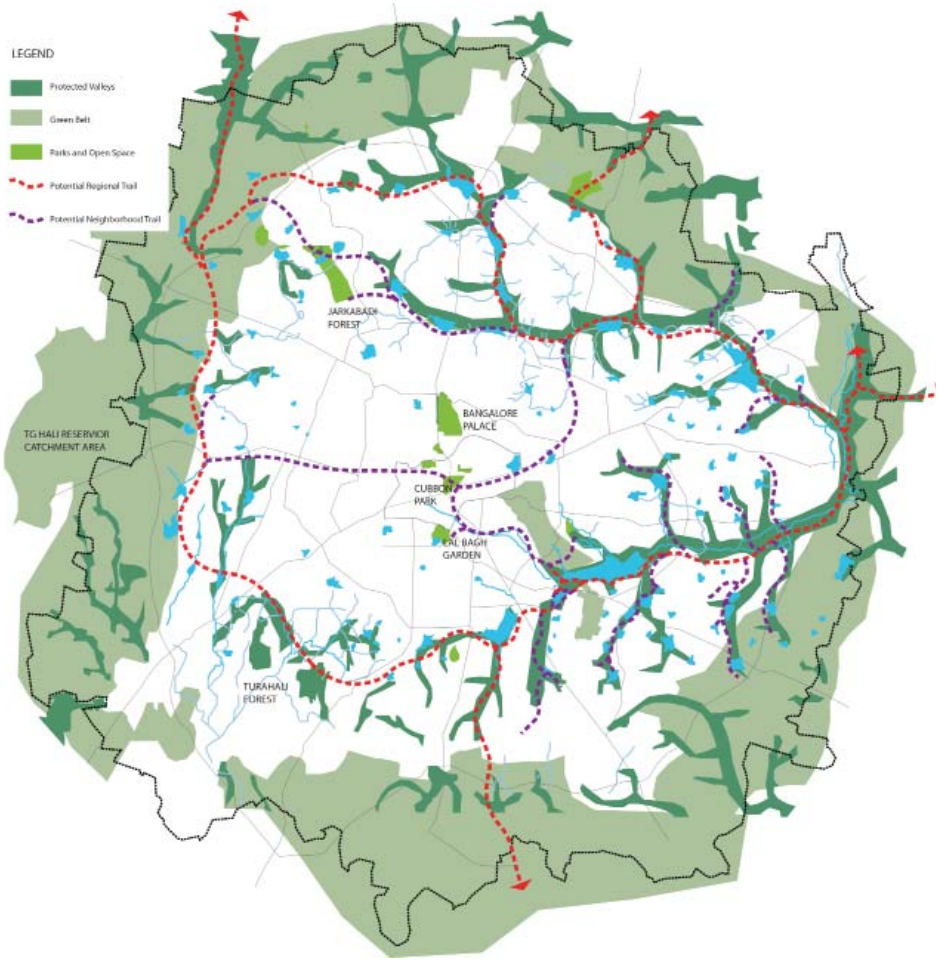
The Challenge: *Case Study - Mexico City Plan Verde*

Air and water pollution are associated with a more negative global image of a City. The Government of Mexico City's is implementing a comprehensive, 15-year Green Plan – climate action program - to reduce greenhouse gas (GHG) emissions and transforms its poor environmental performance. The plan encompasses a wide range of programs and activities to address climate change, reduce GHG emissions, and encourage businesses and citizens to adopt climate-friendly behavior.

The Green Plan has seven pillars: land conservation, housing and public spaces, water supply and sanitation, transportation and mobility, air pollution, waste management and recycling, and the Climate Action Program. The implementation of the Green Plan is a positive example of how the leadership of the City created a new "horizontal" agency to implement the Green Plan, that included members from each major department of City government - from civil works, transportation, social services, planning, housing, etc. to avoid the silo management structure that had dogged the city in the past in being able to implement policies that would affect several departments. The new "green plan" agency is able to be very effective in implementing plans and policies that transcend the typical silo mentality.

This case study of Mexico City is an interesting example of how a global mega city can undertake a radical transformation to address its enviornmental problems. Bangalore's enviornmental challenges are not beyond its reach yet and decisive action, such as Mexico City took, will allow Bangalore to improve the disastrous trajectory of its resource problems.

Vision 2035: *Open Space and Public Access*



Any city that hopes to thrive and prosper in the 21st Century will need a robust and rich system of public open space. Parks and open spaces, and water bodies are a key indicator of Quality of Life in a City, as highlighted in a report by McKinsey Global Institute (MGI:India's Urban Awakening 2010).

As the countries of the world urbanize at a rapid pace it is increasingly hard and increasingly crucial to establish and maintain urban, public open spaces for their rejuvenating characteristics, but also for the way that they increase the creative and social collaborations of their citizens.

In many communities around the world public access is increasingly seen as both a right and relatively easy way to provide a connection to nature. As Bangalore modernizes and as the standard of living for all its citizens become more equitable with those at the lowest end experiencing more of its benefits, the perceived need for seclusion by the wealthy will be less pressing. If the right of the public to walk on trails around Bangalore's lakes is lost now, it will be hard to get back. The benefits of open space provided now to all will bring about a more prosperous city, more quickly.

Examples of cities and communities working to ensure public access include the Bay Trail around San Francisco Bay and right of the public to access the ocean in California. Both are tangible amenities that have contributed to the economic vitality of the Bay Area and California by attracting a creative and productive workforce. The benefits of open space provided now to all will continue to allow Bangalore to be a properous city.

Vision 2035: *Sustainable Water Resources*

At this point in time there is no real debate around the fact that water scarcity is a serious global issue. With the rapidly growing cities in India and across the world significant attention must be paid to this vital resource. Bangalore is truly at a cross roads – supply is not keeping up with demand leading to health and economic impacts to the City's residents. This is not an issue that a single government agency can solve, but it is an issue the City can solve. City governments throughout the world deal with this challenge by creating Sustainable Water Supply Plans. This has proven to be an effective tool to combat rapid growth and the challenges that come with an unpredictable climate (i.e. drought). A Sustainable Water Supply Plan is focused not only on supply but also on the synergistic benefits of an overall portfolio. It is not a static document but is something that once prepared is repeatedly updated on a five-year cycle to account for ongoing changes to the built and natural environment. A Sustainable Water Supply Plan will consider all aspects of Bangalore's water portfolio: from the groundwater sources, to the rivers, to the water savings fom conservation efforst to the lakes that speckle the Garden City. The benefits of developing a holistic plan, that includes a role for the nalas and lakes, include:

- Safe and reliable water supply
- Flood control
- Improved open space networks
- Enhanced property values
- Increased multinational corporate investment in the city
- Re-establishment of traditional enterprises
- Creation of new business opportunities around lake restoration and management
- Academic leadership
- Continue Bangalore's role as a leading city in India
- Tourism

Sustainable Water Supply Plan: *Key Elements*

• Wastewater Management:
ensuring only treated sewage and treated industrial effluent enters the lake system

• Stormwater Management:
ensuring urban runoff is free from solid waste and treated prior to entering the lake system

• Lake and Nala Restoration:
ensuring the lake system stays healthy, supporting Bangalore's water resource portfolio, and providing habitat for local ecologies and open space for local residents

Integrated Water Resources Management Plan: Goals

The following goals and guiding principles have been paramount in the approach taken to develop the preferred approach for this Vision Plan and its implementation.

1. Support a Sustainable Water Cycle in Bangalore

• Restore the historic hydrologic cycle. Historically the tanks of Bangalore were created to function as a comprehensive water resource management system. Stormwater runoff was channeled via the nalas to the tanks where it was retained. The lakes served many purposes including storage for domestic uses, infiltration zones to recharge the groundwater aquifers, and a source of economic livelihood (fishing and water supplies for irrigation and small-scale industry).

• Replenish the underlying aquifers to sustainable levels. Nearly all of the city's water comes from the Cauvery and Arkavathy Rivers. However demands exceed capacity by over 30% leading to ongoing severe water shortages throughout the City. Management of Bangalore's water supply is of utmost importance, and lakes can play a role in the balance of withdrawals and recharge. All natural systems have a point of equilibrium. The lake system within Bangalore has a carrying capacity in terms of water it can supply for domestic uses (both directly and via aquifer recharge). The resource must be managed properly to ensure the balance is restored and kept in tact going forward.

• Allow the lakes and nalas to function in a flood management capacity during monsoons via detention and channeling respectively.

Integrated Water Resources Management Plan: Goals

2.) Improve Lake Water Quality and Beneficial Use of the Resource

• Improve water quality within lakes by implementing strategies to treat point source and non-point source pollution entering the public storm drains, nalas, and lakes. Use the nalas and lake wetlands to further treat and purify the water.

3.) Provide Public Benefit and Accessibility to the Resource

• Connect lake and nala restoration activities to publically accessible improvements such as open space, parks and trails. Adjacent residents will see improvements in their quality of life as well as demand to live in their neighborhoods.

4.) Improve Ecological Value

• An improved lake environment will bring a rejuvenation of the local ecology - from plants to aquatic animals and birds. The restored nalas will act as linkages to support a healthy evolution of the aquatic and terrestrial life forms.

5.) Support Proper Governance and Transparency to all Stakeholders

• A publicly and privately supported and transparent process for the restoration and management of this resource will ensure participation by stakeholders.

Lake Merrit, Oakland, CA

Integrated Water Resources Management Plan: *Wastewater Management*

The drainage system for the southern and southeastern parts of Bangalore is made up of three chains of lakes that connect to the Bellandur Lake. In the 1980s, unplanned urbanization resulted in a break in this chain of lakes, inhibiting downstream flow of surplus water in the event of heavy rainfall. Sufficient amounts of rainwater do not enter the lake regularly, while excess untreated wastewater, composed of untreated sewage and effluents from industry, does. Surplus flow cannot flow downstream due to the disruption in the drainage system; instead, in periods of heavy rain, water and sewage from the stormwater drain overflow into the lakes.

Sewage treatment is currently not being utilized efficiently. The Bangalore Water Supply and Sewage Board has three major sewage treatment plants in place, with a total capacity of 458 MLD, in contrast to a total waste production of 688 MLD (Environmental Impact of Developmental Activities in the Bellandur Lake Catchment, Ramachandra, 2008). The treatment plants, however, are not utilized to full capacity, meaning that an even greater amount of untreated sewage enters the drainage system.

To remedy this situation two key areas of focus are necessary: (1) the conveyance infrastructure to keep the sewage separated from stormwater and route the wastewater flows to the treatment plants; and (2) the sewage treatment plant upgrades and improvement projects required to ensure there is adequate capacity for peak flows. Key to long term success of these projects will be proper Operations and Maintenance budgets and protocols to ensure that facilities remain operational at all times.

Integrated Water Resources Management Plan: *Wastewater Management*

From a planning perspective there are two primary approaches to designing these infrastructure upgrades. And although generally outlined below, further detailed study specific to BWSSB's existing and proposed infrastructure plans is needed to determine the best approach within the Bellandur Lake watershed.

1. Watershed-wide Centralized Approach

a. Regional conveyance infrastructure routes sewage to sewage treatment plants (STP)

b. Regional STPs treat all sewage flows to a tertiary level

c. Treated wastewater is released into the nalas/lakes after tertiary treatment and/or

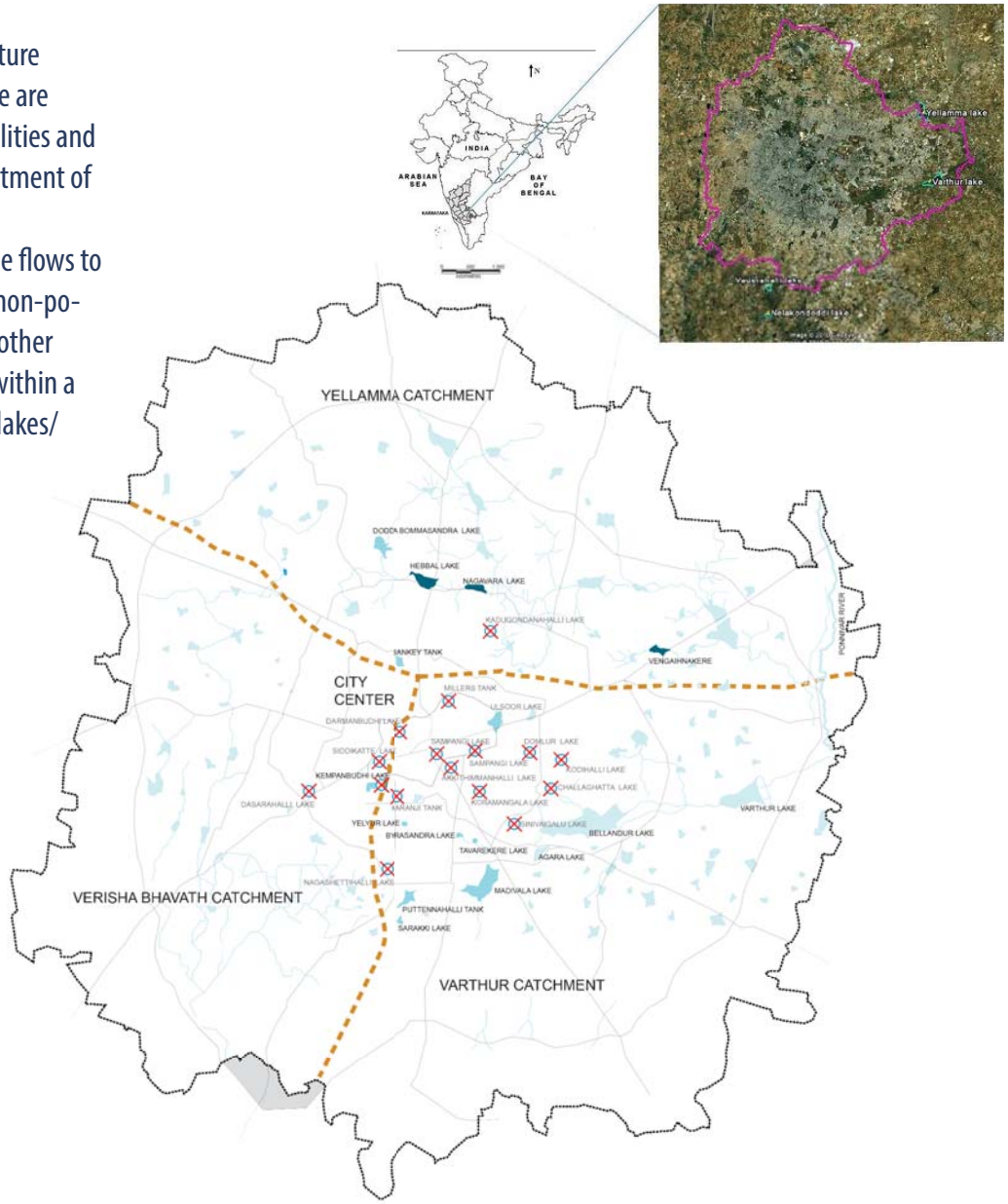
d. Treated wastewater is injected into the groundwater aquifer and/or

e. Treated wastewater is provided regionally as a non-potable water source for irrigation and other non-potable water applications (approaches c and d is what water-poor cities like Singapore are doing).

2. Eco-District Approach

a. Local conveyance infrastructure routes sewage to local STPs. These are smaller and more distributed facilities and could be designed to include treatment of stormwater base flows.

b. These local STPs treat sewage flows to tertiary levels prior to reuse as a non-potable water source for irrigation, other non-potable water applications within a smaller district, or release to the lakes/ nalas.



Integrated Water Resources Management Plan: *Wastewater Management*

Determining the most beneficial use of treated wastewater is directly related to Banglaore's overall water supply strategy. The three primary uses for this water and associated challenges include:

1. Release into Nalas and Lakes: The water quality must be of a level that will be beneficial to the local ecosystems. The lakes will then become both a storage vessel prior to reuse as well as a mechanism to promote infiltration back into the underlying aquifer. This will require coordination with lake restoration projects to ensure they have infiltrative potential and current contamination in lake sediments is remediated/removed prior to infiltrating water through the soils at the lake edges and bottom.

2. Inject into Groundwater Aquifer: Injected tertiary treated effluent needs a minimum residence time prior to withdrawal for use as potable water. The treated wastewater could also be injected into non-potable aquifers or at a shallow elevation such that it takes time (years) to make its way down into the primary aquifer. Internationally, typical minimum residence times are one-to-two years for treated wastewater that is injected into the ground.

3. Distribute for Reuse: Redistributing treated wastewater (reclaimed water) is infrastructure intensive as well as potentially a regulatory and public health concern. Education around proper use of this separate water supply network will be necessary to ensure it is used appropriately.

Final determination on the preferred strategies for implementation will depend on the BWSSB's system master planning and the conclusions of a City-wide Sustainable Water Supply Plan.

Integrated Water Resources Management Plan: *Case Study - East Kolkata Wetlands*

At 12500 acres, the East Kolkata Wetlands (EKW) represent one of the world's largest assemblages of sewage-fed fish ponds, and its largest resource recovery system combining agriculture and aquaculture. The fish, vegetables and other produce of the 264 bheries, or aquaculture ponds, support 20,000 families and are essential to Kolkata's food security. Declared by the Indian Government to be a Wetland of International Importance under the Ramsar Convention of 2003, the system also serves as a prime example of the integration of traditional knowledge into conservation practices.

Once a brackish backwater swamp called the "salt lakes," a portion of the present-day EKW were acquired by Kolkata (then lacking any waste-management system) in 1864 as a site for solid waste disposal. Freshwater aquaculture was first attempted in 1918, when sewage application began to be sequenced based on the detention time required to maximize water quality for fish habitat. The wetlands are now officially recognized as a Waste Recycling Region, and despite ongoing pressure to reclaim them for development, support for their continued conservation has gradually increased.

The East Kolkata Wetlands are an example of ecological engineering: integrating natural process with society's infrastructure needs to everyone's benefit. An integrated approach is what Bangalore must pursue to succeed with its multi-faceted and complex enviornmental and technical challenges.

Integrated Water Resources Management Plan: *Urban Stormwater Management*

As the City of Bangalore has transformed into a densely developed region, its nalas have been piped and diverted and the lakes filled. Instead of infiltrating into the underlying soils, runoff mobilizes pollutants and trash and carries them into the storm drains, nalas, and lakes. During monsoon rainfall events stormwater enters even the sewer system leading to overflows at the treatment plants into the natural environment.

The key challenges surrounding Urban Stormwater Management that must be addressed include:

1. High level of urban pollution locally (cars, debris, industry, agriculture, etc)
2. An inadequate solid waste management program that leads to large volumes of litter entering the stormdrain networks
3. An incomplete network of municipally owned and operated storm drain infrastructure (primarily existing nalas)
4. A tendency/ability to reroute storm drain infrastructure as a result of development pressure in a manner that is inconsistent with a comprehensive drainage master plan
5. Illegal dumping / discharges into conveyance infrastructure including nalas and lakes
6. The removal of trees and other forms of landscaping that mitigate urban runoff
7. An accepted mode of development that increases impervious surfaces without considering the consequence to the greater water supply issues of Bangalore

The approach to managing urban stormwater runoff must recognize these challenges and develop solutions that work in concert with the other primary Plan elements, wastewater treatment and lake restoration, while supporting resolution of the fundamental infrastructure challenge in the City of Bangalore, developing a sustainable water supply.

Bellandur Lake, Bangalore

Integrated Water Resources Management Plan: *Urban Stormwater Management*

The key Urban Stormwater Management plan components are:

1. Development of a Stormwater Master Plan for the Watershed that at a minimum will identify conveyance routing for all areas within the watershed and regional treatment facilities if appropriate. This plan should be developed in conjunction with the sewer infrastructure master planning such that the two systems can be optimized from a phasing and cost perspective.
2. Policy and Code Enforcement to ensure new development and redevelopment projects follow the master plan and are held responsible for their stormwater flows. This primarily ensures that stormwater and wastewater are not combined in one system and that stormwater flows are not routed to local nalas and lakes.
3. Education programs targeted at various groups including the general public, developers/project owners, and government agencies, in an effort to reduce litter/debris entering the lakes as well as to improve the sustainability of development projects.
4. Development of small-scale decentralized pilot projects that begin to transform the City over time into one that uses green infrastructure to combat urban pollution. These projects will emphasize stormwater source control rather than depending entirely on conventional drainage infrastructure.
5. Development of medium and large-scale end-of-pipe treatment projects that clean stormwater prior to release into lakes and nalas. These projects would typically be constructed wetlands or small STPs and may be able to be phased in over time as the watershed further develops.

Integrated Water Resources Management Plan: *Lake and Nala Restoration*

Lalbagh Lake, Bangalore

The restoration of the lakes and nalas cannot happen without considering the management of wastewater and storm-water within the watershed. The flow rates and quality of these two sources will play a critical role in the restoration approach taken. Additionally, the goal for the lake it self in the context of the larger watershed as well as the future use of the lake water itself are important factors. Lakes will have different design parameters depending on their location within the watershed and primarily design objective: i.e. infiltration objective: i.e. all water treatment; habitat creation; and/or recreation. The approach taken to restore the lakes and nalas must recognize that the timing and phasing of activities is critical. The restoration of a lake downstream of pollution sources will only be a temporary fix if the pollution sources themselves are not remediated.

The actual restoration from a watershed perspective must follow a simple sequence:

1. Ensure the lake is receiving water as per its historic hydrologic function.
2. Ensure water entering the lake is free from major pollutant loads including untreated sewage and untreated industrial waste.
3. Remove and treat the contaminated lake bottom sediments for use as fill in regional construction projects.
4. Remove invasive vegetation and plant with native species.
5. Integrate Urban Stormwater Management plan components into the lakes and nalas as necessary.
6. Manage and monitor the lake water quality and sediments to ensure a healthy aquatic habitat longterm.

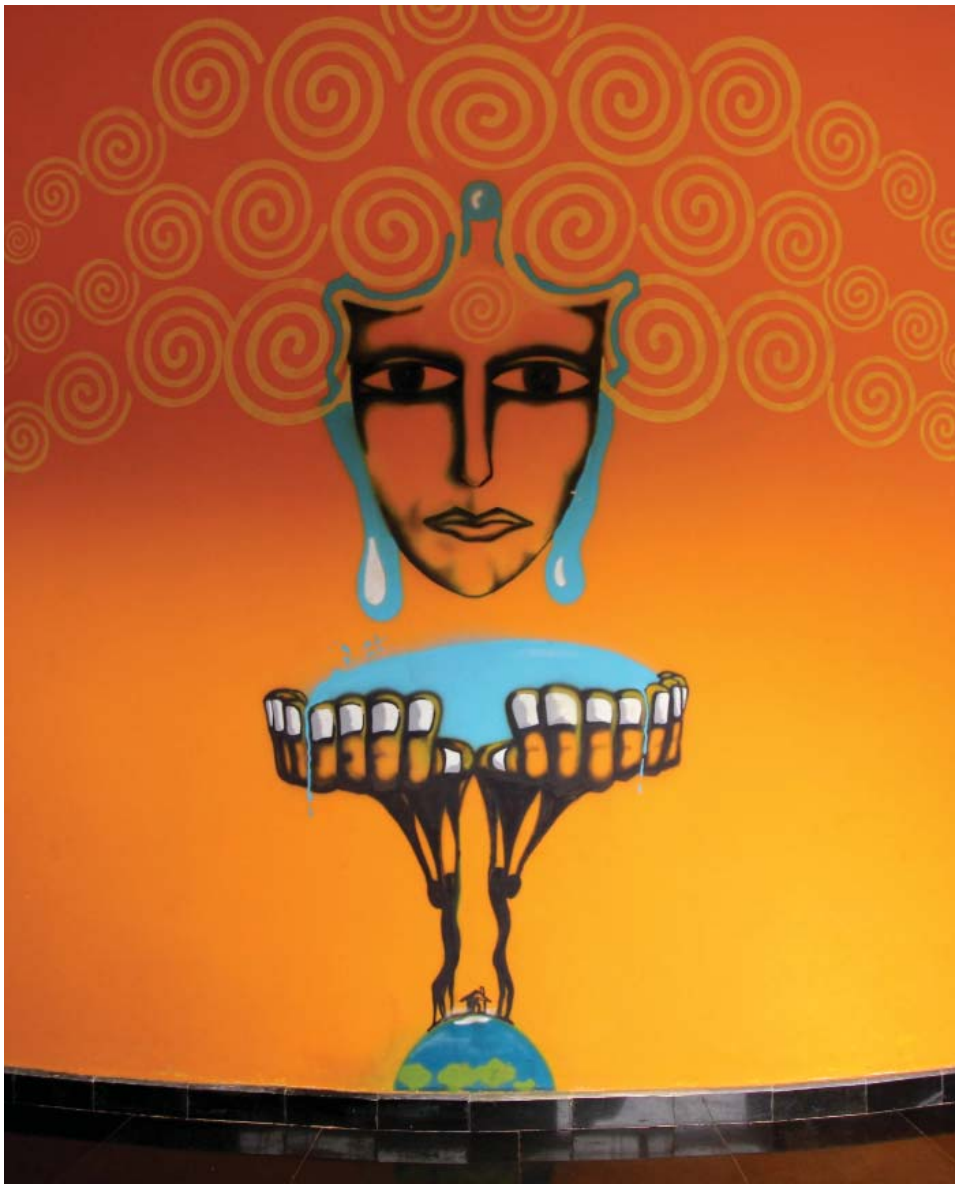
Burnaby Lake Rejuvenation: *Case Study*

Formed by an ancient glacier over 12,000 years ago, Burnaby Lake is a 300-hectare natural environment situated in the heart of the Vancouver bedroom community of Burnaby, BC. The surrounding ecosystem serves as the home to over 400 varieties of plants and wildlife, 16 of which are rare and endangered species. Over the past thirty years, natural sedimentation, and development and construction activities in the 7,300 hectare Brunette River watershed, in which Burnaby Lake resides, resulted in the steady accumulation of heavy layers of contaminated sediments on the bottom of Burnaby Lake. This led to the gradual disappearance of the lake's precious, open water characteristics. The gradual disappearance of the lake's precious open water characteristics and accelerated degradation of its aquatic quality was endangering the future sustainability of the lake's valuable ecosystem. Three key areas of the lake rejuvenation project:

1. Dredging, processing the sediment, and treating the water
2. Managing and monitoring the environment
3. Managing the residuals

The Burnaby Lake Rejuvenation Project provided immediate and long-term environmental benefits. The project reversed the effects of sediment infilling, increased the area of deeper open water, removed contaminated sediments for fish and wildlife protection, improved water quali tyconditions for salmonids, and improved the lake tributary for fish migration.

Priority Project: *The Sustainable Water Supply Plan*



Priority Project: The Sustainable Water Supply Plan

Created for use by the BWSSB, and in collaboration with all agencies that have responsibilities affecting the water resource portfolio of Bangalore, the Sustainable Water Supply Plan will guide short and long-term policy in Bangalore as related to water management. The Water Supply Plan includes a detailed assessment of existing supplies, storage and demands as well as analysis of additional potential supplies such as recycled water and lake water. The Plan will be the guiding document for the BWSSB and the City of Bangalore as decisions are made regarding water resource management in the future. Principally the plan will set policy that must be followed by all Bangalore Agencies and which will lead to sustainable water supply in the future.

The key plan components include:

1.) Document Existing Water Supplies: surface water and groundwater.

2.) Document Additional Potential Water Supplies: recycled water, stormwater, aquifer recharge, lake water, expanded surface water.

3.) Document Demand: residential, commercial, industry, agriculture, parks and open space.

4.) Document Supply / Demand Forecast: this water budget is calculated in 5-year increments by use sector consistent with the City of Bangalore's Comprehensive Development Plan. A comprehensive approach must be taken, including targeting conservation and efficiency, to ensure supplies are managed and/or developed to catch up to and meet future demands.

5.) Document Policy Changes: in conjunction with the preparation of the 2015 Comprehensive Development Plan, develop policy via codes and ordinances that will guide Bangalore towards Plan implementation.

Vision Plan Implementation Strategy: *The Sustainable Water Supply Plan*

The single most important next step for the City of Bangalore to take in the pursuit of lake restoration is to begin the process of developing a Sustainable Water Supply Plan. Municipalities around the World have relied on such plans as a way to guide development in a sustainable manner. Bangalore is at a crossroads in terms of its ability to compete long-term as a global City. The risks associated with continuing in the business as usual mode are far too great to warrant inaction. It is the Sherwood Institute's conclusion, supported by many academic institutions and scientists, that the lakes of Bangalore play an important role in the overall water resource picture; and hence will benefit from new policy that binds them with the City's water supply plan, a role they played in the past.

The Sustainable Water Supply Plan should be:

1.) Funded by the State of Karnataka
2.) Administered by a Steering Committee headed by the BWSSB and supported by the BDA, LDA, BBMP, KSPCB, and EMPRI
2.) Written by an outside expert consultant with past experience writing Water Supply Plans for cities / communities
3.) Completed in sequence with the City of Bangalore's 2015 Comprehensive Development Plan