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FINANCIAL COMPENDIUM AND FEASIBILITY ANALYSIS OF WASTEWATER REUSE FOR INDUSTRY AND AGRICULTURE IN SOLAPUR AND VIJAYAWADA

Prepared by

CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

LED BY: IWMI International Water Management Institute

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INTEGRATED RURAL URBAN WATER MANAGEMENT FOR CLIMATE BASED ADAPTATIONS IN INDIAN CITIES (IAdapt)

Financial Compendium and Feasibility Analysis of Wastewater reuse for Industry and Agriculture in Solapur and Vijayawada

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The project focuses on empowering cities to transition from traditional approaches of water management (which considers water supply, wastewater and storm water as separate entities to be planned, implemented and operated in silos) to an 'Integrated Approach' based on the principles of integrated water resource management (IWRM) and integrated urban water management (IUWM).

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Disclaimer

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Abstract

In India, 38,254 million litres of sewage is generated every day considering both Class-I and Class-II towns of which 11,787 MLD is treated and rest flows into surface water bodies in and around cities. Many cities are situated in water-scarce zones where industrial and agricultural demand for water is being met using freshwater. In recent years, governments at different levels, private players, donors and expert groups have explored alternative water supply arrangement for industry and agriculture sectors, in order to meet their water demand from recycled wastewater. Most of the wastewater is treated up to secondary level as Urban Local Bodies (ULBs) are not obliged go beyond it. Municipal wastewater treated up to secondary level cannot be utilized for industrial use and it is also not suitable for agricultural purpose in most cases. Therefore, the possibility of generating revenue out of secondary treated wastewater is limited and the burden of treating wastewater is left with financially distressed ULBs. The government is trying to manage financial distress and increase efficiency introducing options like Public Private Partnerships (PPPs). We argue that wastewater reuse via PPPs need to generate both sufficient water quality and adequate revenue stream through proper tariffs to make it sustainable. In this paper, we consider Vijaywada city, where both industrial and agricultural demand for water exists and wastewater is till date treated at the secondary level only. We use financial feasibility analysis to explore whether upgrading existing secondary treatment plants to tertiary level is financially feasible and which tariffs applicable to industry and agriculture sector should be set to make the model more sustainable in the long run. Within the financial models, we propose different PPP mechanisms that can be utilised for reclaiming wastewater from cities for industries and agriculture.

Executive Summary

Introduction

Urban Local Bodies (ULBs) in India are vested with the responsibility of providing civic, social and economic infrastructure services and facilities in both urban and peri-urban areas. With rapid pace of urbanization, this is more prerogative to these grassroot organizations, since their sources of finance are limited. The infrastructure and services being grossly inadequate even for the existing population, the city authorities in India are in a situation to sketch their action for planned urbanization and peripheral expansion to accommodate migrants and the local population growth. The Report of High Powered Expert Committee (HPEC) for Estimating the Investment Requirements for Urban Infrastructure Services estimates Rs 3.92 million crores as the investment needs to provide urban services conforming to national benchmarks for urban infrastructure over a period 2012-31.The operations and maintenance costs would amount to another Rs.2 million crores (Ahluwalia HPEC 2011).To address the fiscal stress, these bodies may have to resort to borrowings in recent years, often with State Government guarantees, from Housing and Urban Development Corporation (HUDCO), financial institutions, banks, open market, external lending agencies like the World Bank and the Asian Development Bank. This has implications for both Central and State finances, as it reflects the dependency of the ULBs and consequently, the provision of local public services on the policies and programmes. This study is primarily focused to provide a compendium of financial provisions for the Urban Local bodies and carry out a financial feasibility of wastewater reuse for industry and agriculture.

Finance sources for Urban Local Bodies (ULBs)

ULBs have different sources of finances for urban infrastructure which depends on revenue, grants, assignments and devolution by the State Government and grants from Central Government and Finance Commissions, as well as market borrowings. The 74th Constitution Amendment Act, 1992 brought uniformity in the constitution of municipal bodies and empowered Indian municipal corporations with the power and authority to operate as self-governing entities. While the Constitution of India does provide for the devolution of tax revenue between the centre and states, there is no provision that mandates devolution of tax revenue or confers the power to impose taxes to urban local bodies.

The sources of tax and non-tax revenue are relatively small for municipalities to fund capital expenditure. A study conducted by the Thirteenth Finance Commission reveals that ULBs' share in own taxes is around 2-3 percent and their total revenue is less than 0.75 percent of Gross Domestic Product (GDP) leaving little room for capital expenditure. Different studies reveal that there are wide differences among various ULBs in tax jurisdiction, degree of control exercised by the State Governments in fixing the tax base, tax rate and tax exemption.

The government transfers can be in the form of (i) Central grants, (ii) State Finance Commission grants (iii) Central Finance Commission assistance, and (iv) other grants from the states. These grants can be tied to projects / programmes catering towards urban infrastructure development, or might be untied trying to resolve losses / completion of such projects.

The commercial sources of borrowings include – (i) government institutions which are concerned with financing for urban infrastructure development (like HUDCO, LIC, GIC etc.); (ii) schedules commercial (public and private) banks; (iii) Sector specific municipal development funds which include – Pan India Pooled Municipal Debt Obligation, State funds and State Financial Intermediaries;

(iv) capital markets – like issuance of bonds and pooled funds. In addition the GoI has opened the doors towards targeting private equity in large scale through the PPPs. The different variants of PPPs which are relevant for India range from Design Build Operate (medium term) to Build Operate and Transfer (long term) type of models which has been discussed in the report.

Financial feasibility analysis of wastewater reuse for industry and agriculture in Solapur and Vijayawada

The present report discusses the financial feasibility of the treating wastewater from two cities (Solapur and Vijayawada) and reuse in agriculture and industry. The financial exercise is performed after consultations with the relevant stakeholders in relation to Integrated Water Management at a city level. The financial model developed for two cities with different tertiary level of treatment is considered to be operational in BOT-type PPP with user fees being collected as a cost recovery mechanism for the private entity. A brief synopsis of the results are present below.

Solapur

We have assumed that the initial adoption rate will be 10 percent for the first year as it takes time to create awareness. Then each year there will be increment by 10 percent so that in 10 years it is possible to sell the whole treated water. In this case the water demand for agriculture is met and then rest is supplied to the industry. Moreover, we assume treating the whole 75 MLD water coming out of secondary treatment and out of which in the first year 10 percent of the wastewater adopted by industry and agriculture and thereby each year it increases by 10 percent. We are treating the whole water from the beginning otherwise installed capacity will remain unutilized and environment will be affected even if it is discharged in the canal due to lack of demand. With 10 percent adoption rate and 25 percent corporate tax rate if we choose sand filtration as the tertiary technique then industry has to pay Rs.25.85 /m3. If we consider reverse osmosis as the tertiary treatment mechanism industry has to pay Rs. 33.60 /m3. In this context it is worth mentioning that Vrishabhavathi Valley STP in Bangalore which operates under the supervision of BWSSB at a capcity of 60 MLD, supplies tertiary treated wastewater to a number of industries. Its cost of production is between Rs. 10-12 per kilo litre. Industrial tariff rate in Chennai industrial water tariff is Rs. 60/KL and household tariff is Rs. 4/KL. Delhi Jal Board (DJB) is planning to sell water form its sewage tretement plant located in Rithala to two power plants at approximately Rs. 8 per kilo litre. The estimate of Hingorani (2011) reveals that under both public and private arrangements should be within Rs. 4-14 and Rs.5-17 per kilo litre. Our tariff is little bit on the higher side as compared to others mainly because of two reasons. One possible reason is that in the span of 8 years our cost has increased. On the other hand, other studies didn't consider the capital expenditure made for setting up tertiary treatment plant. Hingorani (2011) considered only the capital expenditure incurred for transporting water to industry and its pumping and maintenance cost. The other possible reason could be they might have assumed full adoption in the beginning of the production. If the adoption rate is high obviously the cost will go down substantially. But as the adoption rate increases to 20 percent the cost of tertiary treated water goes down to Rs.14.95 /m3 and Rs.22.70 /m3 for sand filtration and reverse osmosis technologies respectively.

In the baseline scenario we assumed the PPP venture will be taxed at the rate of 25 percent which is current corporate tax regime. But since this is development project PPP might be given exemption from paying corporation tax. In case of zero taxation rule if the adoption rate is 10 percent cost to the industry goes down to Rs. 22.30 and Rs.28.90 for sand filtration and reverse osmosis process. Under the assumption of 20 percent adoption cost goes down further to Rs. 19.85 and Rs. 25.60 for sand filtration and reverse osmosis process respectively.

In the baseline scenario we have assumed that cost of borrowing is 8 percent. But the interest rate might fluctuate in future and if it rises to the level of 10 percent there will be 70-75 paisa increase in the cost of treated water.

We have assumed that the initial adoption rate will be 10 percent for the first year as it takes time to create awareness. Then each year there will be increment by 10 percent so that in 10 years it is possible to sell the whole treated water. In this case the water demand for agriculture is met and then rest is supplied to the industry. We are treating the whole water from the beginning otherwise installed capacity will remain unutilised and environment will be affected even if it is discharged in the canal due to lack of demand.

Vijaywada

There are two types of secondary treatment technologies exist in Vijaywada namely, UASB and MBBR. With 10 percent adoption rate and 25 percent corporate tax rate if we choose sand filtration as the tertiary technique then industry has to pay Rs.24.80/m3 and Rs. 31.60 for sand filtration and reverse osmosis process respectively with UASB technology at the secondary level. The cost of treated water will be slightly higher in case of MBBR technology which are 26.10 and 32.95 for sand filtration and reverse osmosis respectively.

In this context it is worth mentioning that Vrishabhavathi Valley STP in Bangalore which operates under the supervision of BWSSB at a capcity of 60 MLD, supplies tertiary treated wastewater to a number of industries. Its cost of production is between Rs. 10-12 per kilo litre. Industrial tariff rate in Chennai industrial water tariff is Rs. 60/KL and household tariff is Rs. 4/KL. Delhi Jal Board (DJB) is planning to sell water from its sewage tretement plant located in Rithala to two power plants at approximately Rs. 8 per kilo litre. The estimate of Hingorani (2011) reveals that under both public and private arrangements should be within Rs. 4-14 and Rs.5-17 per kilo litre. Our tariff is little bit on the higher side as compared to others mainly because of two reasons. One possible reason is that in the span of 8 years our cost has increased. On the other hand, other studies didn't consider the capital expenditure made for setting up tertiary treatment plant. Hingorani (2011) considered only the capital expenditure incurred for transporting water to industry and its pumping and maintenance cost. The other possible reason could be they might have assumed full adoption in the beginning of the production. If the adoption rate is high obviously the cost will go down substantially. But as the adoption rate increases to 20 percent the cost of tertiary treated water goes down to Rs.9.70/m3 and Rs.15/m3 for sand filtration and reverse osmosis technologies combined with UASB secondary treatment technology. In case of MBBR it goes down to Rs.10.90/m3 and Rs.16.20/m3.

In the baseline scenario we assumed the PPP venture will be taxed at the rate of 25 percent which is current corporate tax regime. But since this is development project PPP might be given exemption from paying corporation tax. In case of zero taxation rules if the adoption rate is 10 percent cost to the industry goes down to Rs.21.25 and Rs.27.10 for sand filtration and reverse osmosis process combined with UASB technology. Under the assumption of 20 percent adoption cost goes down further to Rs.18.85 and Rs.24.00 for sand filtration and reverse osmosis process respectively combined with UASB technology.

In case of zero taxation rule when the adoption rate is 10 percent cost to the industry goes down to Rs.22.45 and Rs.28.20 for sand filtration and reverse osmosis process combined with MBBR technology. Under the assumption of 20 percent adoption cost goes down further to Rs.19.95 and

Rs.25.10 for sand filtration and reverse osmosis process respectively combined with MBBR technology.

In the baseline scenario we have assumed that cost of borrowing is 8 percent. But the interest rate might fluctuate in future and if it rises to the level of 10 percent there will be marginal increase of 80 paisa in case of sand filtration technique with both the technologies and 50-105 paisa in case of reverse osmosis in the cost of treated water.

Financial sources of the ULBs – Resources for Municipal governance

Introduction

Urban Local Bodies directly influence the welfare of the people by providing civic, social and economic infrastructure services and facilities in both urban and peri-urban areas. Given their strategic position in delivering services in the hierarchy of Government set up, following the Constitutional (73rd & 74th) Amendment Acts, more functions, powers and resources have been provided to them. The Constitution (74th Amendment) Act, 1992 has mandated grassroot level democracy in urban areas by assigning the task of preparation and implementation of plans for economic development and social justice to elected municipal councils and wards committees. It has incorporated the Twelfth Schedule into the Constitution of India containing a list of 18 functions as the legitimate functional domain of Urban Local Bodies (ULBs) in the country. In view of this position, the demands placed by the public on municipal authorities for the provision of various civic services have increased considerably.

At the same time urbanization is an important ingredient of economic development. The trend towards greater urbanization is observed across the developing world. Going by this trend, India is slated to have 50 per cent of its population living in cities and towns in the next few decades, up from the current proportion of about 30 per cent. Although India's urban population has been growing, the level and pace of urbanization have been low in comparison with other developed and developing countries. After liberalization of the economy, India made strides in economic growth; a large part of it has been through the contribution of urban areas.

However, over a period of time, the functions and responsibilities of LBs have increased considerably without commensurate enhancement of their resource base. While the Twelfth Schedule of the 74th Amendment Act, 1992 demarcates the functional domain of municipal authorities, the Amendment Act has not provided for a corresponding 'municipal finance list' in the Constitution of India. The assignment of finances has been completely left to the discretion of the State Governments, excepting in that such assignment shall be 'by law'. This has resulted in patterns of municipal finances varying widely across States and in a gross mismatch between the functions assigned to the ULBs and the resources made available to them to discharge the mandated functions. The ULBs depend on the respective State Governments for assignment of revenue sources, provision of inter-governmental transfers and allocation for borrowing with or without State guarantees. Constitutionally built-in imbalances in the functions and finances eventually reflect in the high dependency of urban local bodies on State Governments and of the State Governments on the Central Government. Constitutionally built-in imbalances in functions and finances assigned to various levels of government eventually reflect in the high dependency of local bodies on State Governments and the latter, in turn, on Central Government for funds.

Under the constitutional scheme of fiscal federalism, funds from the Central Government are devolved to the State Governments. Following the recommendations of the State Finance Commissions (SFCs) and taking into account the devolutions made by the Central Finance Commission (CFC), the State Governments are required to devolve resources to their local bodies. However, due to endemic resource constraints, they have not been in a position to allocate adequate resources to their ULBs. This is further compounded by the fact that even the existing sources of revenues are not adequately exploited by many of the ULBs. The above factors have led to rising fiscal gaps in these institutions, with resources drastically falling short of the requirements to meet the backlog, current and growth needs of infrastructure and services in cities, and, thereby, failing to meet with the expectations of citizens and business. To address the fiscal stress, these

bodies may have to resort to borrowings in recent years, often with State Government guarantees, from Housing and Urban Development Corporation (HUDCO), financial institutions, banks, open market, external lending agencies like the World Bank and the Asian Development Bank. This has implications for both Central and State finances, as it reflects the dependency of the ULBs and consequently, the provision of local public services on the policies and programmes. This study is primarily focused to provide a compendium of financial provisions for the Urban Local bodies and carry out a financial feasibility of wastewater reuse for industry and agriculture.

Key Financial Resources for municipal governance

The resource base of urban local bodies (ULBs) typically consists of their own tax and non-tax revenue, state revenue, grants and subsidies from the central and state governments, loans from state governments, loans from banks and other financial institutions and market borrowings.

1. Own revenues – consisting of tax (property tax being the major constituent) and non-tax revenues

The 74th Constitution Amendment Act, 1992 brought uniformity in the constitution of municipal bodies and empowered Indian municipal corporations with the power and authority to operate as self-governing entities. While the Constitution of India does provide for the devolution of tax revenue between the centre and states, there is no provision that mandates devolution of tax revenue or confers the power to impose taxes to urban local bodies. The following table delineates tax and non-tax revenue sources for municipal corporations:

Table 1. 1: Tax and Non-Tax revenue of the ULBs

Sources of Tax Revenue in Indian Cities from Municipal Acts	Sources of Non-Tax Revenue in Indian Cities from Municipal Acts
Advertisement tax	Betterment fees
Betterment / development tax	Birth / death registration fees
Cable operator tax	Dangerous and Offensive Trade license fees
Drainage tax	Duty on transfer of immovable property
Education tax	Fee for building application
Entertainment tax	Fee for fire services
Entry/terminal tax	Fees for registration of animals
Environment tax / land revenue	Fees on dogs
Latrine tax	Market fee
Octroi (local taxes on goods entering the city)	Mutation fees
Passengers and goods tax	Parking fees
Pilgrim tax	Penalty for late tax payment
Profession tax	Receipts from fines
Property tax	Receipts from interest
Sanitation/ conservancy tax	Rent from municipal properties
Scavenging tax	Sanitation/ conservancy charge
Tax/toll on animals	Slaughterhouse fees
Taxes on vehicles	Stamp duty
Timber tax	Surcharge on sales tax
Toll/tax on bridges/vehicles	Water charges

Source: 74th Amendment, Constitution of India

2. Grants, assignments and devolution by the State Government and grants from Central Government and Finance Commissions

This includes – (i) Plan grants made available through planned transfers from the upper tier of government under various projects, programmes and schemes; (ii) Non-plan grants made available to compensate for the loss of income and some specific transfers.

Two of the most prominent schemes through which ULBs can access funds for urban infrastructure are –

- Atal Mission for Rejuvenation and Urban Transformation (AMRUT), focussing on water supply and sewerage improvement. The mission also includes other components, such as improving storm water drains to reduce flooding; pedestrian, non-motorised and public transport facilities; parking spaces; and green spaces, parks and recreation centres, especially for children. AMRUT has adopted a step-by-step approach wherein the first step and primary objective are to achieve universal coverage of assured water supply and sewerage connections. Once the first step is successfully completed, other benchmarks will be targeted.
- Smart Cities Mission (SCM), aimed at developing smart solutions for selected urban areas. Smart solutions will improve the provision of urban infrastructure and services; they cover water and sanitation, electricity, urban mobility and public transport, affordable housing, IT connectivity and digitalisation, e-governance and citizen participation, sustainable environment, citizen safety, and health and education. SCM has adopted a compact area development approach wherein the focus is on area-based development. This includes transforming existing areas in identified smart cities, including slums, into better planned ones. It also includes the development of new areas around the smart cities to accommodate the expanding population in urban areas. Additionally, the mission emphasizes developing models that incorporate smart solutions, innovation, best practices, and new technology, and that use data and evidence in decision-making.

3. Non Grant financial sources/loans for urban infrastructure

Financing of urban infrastructure typically requires not only a large upfront capital investment, but also periodic replenishment expenditure and annually recurring operations and maintenance expenditures.

Instruments for non-grant financial sources

Government Institutions

Borrowing by ULBs was typically through guaranteed instruments financed by government-owned institutions, such as the Housing and Urban Development Corporation Limited (HUDCO) and Life Insurance Corporation (LIC). Both HUDCO and LIC were mandated by Government of India directives to lend a certain amount to specific sectors, including the urban sector. HUDCO has been a major provider of long-term finance for housing and urban infrastructure. By leveraging central government funds and raising resources directly from the capital market, HUDCO has increased its financing of urban infrastructure projects, particularly water supply, roads and other commercial projects. HUDCO's preferred mode of financing is through the state housing boards, development authorities and municipal corporations. All of its financing carries state government guarantees. Because local government lending involves a specialized kind of financial analysis and its

development lags behind lending to central government and large private firms, specialized financial institutions have been created to meet the financing needs of local governments.

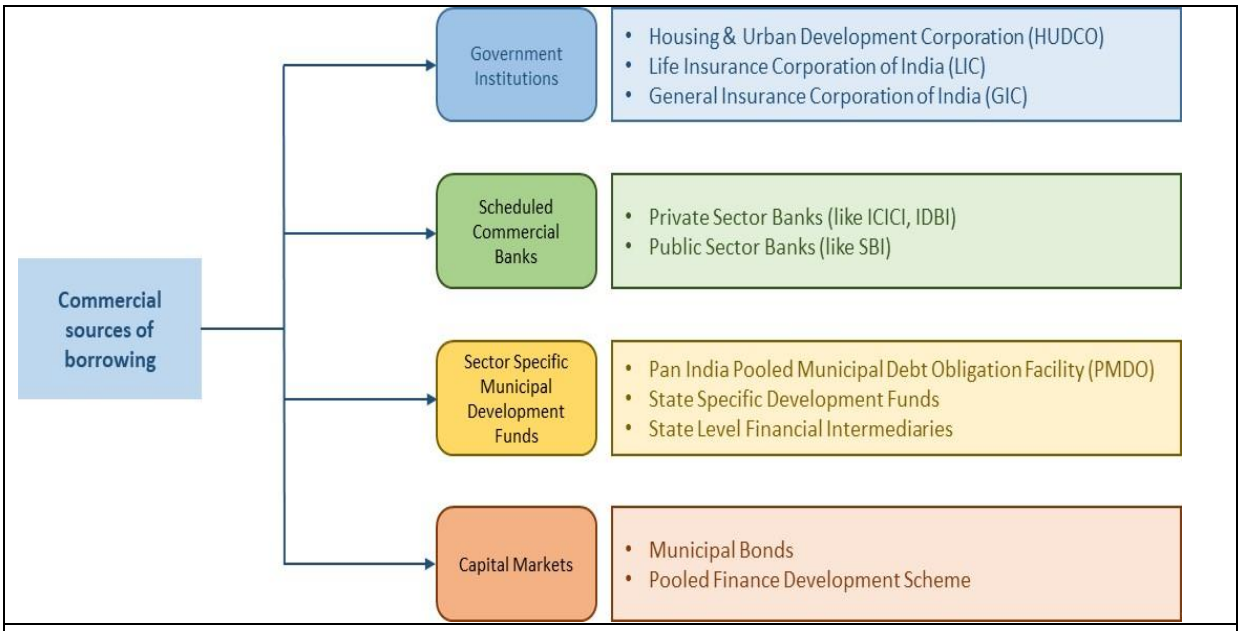


Figure 1. 1: Commercial Sources of borrowings of ILBs

The LIC and GIC have extended term loans to parastatal agencies for urban infrastructure projects, on the basis of state government guarantees. The role of financing and insurance companies has thus been significant in funding and financing urban infrastructure projects. Their lending for urban infrastructure and services has been characterized by the directed credit regime under which different financial institutions were mandated to invest in specific priority sectors. The LIC, for example, was required to invest 25 percent of its annual accretion of funds to social sectors, including water and sanitation. However, financing under this route has reduced in recent years, as explicit State Government guarantees reduced in the context of fiscal pressures on State Governments.

Scheduled commercial banks

Currently, India has 86 Scheduled Commercial Banks (SCBs) – 18 public sector banks (that is, with the Government of India holding a stake), 22 private banks (these do not have government stake; they may be publicly listed and traded on stock exchanges) and 46 foreign banks. SCBs with state or GoI ownership are the most active. Lately, municipal governments have accessed borrowings from banks (government-owned banks and private banks), insurance companies and state development authorities. Since the tenure of commercial banks liabilities is generally short/medium term (< 3 years), municipal governments borrow from these sources to bridge financing gap arising in their capital expenditure programs.

Sector Specific Municipal Development Funds/Facilities

Pan India Pooled Debt Obligation Facility (PMDO)

The Pooled Municipal Debt Obligation (PMDO) facility has been structured through a partnership of 15 Banks/FIs including IL&FS with a corpus of Rs 2750 cr to primarily finance urban local bodies and Special Purpose Vehicles (SPVs) promoted under PPP arrangements, to implement urban infrastructure projects for Water Supply and Sewerage, Solid Waste Management, Roads and Urban Transport, Environmental Projects, Healthcare and Education etc. The underlying strategy of the PMDO is to improve credit worthiness and bankability of urban infrastructure projects, and use

efficient transaction structures built on robust risk management processes, that have been successfully replicated in other Infrastructure sectors. The local bodies are encouraged to conceive and implement projects in the Public Private Partnerships (PPP) framework based on long-term concession agreements, to make service delivery more efficient and to utilize private sector funding by tapping the commercial debt and equity market. This arrangement is expected to relieve the urban local bodies of substantial investment burden on their books and to make scarce public resources available for core civic services. The contributors to the corpus includes –

Table 1. 2: Financial Institutions associated with PMDO

Banks	**Financial Institutions**
Allahabad Bank Bank of India Canara Bank Corporation Bank Dena Bank Indian Bank Oriental Bank of Commerce Union Bank of India Vijaya Bank Syndicate Bank IDBI	IIFCL Life Insurance Corporation of India IL&FS Financial Services Ltd.
Source: http://www.iuiml.com/html/pmdo.html	

State Urban Development Funds

Some states created state-level urban development funds to channelize long-term concessional lines of credit from development institutions and multi-lateral agencies to ULBs. For instance, the Tamil Nadu Urban Development Fund (TNUDF) created to channelize concessional lines of credit available in a non-guaranteed manner, has accessed long-term lines of credit from World Bank, KFW etc. and has managed a good loan recovery performance for more than 20 years. Odisha recently created the Odisha Urban Infrastructure Development Fund (OUIDF) on a similar model. Several other states have tapped multi-lateral lines of credit, albeit on guaranteed mode for financing urban infrastructure programs.

State level Financial Intermediaries

State level Financial Intermediaries has not yet been utilized much in India. Two most prominent examples which have mixed public oversight with private finance—are the Tamil Nadu Urban Development Fund (TNUDF) and the Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC). The Tamil Nadu Urban Development Fund (TNUDF) is a financial intermediary facilitating access to capital markets for the financing of infrastructure by urban local bodies (ULBs, which include municipal corporations, municipalities, and town panchayats) in the Indian state of Tamil Nadu. It was established in 1996 as a trust fund, motivated by the government of Tamil Nadu's successful experience with the Municipal Urban Development Fund financed by the World Bank. The fund is managed by Tamil Nadu Urban Infrastructure Financial Services Limited (TNUIFSL), a public limited company with equity participation from the state of Tamil Nadu and various private financial institutions (ICICI Bank, Housing Development Finance Corporation Limited, and IL & FS Financial Services Limited), making it a PPP with the private sector holding the majority. This arrangement allows for public-sector involvement but keeps management of the fund at a distance from the government.

The TNUDF's financial resources consist of capital provided by the partners as well as funding from a World Bank line of credit, market borrowing, and other institutional borrowing—from the Japan Bank for International Cooperation and KfW (German Development Bank), among others. The fund makes a profit and performs well, with a loan recovery rate of 100% in the financial year 2015/16. Its institutional creditors are repaid through the government of Tamil Nadu and the Indian government. The technical assistance and capacity building provided by TNUDF increase the fiscal, technical, and managerial capacities of the ULBs, for example with regard to accrual-based accounting, collection efficiency, effective service delivery, and tariff rationalization, which is particularly beneficial for smaller ULBs. This increases transparency and makes ULBs more attractive for private investors. It also stimulates further reforms in accounting, tax mobilization, e-governance, decentralization, etc. This public–private debt facility helps to build the creditworthiness of ULBs and advances the development of a municipal debt market, but the lending policies are somewhat rigid. They do not allow for the resetting of interest rates and are not conducive to early repayment of the principal, which reduces their competitiveness with pure market models in the long run.

Similarly, KUIDFC a public-sector company responsible for developing and implementing urban infrastructure projects. It was incorporated in 1993 with an aim to assess the needs of cities and towns, formulate projects, act as a nodal agency for project implementation and raise funds for infrastructure. KUIDFC was in charge of managing the Karnataka Water and Sanitation Pooled Fund (KWSPF), allowing access to the capital market in the Greater Bangalore Water Supply and Sanitation Project.

Specialized Infrastructure Finance Entities

Government of India approved a scheme for financing viable infrastructure projects through a Special Purpose Vehicle called the India Infrastructure Finance Company Ltd. Accordingly, India Infrastructure Finance Company Ltd (IIFCL) was established in January 2006 as a wholly owned Government of India company and commenced its operations from April 2006.

Infrastructure Development Finance Company Limited (IDFC) was set-up as a company focused on development and financing of private infrastructure. Government of India earmarked an amount of Rs 10 billion ($ 20 million) as its contribution to this company. IDFC was conceived as a public-private-partnership with GOI as a 40% equity shareholder. IDFC's balance sheet grew rapidly with CAGR of disbursements at the rate of 48% in the period FY2005 – FY2008. While in the initial years telecom was the mainstay, the portfolio gradually shifted to higher quantum of assets in energy and transport sectors.

Infrastructure Leasing & Financial Services Limited (IL&FS) is one of India's leading infrastructure development and finance companies. IL&FS was promoted by the Central Bank of India (CBI), Housing Development Finance Corporation Limited (HDFC) and Unit Trust of India (UTI). Over the years, IL&FS has broadbased its shareholding and inducted institutional shareholders including State Bank of India, Life Insurance Corporation of India, ORIX Corporation – Japan and Abu Dhabi Investment Authority. IL&FS has a distinct mandate – catalyzing the development of infrastructure in the country. The organization has focused on the commercialization and development of infrastructure projects by provision of value-added financial services. IL&FS has conceived and promoted a pan-India facility for financing urban infrastructure – Pooled Municipal Debt Obligation Facility.

Capital markets

Municipal Bonds

While commercial loans may also be tapped by ULBs to address this requirement, Municipal Bonds when structured well, typically provide greater flexibility in terms of tenure and repayment options. Peterson (2003) elaborates on the benefits of municipal bonds over borrowing from a commercial or municipal bank. First, banks must establish a 'relationship banking' scenario; however, purchasers of bonds are not obligated to have a long-term relationship with the issuer. Moreover, market competition of this kind that focuses on the cost of capital is expected to produce savings for experienced issuers. Second, while the loan departments of banks are required to possess proprietary information regarding a particular ULB—and they must develop techniques to ascertain the creditworthiness of the ULB—a municipal bond market relies on public disclosure of financial and other information by the ULB. Credit rating agencies use extensive methodologies to assess the creditworthiness of issuers, including ULBs, in bond markets. Third, most commercial banks focus on short-term lending, which is appropriate for incremental financing but not for long-term financing.

Municipal Bonds are marketable debt instruments issued by ULBs in India either directly or through any intermediate vehicle (Corporate Municipal entity/statutory body/special purpose distinct entity) with an objective to on-lend towards projects implemented by the ULB. The funds raised may be utilized towards implementation of capital projects, refinancing of existing loans, meeting working capital requirements etc., depending on powers vested with the ULBs under respective municipal legislation. The rationale of bond financing emerges from the following –

1. Leverage future cash flows to finance capital expenditure: ULBs are often required to fund capital projects that require huge capital investments, larger than available resources. Bonds help ULBs to access through finance market investors promising to pay a definite sum of money (as interest/coupon rate and principal after a specified time period) against the borrowing.
2. Attract new long-term investors and resources into urban projects: Bond programs enable ULBs to attract long-term sources and resources from a variety of investors including insurance funds, retirement funds, mutual funds, and external funds.
3. Build a credit profile and credit history: Initial bond issues may require extensive structuring to achieve a good credit rating, by doing regular issuances, ULBs can gradually build a credit profile and history that can bring down financing costs and credit enhancements needs in the medium term.
4. Increasing efficiency and delivery of services: (i) Debt financing has an inherent advantage over grants from higher levels of government (Report on Indian Infrastructure and Service, 2011) since it entail an obligation to repay. Hence, ULBs are constrained to duly plan, design and execute projects with the objectives of obtaining adequate revenues, minimizing operation and maintenance (O&M) costs, and generating a surplus over the O&M costs, which is sustained over the lifetime of the asset created. On the other hand, grants have a tendency to result in soft budget constraints, leading to wasteful expenditure. (ii) Exposure to capital markets require a strong set of disclosure and information sharing. Therefore this pushes the ULBs towards implementing stringent reporting, disclosure standards, monitoring of quality of services (implying greater transparency and accountability towards citizens).
5. Flexibility of both ULBs and investors: The municipal bond mode of financing allows both the borrowers and the lenders to have greater flexibility. Local government bond issuers are likely to be less restricted by annual budget cycles and the capital grants' decisions of higher

levels of government. Further, they can unbundle their functions, which enables them to make separate decisions about the placement of their liquid deposits and about obtaining advice regarding the financial and/or technical components of their infrastructure projects (Peterson, 2003). However, it should be noted that the danger of such unbundling is that a credit partner who understands various aspects, especially the financial impacts of different activities of the ULB on each other, would be absent (Peterson, 2003). The flexibility available to the lenders arises out of the possibility of trading municipal bonds prior to the end of their tenor in the secondary bond market. Liquidity in such a market is essential for the development of the primary municipal bond market.

Types of Bonds issued in India

Municipal Bonds are broadly classified under two categories –

- General Obligation Bonds are bonds issued against the credibility and tax revenues of the issuing municipality. These bonds are issued to raise funds for the projects that do not directly generate revenue unlike roads, railways, etc. Payment to bondholders is done by using the tax revenues generated by the municipality.
- Revenue Bonds are issued to finance revenue-generating projects and the revenue thus generated is used to repay bondholders.

All Municipal Bonds issued by ULBs have been more in nature of general obligation bonds, financed by escrowing property tax or other internal ULB revenues. Most Municipal Bonds in India have been raised to finance water supply and sewerage projects. This is because the Municipal Acts allow levy of user charges, it is technically easy to measure consumption, bill and collect user charges and penalise for non-payment. Further, the amount and frequency of expected revenues can be predicted with some certainty.

Table 1. 3: List of bonds issued in India

Taxable Municipal Bonds in India –

Year	City	Amount (INR Crore)	Project Type
1998	Ahmedabad	100	Sanitation and Water Supply
1999	Ludhiana	10	Sanitation and Water Supply
1999	Nashik	100	Sanitation and Water Supply
2001	Nagpur	50	Water Supply
2001	Madurai	30	City Roads
2004	Visakhapatnam	20	Water Supply

Tax-free Bonds in India

Year	Municipal Bodies	Amount (INR Crore)	Project Type
2002	Ahmedabad Municipal Corporation	1,000	Water supply and sewerage project
2003	Hyderabad Municipal Corporation	825	Road construction and widening
2002	Nashik Municipal Corporation	500	Underground sewerage scheme and stormwater drainage system
2004	Visakhapatnam Municipal Corporation	500	Water supply system
2003	Hyderabad Metropolitan	500	Drinking water project

	Water Supply and Sewerage Board		
2004	Ahmedabad Municipal Corporation	580	Water supply project, stormwater drainage project, road project, bridges and flyovers
2003	Chennai Metropolitan Water Supply & Sewerage Board	420	Chennai water supply augmentation project
2005	Chennai Metropolitan Water Supply & Sewerage Board	500	Chennai water supply project
2005	Chennai Municipal Corporation	458	Roads
2005	Ahmedabad Municipal Corporation	1,000	Roads and water supply
2007	Nagpur	212	Nagpur water supply and sewerage project
Source: Vaidya and Vaidya (2010) Market-Based financing of Urban Infrastructure in India. Book chapter in Kochar and Ramachandran ed. (2010), Building from the bottom. Academic Foundation, New Delhi, India.			

Challenges in Issuance of municipal bonds

Although municipal bond issuance dates back to mid-1990s in India, the number and the value of the issuances are relatively small. During 1998-2010, 25 municipal bond issue were issued in India. These include taxable and tax-free bonds and pooled financing issues raising approximately INR 2700 Crores (USD 386 million) worth of municipal bonds. This is insignificant compared to the INR 120+ lakh Crores (USD 1.7 trillion) Indian bond market. The summary of key problems/constraints faced by ULBs which restrict the capital market issuance are provided below.

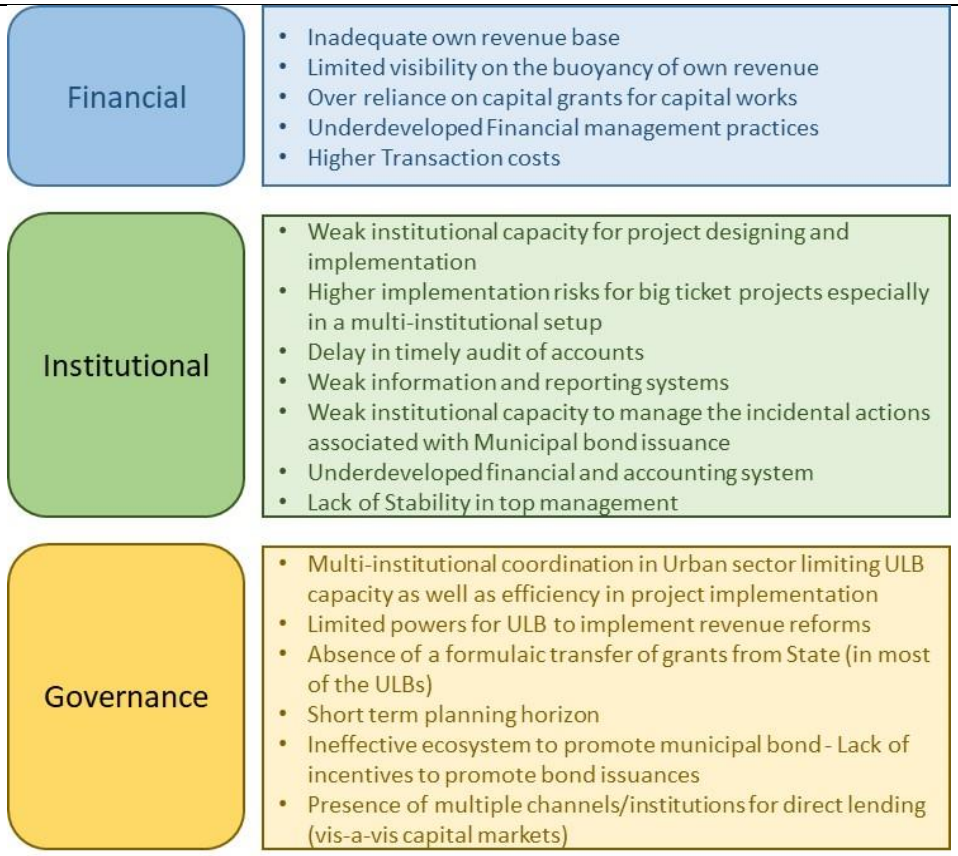


Figure 1. 2: Challenges for Municipal bonds in India

While municipal bonds are perceived as an asset class for risk-averse investors, some of the inherent risks of municipal bonds (similar to other fixed income instruments) include the following.

a. Credit Risk: This risk arises when the issuer fails to make coupon payments and/or principal repayment as per the agreed schedule. Municipal bonds are rated by credit rating agencies to compute the probability of default and measure the associated credit risk relative to other bonds. Investor capital is further preserved by way of bond insurance.
b. Call risk: If a municipal bond is callable, the issuer has the option to repay the principal before its maturity date. An issuer may choose to call the bond if interest rates decline, and then refinance it at a lower rate. This would terminate expected cash flows prematurely.
c. Inflation risk: In an economy plagued by high inflation, interest rates are expected to rise. This would erode value of existing bonds, paying out fixed coupon rates.
d. Interest-Rate Risk: Since municipal bonds pay out fixed coupon rates, investors receive lower than market yield, if interest rates move upwards. The same risk may be mirrored for tax free municipal bonds, if investors expect a reduction in tax rates.
e. Liquidity Risk: In the absence of an active market for a particular municipal bond, the investor may be forced to hold the bond or liquidate it at a lower price.

Municipal Bonds: Pre-Requisites for Effective Issuance

Financial Discipline and Information disclosure: Long term investors are particularly demanding on aspects like accounting discipline, quality of financial reporting and periodicity/level of information dissemination and disclosures. This entails –

- Threshold maturity of accounting systems incorporating accrual accounting principles,
- Timely finalization and audit,

- Timely disclosure of high quality information

SEBI (Issue and Listing of Debt Securities by Municipalities) Regulations, 2015 require ULBs to prepare accounting statements in accordance with the National Municipal Accounts Manual or the State Manual for at least last three years (*Sections 2.2.1 for salient features of SEBI Regulations and 3.1 for aspects related to the financial discipline and disclosure required by ULBs*).

Ring-fenced projects: Well-prepared ring-fenced projects with approved DPRs are an important pre-requisite for successful bond financing structure. This creates a confidence within investors about a clear modality about use of the funds.

Shelf of projects for sustainable financing: In order to attract sustained investor interest in Municipal Bonds as a source of financing of infrastructure projects and services, ULBs would be expected to view the Bonds as an on-going alternative financing channel, rather than as a one-off initiative. Therefore, a ULB which presents a shelf of projects will help long-term investors identify potential investment avenues beyond the first issuance and incentivize them to allocate resources on a regular basis.

Threshold bond issuance size: While the assessed debt capacity of a ULB is a primary determinant in sizing a bond issue, supply-side considerations and transaction costs also need to be factored in. Since bond issuance involves relatively higher transaction costs, a minimum threshold size of issuance is preferable. Further, since, long term funds are expected to be major players in the Municipal Bond market, it would be prudent to factor in market appetite while sizing up a bond issue.

Escrowed Revenues: Addressing risk perception of investors is crucial. Setting up of an escrow mechanism is one of the key solutions for this. The objective of escrowing is to earmark specific revenue streams of the ULB for debt servicing to improve visibility and certainty of cash flows to Investors, thereby improving credit quality and issue rating of the Bonds. The identified revenue streams would have to be sufficient to meet the repayment obligations of the ULB.

Credit Ratings

Details of cities and towns and respective Credit Ratings are as below:

Table 1. 4: Credit ratings of the cities in India

Credit Rating	**Cities/Towns**
AA^+ (3)	New Delhi Municipal Council (NDMC), Navi Mumbai and Pune
AA (3)	Ahmedabad, Visakhapatnam and Greater Hyderabad Municipal Corporation
AA^- (4)	Surat, Nashik, Thane and Pimpri-Chindwad
A^+ (5)	Indore, Kishanganj(Rajasthan), Kolkata, Vadodara(Gujarat) and Warangal(Telangana)
A (1)	Jhunjhunu (Rajasthan)
A^- (8)	Alwar, Bhiwadi, Beawar, Jaipur(Raj), Bhopal,Jabalpur(MP), Mira Bhayandar(Maha) and New Town Rajarhat(W.Bengal)
BBB^+ (5)	Ajmer , Kota and Udaipur(Rajasthan), Ludhiana(Punjab) and Jamnagar(Guj)
BBB (14)	Kakinada, Anantapur, Kurnool and Tirupati (Andhra Pradesh), Davanagere and Hubbali-Dharwar(Karnataka), Kochi and Trivendrum (Kerala), Panaji (Goa), Kolhapur and Nagpur(Maharashtra), Jodhpur, Nagaur and Tonk(Rajasthan)
BBB^- (12)	Amaravati (Maharashtra), Belgavi (Karnataka), Bharuch and Bhavnagar (Gujarat),

	Bharatpur, Bhilwara, Bikaner and Hanumangarh(Rajasthan), Chittor and Cuddapah (Andhra Pradesh), Cuttack (Odisha), Ranchi (Jharkhand).
BB^{+} (14)	Proddatur, Nandyal and Nellore (Andhra Pradesh), Kollam and Kozhikode (Kerala), Kalol, Nadiad and Navsarai (Gujarat), Nanded and Solapur (Maharashtra), Gangapur City, Dhaulpur, Pali and Sawai Madhopur (Rajasthan)
BB (14)	Adoni and Tadipatri (Andhra Pradesh), Dwaraka (Gujarat), Aizawal (Mizoram), Thrisur (Kerala), Berhampur, Rourkela and Sambhalpur (Odisha), Bundi, Churu, Chittorgarh, Hindaun, Jodhpur and Sujangarh (Rajasthan)
BB^{-} (7)	Adityapur, Chas, Deogarh and Giridh (Jharkhand), Mori (Gujarat), Baran and Jhalawar (Raj)
B^{+} (3)	Baripada and Puri (Odisha) and Hazaribagh (Jharkhand)
B (1)	Bhadrak (Odisha)

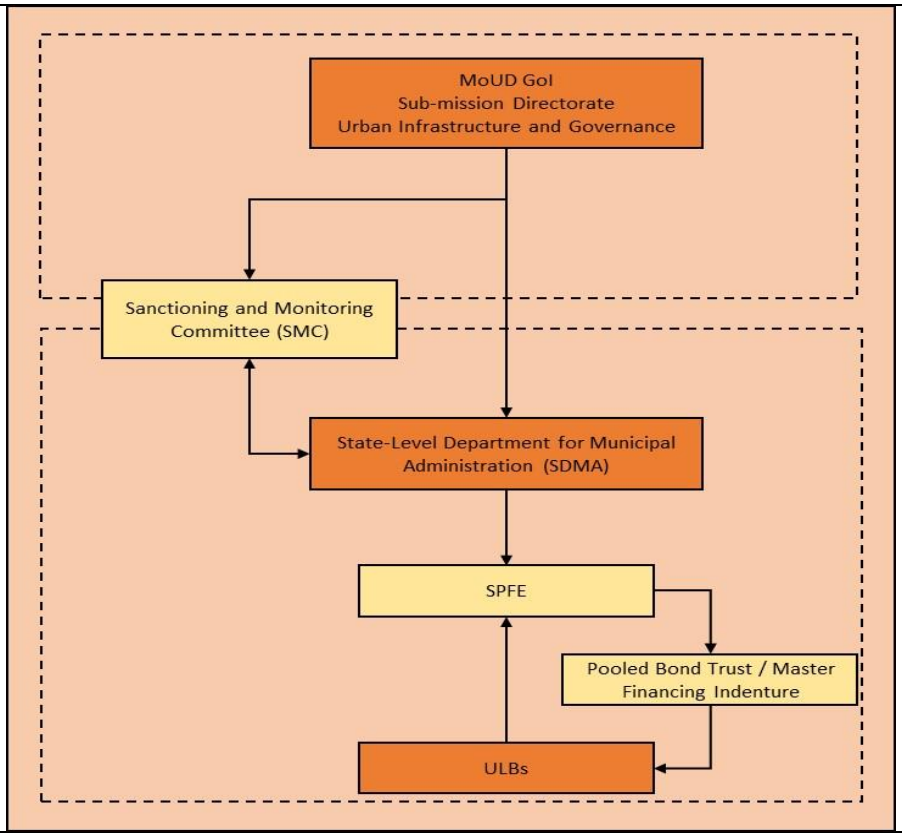
Pooled Finance Development Scheme

In 2006, GoI approved the Pooled Finance Development Fund Scheme (PFDF) to provide credit enhancement to ULBs to access market borrowings through State-Level-Pooled Finance Mechanism. The broad objectives are –

1. Facilitate development of bankable urban infrastructure projects through appropriate capacity building measures and financial structuring of projects.
2. Facilitate Urban Local Bodies to access capital markets through Pooled Financing Bonds on behalf of one or more identified ULBs for investment in urban infrastructure projects, by providing credit enhancement grants to State Pooled Finance Entities (SPFEs).
3. Reduce the cost of borrowing to local bodies with appropriate credit enhancement measures and through restructuring of existing costly debts.
4. Facilitate development of Municipal Bond Market.

The SPEFs could either be a trust or a Special Purpose Entity, provided that the entity is only a pass through vehicle. The basic advantage of setting up of SPFE would be that it would enable the ULBs to enter the bond market on a regular basis and take advantage of scaled up operations. Further, efficient SPFEs can generate fair degree of goodwill in the bond market and may be able to achieve much higher levels of efficiency in operations than individual ULBs. Most importantly, it shall be able to hedge risks against much larger spectrum of activities than individual ULBs. The Central Government would support SPFEs through the PFDF. Of the funds made available with the Central Government for PFDF, 5% would be utilized for project development assistance. Balance 95% would be utilized for contribution to the Credit Rating Enhancement Fund (CREF) to improve the credit rating of the Municipal Bonds to investment grade.

Several states such as Andhra Pradesh, Karnataka, Nagaland, Orissa, Rajasthan, Tamil Nadu, Kerala and Assam have set up SPFE to implement the pooled financing scheme. In Tamil Nadu, the state government has notified the Tamil Nadu Urban Development Fund (TNUDF) as the designated State Pooled Finance Entity. In Karnataka, the nodal agency notified for pooled financing is the Karnataka Urban Infrastructure Development Finance Corporation (KUIDFC). The “Pooled Fund” raised by the SPFE will be lent to specific projects undertaken by one or more ULBs. The borrowing is done through a Special Purpose Vehicle (SPV) that is set up by the SPFE. Investors in the pooled fund benefit from credit enhancements such as escrow account, debt reserve and third party guarantees.



Institutional Framework for Pooled Finance

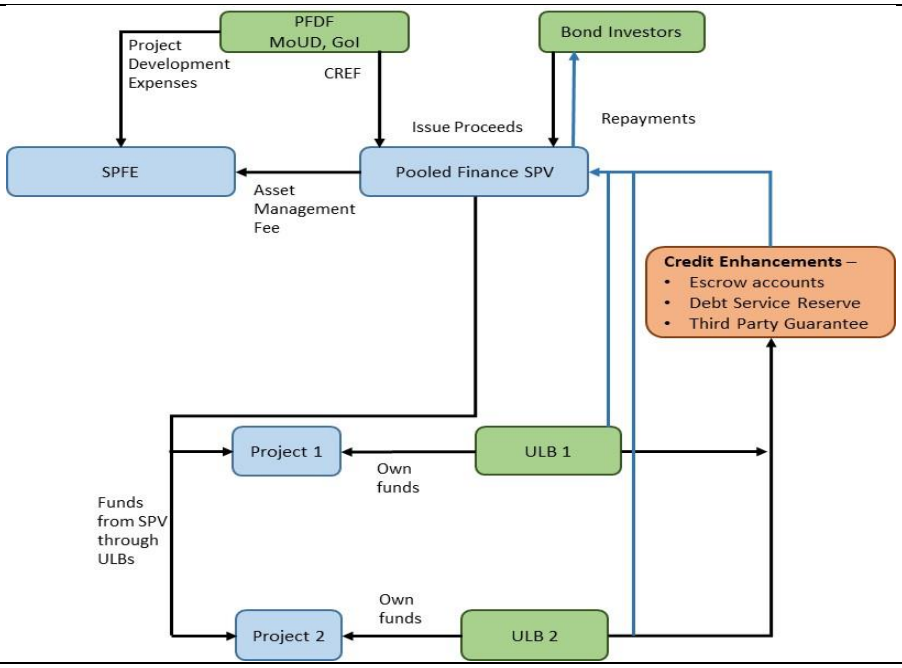


Figure 1. 3: Flow of funds in the Pooled Finance Development Scheme

Source: Ministry of Urban Development, "Pooled Finance Development Scheme Toolkits", 2008

Targeting private capital with the help of Public Private Partnerships (PPPs)

The Government of India has been promoting public private-partnerships (PPP) as an effective tool for bringing in private sector efficiencies for creation of economic and social infrastructure assets and for delivery of quality public services. For financial support to PPPs in infrastructure a Viability

Gap Funding (VGF) Scheme has been implemented. The India Infrastructure Project Development Fund (IIPDF) was launched in December 2007 to facilitate quality project development for PPP projects and ensure transparency in procurement of consultants and projects. The National PPP Capacity Building Programme was launched in December 2010. The following schematic diagram presents the concept of accessing the funds for PPP projects.

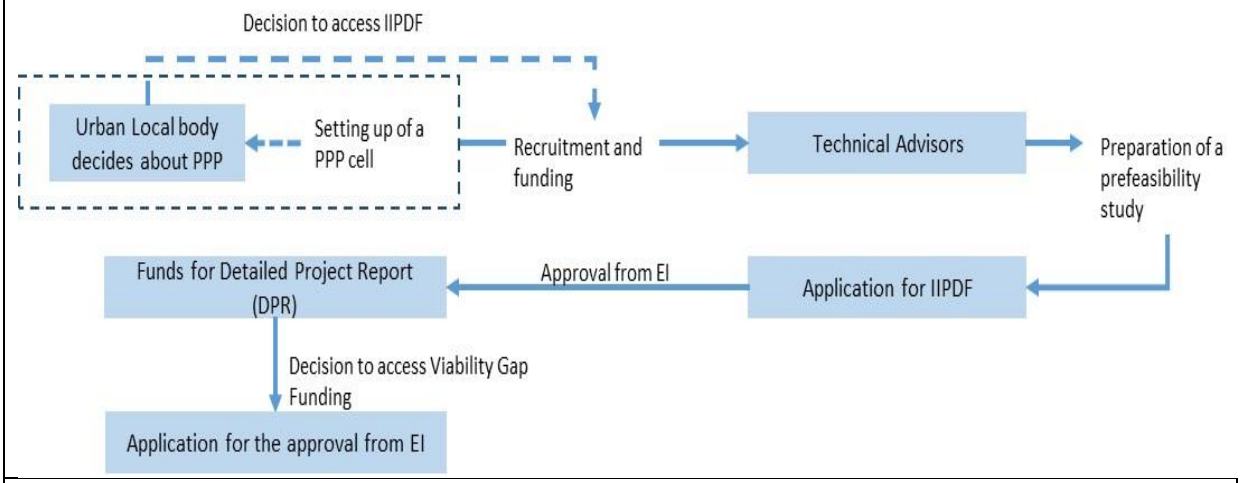


Figure 1. 4: Access to IIPDF and VGF

India Infrastructure Project Development Fund (IIPDF)

IIPDF is a Revolving Fund with a corpus of 100 crore ***to quicken the process of project preparation***. The corpus fund has been created in Department of Economic Affairs, Ministry of Finance, Government of India for supporting the development of credible and bankable Public Private Partnership (PPP) projects that can be offered to the private sector. The procurement costs of PPPs, and particularly the costs of Trasactions Advisors[1], are significant and often pose a burden on the budget of the Sponsoring Authority[2]. Department of Economic Affairs (DEA) has identified the IIPDF as a mechanism through which Sponsoring Authority will be able to source funding to cover a portion of the PPP transaction costs, thereby reducing the impact of costs related to procurement on their budgets. From the Government of India's perspective, the IIPDF must increase the quality and quantity of 'bankable projects' that are processed through the Central or States' project pipeline.

The expenses by the Sponsoring Authority which might be included are as follows - feasibility studies, environment impact studies, financial structuring, legal reviews and development of project documentation, including concession agreement, commercial assessment studies (including traffic studies, demand assessment, capacity to pay assessment), grading of projects etc. required for achieving Technical Close of such projects, on individual or turnkey basis, but would not include expenses incurred by the Sponsoring Authority on its own staff. To seek financial assistance from the IIPDF it would be necessary for the Sponsoring Authority to create and empower a PPP Cell to not

[1] Consultants hired through a transparent system of procurement by the sponsoring authorities to assist them in designing the project and/or providing technical, financial and legal input for the project design, and providing advice for the management of the process of procuring the private sector partner for the PPP project. These include Transaction Advisers selected from the panel of Transaction Advisers announced by DEA from time to time.

[2] Central Government Ministries/Departments, State Governments, Municipal or Local Bodies, Public Sector Undertakings or any other statutory authority (such as the Delhi Development Authority).

only undertake PPP project development activities but also address larger policy and regulatory issues of Sponsoring Authorities. The Fund will assist ordinarily upto 75 percent of the project development expenses to the Sponsoring Authority. On successful completion of the bidding process, the project development expenditure would be recovered from the successful bidder. However, in case of failure of the bid, the assistance would not be recovered. The Sponsoring Authority as a commitment needs to co-fund 25 percent of the development cost (which would include the cost of the prefeasibility study to determine whether the project is amenable to PPP). The IIPDF is administered through an Empowered Institutions which will (i) select projects for which project development costs will be funded; (ii) set the terms and conditions under which the funding will be provided and recovered and (iii) set milestones for disbursing and recovering (where appropriate) the funding. Disbursements by the IIPDF will be made in instalments based on milestones achieved. These milestones will be those set out in the MFC and approved by the EI.

Initially the Sponsoring Authority need to pay for the Technical Advisors for a pre-feasibility get an approval from the EI based on which they receive the fund for further procurement study of the PPP. Within 3 weeks a decision of unconditional funding approval, approval subject to certain conditions or no funding (the conditions may also include confirmation of project details before a commitment of funding, and an assessment of the affordability and value-for-money implications of recovering procurement costs as a success fee from the project) is being made after the application is being made for funding from IIPDF.

Viability Gap Funding (VGF) for private entities in PPP initiatives

To remove the shortcomings of (i) non-availability of infrastructural projects, (ii) non-viability of project due to long gestation gap and limited financial returns, and (iii) to increase flow of private sector resources (both financial, technological and managerial); the Government of India (GoI) is promoting PPPs through a special support known as 'viability gap funding' (VGF). Primarily, the main aim of this support is to reduce the capital cost of the project through credit enhancement and to make them viable and attractive for private investors through supplementary grant funding. Provisions of this facility is made on a year-to-year basis.

GoI has established a VGF to financially aid the PPP infrastructure projects in the form of grants, one time or deferred and is administered through the Ministry of Finance. Provision has been made to provide up to 20 percent of the total project cost as capital gap to meet the funding gap. Further, in such projects the sponsoring agency/department/state can provide an additional 20 percent of the project cost VGF support.

VGF scheme aims towards addressing the following concerns –

- The issue of 'affordability' of user-fee
- Leverage government grant for the commercial viability of the project
- Promote user-pay principle
- Ensure market-based selection of the developer/promoter
- Promote the concept of developer (in place of 'contractor') and address project life-cycle costs

Applicability of the VGF –

1. These PPP projects can be posed by the central ministry, state governments and statutory authorities (like urban local bodies – Municipal Authorities and Councils) who owns the

underlying asset or private agency with sponsorship form the relevant central or state government agency.

2. This scheme will apply only if contract/concession is awarded in favour of private sector company in which 51 percent or more of the subscribed and paid-up equity is owned and controlled by a private entity.
3. A private company is eligible for VGF if it is selected through a competitive bidding and is responsible for financing, construction, maintenance and operation during the concession period.
4. The project should provide a service against a pre-determined tariff or user charge.

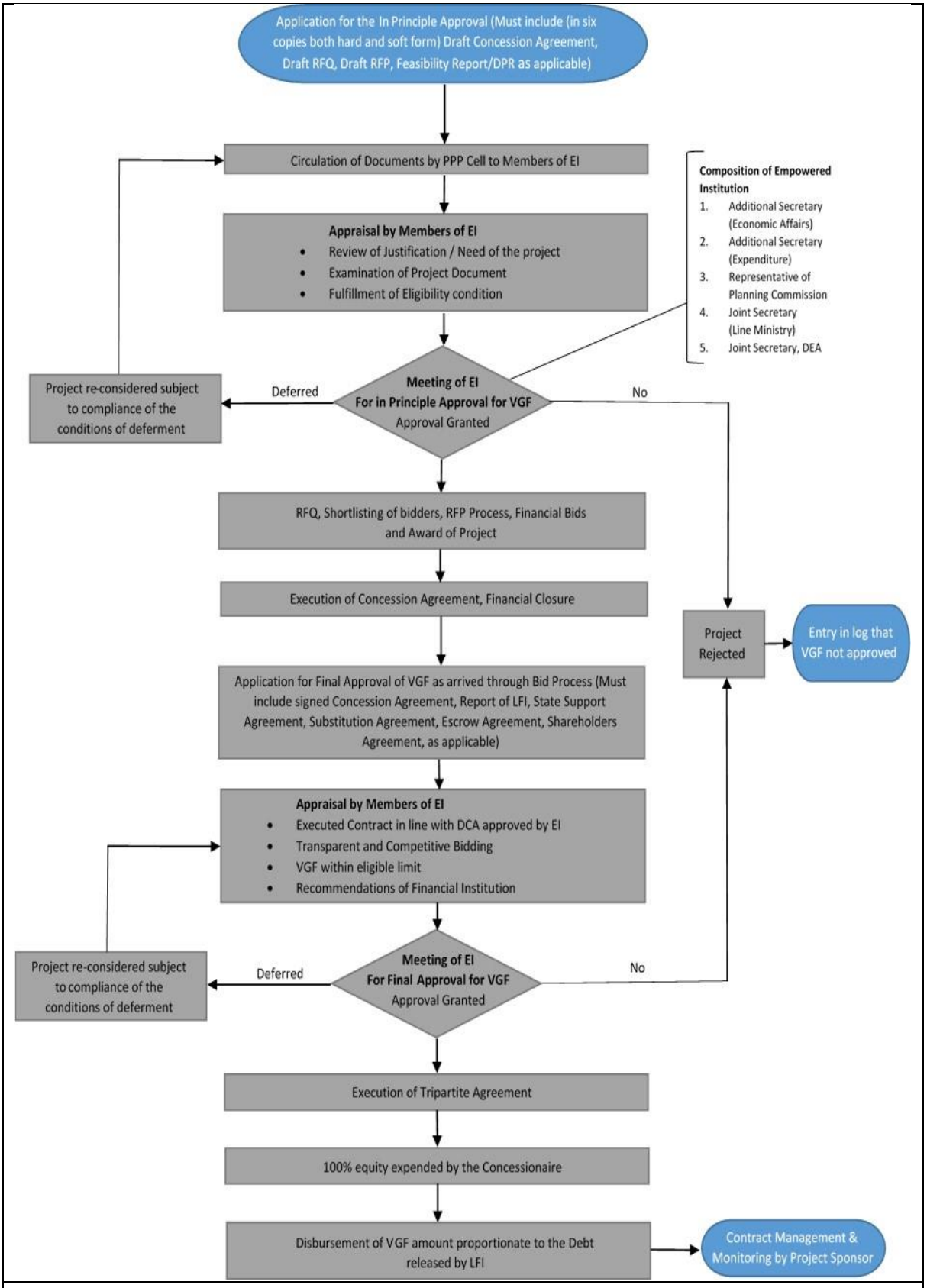
Criteria for funding –

- The project must be implemented (constructed, maintained, and operated) during the project term by an entity with at least 40 percent private equity.
- The project must belong to one of the following sectors –
  - Roads, railways, seaports airports,
  - Power,
  - Water supply, sewerage, and solid waste management in urban areas,
  - International convention centres.
- New sectors added include – (i) irrigation, (ii) terminal markets, (iii) common infrastructure in agricultural markets, (iv) soil testing laboratories, and capital investment in fertilizers, (v) Oil and Gas, (vi) telecommunications.
- The implementing agency must be selected through a transparent and open competitive process. The extent of the VGF shall be determined on the basis of the net present value of the actual VGF required. For this purpose and all calculations, the rate of discount shall be rate of interest on the 10-year gilts on the date of the submission of the bids.

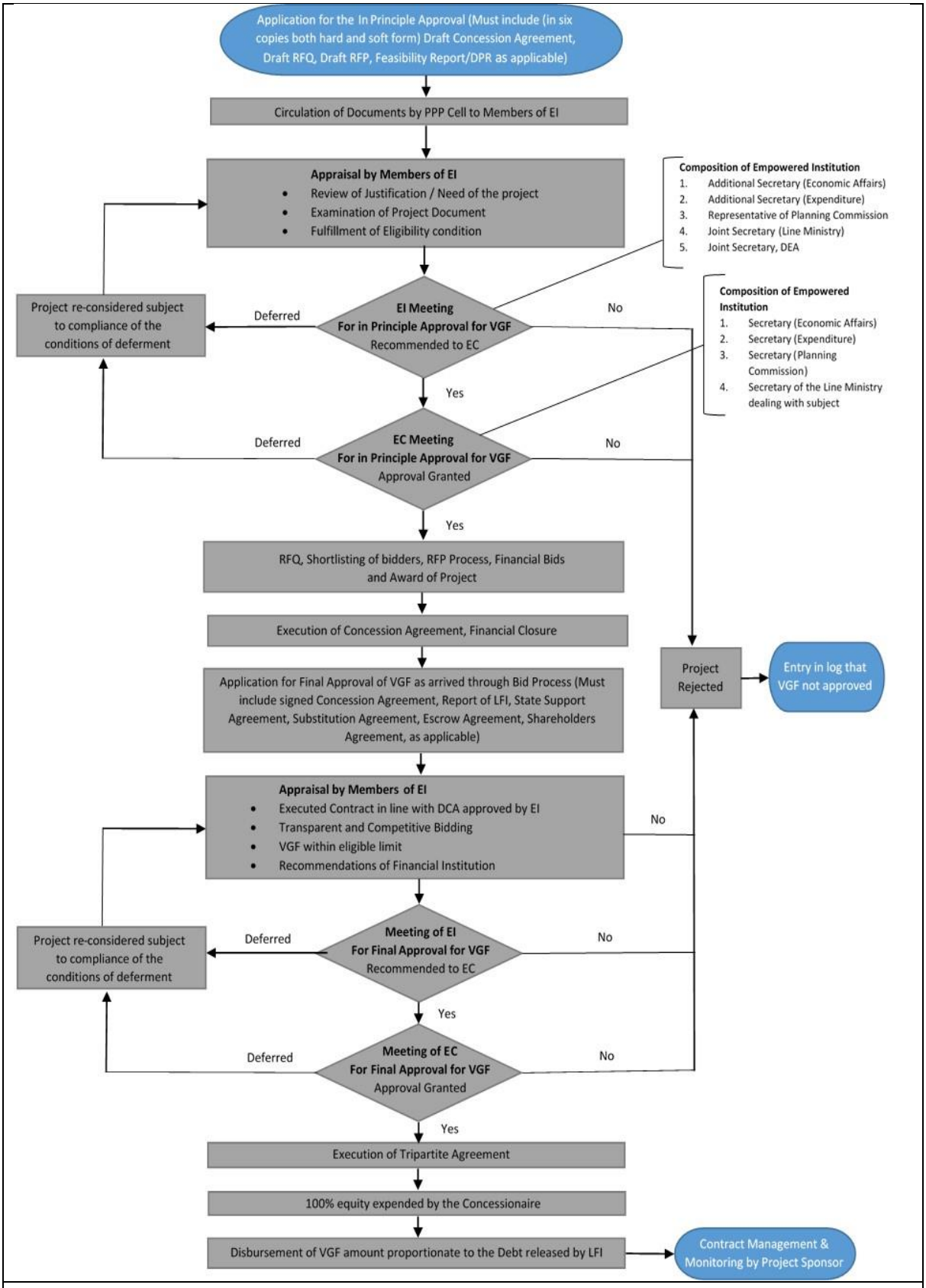
Funding –

VGF can take various forms, including but not limited to capital grant, subordinated loans, operation and maintenance (O&M) support grants or interest subsidy. A mix of capital and revenue support may also be considered. However, the clauses need to be supported through the funding process –

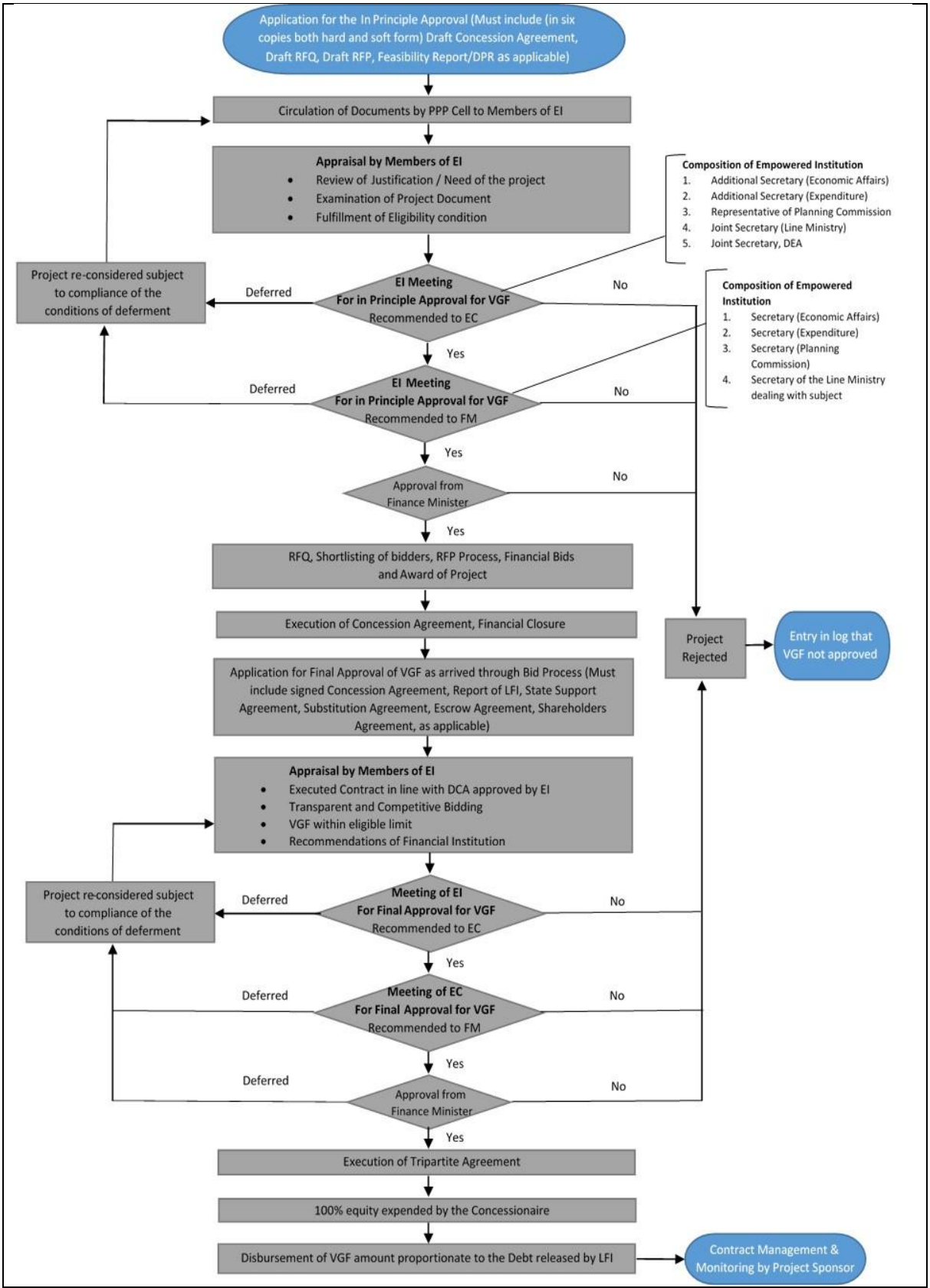
1. The funding is to be disbursed contingent on agreed milestones, preferably physical, and performance levels being achieved as detailed in funding agreements.
2. The funding is to be provided in instalments, preferably in the form of annuities, and with at least 15 percent of the funding to be disbursed only after the project is fully functional.



VGF Process where VGF sought is up to Rs 100 crore



VGF Process where VGF sought is between Rs 100 – 200 crore



VGF Process where VGF sought is more than Rs 200 crore

Figure 1. 5: VGF Process Flow for different valuations

Source:

PPP variants in the sewerage sector:

There exist two major categories of PPPs – (i) Engineering Procurement and Construction (EPC) along with O&M; (ii) concession arrangements. In the first category, the ownership of the project lies with the public entity, and either or both service and management contracts are handed over to the private parties. The private entities therefore are limited to design, build and operate the project **(known as DBO models)** in a time of 5-10 years. The ULB or parastatal meets the capital costs for the project, and uses the private sector to bring in technology and managerial skills to operate and maintain the assets for a period of 5 to 10 years. The construction, technology and operating risks are borne by the private sector operator while the financing risk is borne by the government counterpart. In the second category mentioned, concessions are designed, build, finance, operate and maintain the assets for a longer period, usually more than 10 years. This type can take **Build, Operate and Transfer Model (BOT) models** and **Design, Build, Finance, Operate, Transfer (DBFOT) models** into consideration which has different variants as explained below.

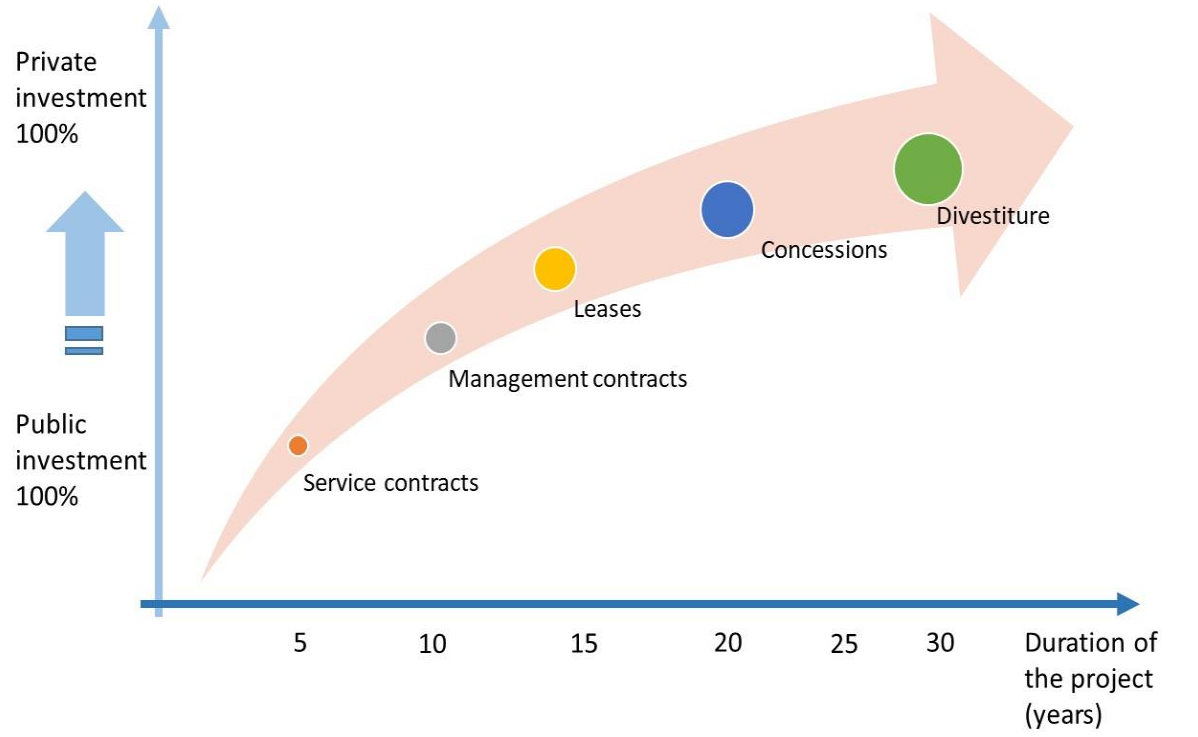


Figure 1. 6: Spectrum of the private participation

Build, Operate and Transfer Model (BOT) – these models are concessions, where the private sector designs, constructs, finances capital expenditure, operates and maintains all assets and at the end of the concession period returns it to the Concession Granting Authority (CGA). There exits ***three*** variants of this model –

1. BOT end user PPP – in this case the end user is an industrial firm or a power plant which is a bulk consumer of water. The end user or consumer itself is the private operator, hence owns and takes responsibility for the project. The end user purchases either treated or raw sewage from the ULB / Water Utility from its STPs/discharge points through a long term wastewater supply or purchase contract; conveys it to its facility; and treats it to a level required by it for its internal process and other non-potable uses. The end user is responsible for financing all the capital and operating expenditures required for the

conveyance infrastructure and additional treatment facilities. In certain cases, the end user undertakes to operate the municipal STPs for the ULB / Water Utility at its own cost as well, in return for free treated sewage supplies from the STPs through a long term agreement. The benefit is the cost savings emanating from a stable source of water of the requisite quality for own use at a cost which is lower than the cost of alternative sources of treated water.

Table 1. 5: PPP distinctions according to ownership, capital investment, tenure and risk bearing

Model	Ownership	Management Expertise	O & M	Capital Investment	Commercial Risk	Tenure
Service Agreement	Public	Public and private (limited to selected task)	Public and private (limited to specific activities)	Public	Public	3 – 5 years
Management Agreement	Public	Private	Private	Public	Public	5 – 10 years
Lease	Public	Private	Private	Public shared / Private limited to working capital	Public shared / Private	5 – 15 years
Concession	Public	Private	Private	Private	Private / shared	15 - 25 years
Divestiture	Private	Private	Private	Private	Private	25 years

2. BOT third party PPP (annuity) – in this case the CGA hires a third part to provide services (such as wastewater collection, treatment and supply for reuse services to the end users) and is paid an annuity to cover the capital and O&M costs.
3. BOT third party PPP (user charge) also known as Design, Build, Finance, Operate, Transfer (DBFOT) – the third party hired by the CGA to provide wastewater collection, treatment and supply for reuse services to end users and collects user charges in return to recover capital investments, O&M costs and meet return expectations.

The key success factors for different types of the PPPs are provided in the following table:

Table 1. 6: Key success factors of different types of PPPs

DBO	BOT end user PPP	BOT third party PPP (annuity)	BOT third party PPP (user charge)

1. Proper scoping of the project with extensive technical and financial data to bidders. Have a clear bid selection parameter. 2. Provide O&M/Management fee guarantees to the private party 3. Public sector's source of funding capital expenditures	1. Ownership by the project end-user who is able to design to project based on the user requirement 2. The willingness of the end-user is driven by the economic factors such as cost of procuring water from alternative sources.	1. Proper scoping of the project with extensive technical and financial data 2. Majority (70-90% of the capital expenditure is financed by the grants from the Centre and the States, low cost long tenure loans from multilateral and bilateral agencies. This ensures low annuity payment requirements 3. Contractual assurances of timely annuity payments 4. The private party need to maintain quality of service for receiving the annuity payment. Contractual assurance is provided towards no-charge of penalty in case there is operator non-performance due to inadequate quantity or poor quality of sewage.	1. Proper scoping of the project with extensive technical and financial data 2. Extensive stakeholder consultation on determination of user charges and generate public support for the project. 3. Political will for implementing the user charges such that there is a assured revenue stream for the private sector 4. Provide right to the private sector for – (i) minimum fixed cost coverage guarantee from end-user; (ii) disconnect reuse water supply in case of payment default

Risks associated with the public-private partnerships in Indian urban infrastructure –

Risks in the planning and construction phase includes – changes in the scope, obtaining permits, community opposition. Risks during the projects operating phase arise from nationalization (transfer of ownership from private sector to government entities), breaches of contract and asset-specific regulations. In the termination phase, risks can occur during the duration/renewal of concessions, asset transfers and the decommissioning of assets. Some risks impact the project across its life-cycle – risk associated with change in industry regulations, changes in taxation, currency transfers and convertibility, judicial, corruption and market distortion risks (WEF, 2015).

In addition to the above risks, there exists challenges with PPPs towards wastewater reuse for industry and agriculture. The key challenge or revenue risk is elaborated below –

High Revenue/Payment Risk: All PPP categories ranging from DBOs to BOT Third-Party PPPs except BOT End-User PPPs carry significant payment or revenue risks.

- DBOs: Non-payment or delayed payment of O&M fees including power bills by the counterpart ULB or state government agency is a big risk factor for the private operator in such contracts. Further, there might be delays even for the EPC component of the DBO contract in case there is no financing by international donor agencies or the Central government.
- BOT End-User PPP: Since the end-user is the operator of the plant, there is no payment risk. However, the risks might increase with an unexpected increase in constructions costs

causing an unexpected loss of profit to the end-user. Another risk is inadequate supply of raw or secondary treated sewage by the ULB in terms of both agreed upon quantity and quality, which can affect the operations of the end-user causing a loss in its profits.

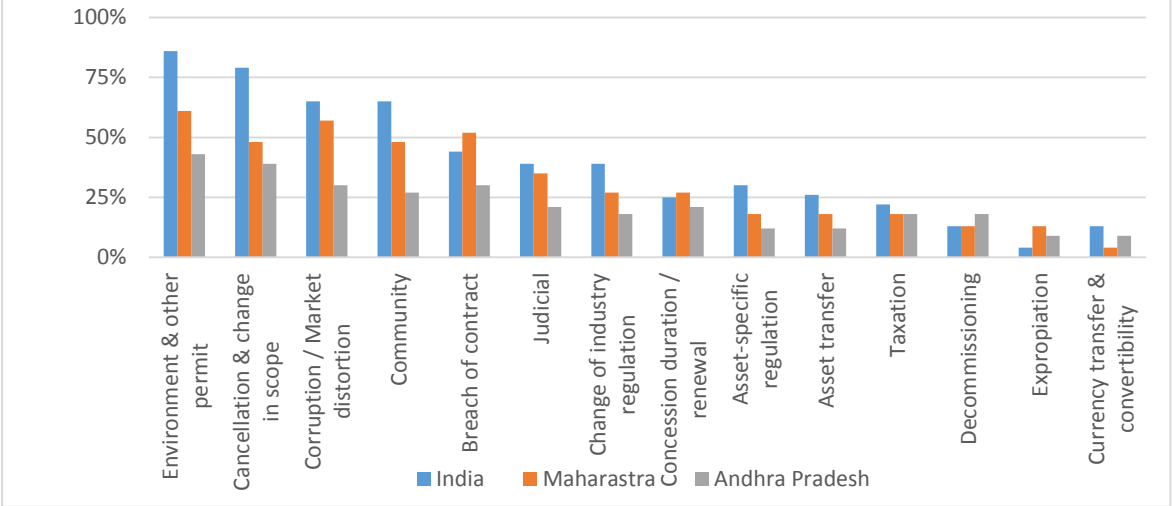


Figure 1. 7: Risks associated with PPPs in India

Source: World Economic Forum (WEF). 2016. Reforms to Accelerate the Development of India's Smart Cities Shaping the Future of Urban Development & Services.

- BOT Third-Party PPP (Annuity): Possibility from frequent non-payment, partial payment or delay in payment of contractually agreed annuity amounts, particularly, if the public sector counterparty is a non-metro city or a financially weak water supply and drainage board of the state government.
- BOT Third-Party PPP (User Charge): In most cases payment for sewage collection and treatment is through the property tax and is not even adequate to cover O&M costs of such systems. Additionally, if freshwater availability is high, the inducement towards paying water tariff by consumers (especially treated wastewater) is quite low.

The other risks at the project level such as inadequate scoping and poor quality data, hasty bid process, land availability and permitting, poor quality of municipal sewage, rigid contracts and limited public / end-user consultations.

One of the ways to circumvent revenue risk concern and allow the private sector to ensure commitment and performance over the duration of the concession is to combine the BOT annuity and DBO models. In such hybrid models, the Concession Granting Authority (CGA) pay 30-40 percent of the capital investment through different instalments linked to the milestones as the construction of the utility progresses. The balance is paid through annuities over the remaining life of the concession. This is unlike the DBO model, where the entire capital investment is borne by the government, and in this model the private sector use their equity during the construction. Further since the O&M costs are usually lower than the capital costs, the private players are not overburdened and usually do not leave during the operational phase. The private sector recover share of capital cost and O&M expenditure through annuities spread over the contractual / operational period. However, the government needs to ensure that it is capable of fulfilling the annuity commitments. Back-stopping arrangements in the form of a fund would provide comfort to both private players and their lenders. The National Mission for Clean Ganga (NMCG) under the Ministry of Water Resources, River Development and Ganga Rejuvenation (Government of India) recently formulated a policy for Public Private Partnership projects in the wastewater sector through

an innovative hybrid annuity model under the ***Namami Gange Program*** in three cities in India – Varanasi (50 MLD STP), Haridwar (2 STPs of 82 MLD) and Mathura (4 STPs of 67 MLD).

Proposed business models

From the above discussion on engaging private equity through PPPs, three different variants of the business model can be proposed on the operational aspects –

(i) **Three party model** – This model is a medium-term tripartite agreement between local body, private developer and industrial units/zones. The contract lay down Design-build-operate type of PPP between the local body and the private entity for a period of 5-10 years after which the wastewater treatment utility is handed back to the local body. The local body provides land and is also the enforcer of the contract through quality compliance and operations. The local body can provide annuities to the private developer for construction, operation and maintenance of the treatment and conveyance facilities or give the right for the user charge collection from the industrial units/zone. The private developed invests in building the treatment plant as well as the conveyance infrastructure and is also responsible for operation of the facilities. They also need to ensure the quality of the water to the industrial consumer who purchase water at a predefined quality, quantity and tariff.

(ii) **End-user PPP model** – This model assumes a contract between the local body and an industrial user. The local body enters into a long-term contract promising a certain volume of wastewater which is treated and reclaimed by the industry for internal consumption. The industry in return pays back for the wastewater at a defined cost and invest and maintain the conveyance units.

(iii) **Two party model** – This model assumes a contract between the local body and a private entity engaged in treatment of wastewater. The local body buy-back the reclaimed wastewater and sell the water to industrial units/industrial zones and in turn provides annuity to the private entity for operation and maintenance of the wastewater treatment plant.

In the following chapters we discuss about financial feasibility of implementing wastewater reuse for industry and agriculture in the two cities of Solapur and Vijayawada respectively with a focus on utilization of private equity through PPPs.

Financial Feasibility Analysis of tertiary treated wastewater used for agriculture and Industry at Solapur

Introduction

Central Pollution Control Board (CPCB) report reveals that 38254 million litres of sewage is generated in India everyday considering both Class I cities and Class-II towns both (CPCB, 2013). Out of which only 30.8% is treated and rest flows into surface water bodies and that contaminates the fresh water bodies in and around cities. Solapur is also not an exception. There are three sewage treatment Plants in Solapur which are operating with Sequential Batch Reactor (SBR) technology. The capacities of plants are 75 MLD, 10 MLD, and 12.5 MLD. 75 MLD plant is located in Degaon and 10 MLD plant is located in Pratap Nagar and the other plant is located in Kumthe. Currently, all the three plants discharge wastewater treated at the secondary level directly into the nearby canal and the water is mostly used to irrigate the plots occupied by sugarcane as only sugarcane withstand this secondary treated water but other crop gets burnt[3] when this water is applied. Moreover, recent literature (2012-16) also suggests that inappropriately treated waste water used for agriculture significantly affects soil texture properties, and also causes possible alterations of the biomass and microbiota (Jaramilo & Restrepo, 2017). Moreover, wastewater treated at the secondary level cannot be used for most of the industries as it does not meet the water quality requirement, in particular Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Nitrate, and Phosphate levels are higher than the permissible level. At present, fresh water required to supply for domestic and industrial use is drawn from Ujani dam. Recently, Maharashtra government has allocated 52.6 million cubic meter of water for National Thermal Power Corporation (NTPC) for its 1320 MW power plant from Ujani dam (Greenpeace, 2016)[4]. The actual water requirement for NTPC plant is 96 MLD. Degaon sewage treatment plant was established with the intention to supply recycled wastewater to NTPC. Since Degaon plant treats water at the secondary level, recycled wastewater cannot be used for the plant. NTPC is supposed to send back 75 MLD water to Solapur Municipal Corporation (SMC) in case it receives the properly treated wastewater. Even if NTPC draws half of the required level of water and the rest can be managed from recycled wastewater, the leftover recycled water can be used for agriculture and other industries. The primary criteria to use the water for industry and agriculture it is essential to treat the water at the tertiary level and then only dependence on fresh water can be reduced to a large extent. As a result of declining dependence on fresh water, sufficient water can be supplied to households which receive water once or twice in a week during summer due to dearth of water at Ujani dam.

It is a well-known fact that in India, urban local bodies are not obliged to treat water beyond secondary level. The burden of even secondary treatment plants remains with Urban Local Bodies (ULBs). Treating water at the tertiary level will impose another level of burden on ULBs. It is needless to say that ULBs do not have requisite funds for operation and achieve integrated wastewater management system. Therefore, the challenge to maintain wastewater systems and achieve resource recovery and reuse is technological, institutional (regulatory and policy framework) as well as financial. We are taking up only one aspect in this study the financial aspect (provided we have different set of technologies to achieve quality parameters for reuse). Therefore, if we add tertiary

[3] Farmers in the command area of Pratap Nagar plant informed this during field work.
[4] We received the same information during field visit to Solapur

treatment facility to the existing secondary treatment plants and treated water is supplied to industry as well as agriculture what type of financial arrangements are needed and what are the possible ways of recovering the expenditures for a sustainable operation of the plant needs attention. In this paper, an attempt is made to find out the feasibility for supplying water treated at the tertiary level to the industry and agriculture in Solapur city. In other words, we are trying to figure out what could be the potential tariff rate for industry and agriculture that would help self-sustaining the system.

Industrial Area and its distance from Sewage Treatment Plants in Solapur

In Solapur district, there are four industrial zones namely-Akkalkot Road, Chincholi, Tembhurni, Mangalvedha, and Kurduwadi. Amongst these four industrial zones Akkalkot Road is the nearest one which is 3 kms away from Solapur city. The other industrial area which is close to Solapur city is Mangalvedha which is around 50 km away from solapur. Rest of the industrial zones are located at least in the 80-120 km range from Solapur city. These industrial areas are mostly dominated by textile, chemical, electrical machinery manufacturing products.

Since the Akkalkot Road is the nearest industrial area in Solpaur, we can think of supplying wastewater to the MIDC Akkalkot Road. The distance from Degaon, Kumthe and Ranna Pratap Nagar STPs to Akkalkot Road MIDC are 10, 16, and 12 kms respectively.

Table 2. 1: Existing Status of Industrial Areas in Solapur District[5]

Area Name	Area (in Hect.)	No. of plots developed	No. of plots allotted	Prevailing rate per Sq. m.	No. of vacant plots
Akkalkot Road	215.48	903	903	3701	NIL
CHincholi	1022.60	720	510	2822	210
Tembhurni	321.44	164	58	1021	106
Mangalvedha	95.06	40	16	1311	24
Kurduwadi	25.97	42	6	1050	38
Total	**1681.55**	**1870**	**1493**		**378**

As the capacity of Pratap Nagar Plant is 10 MLD and the agricultural command area is adjacent to it, water treated at this plant should be used for agriculture only. Water treated at the Degaon Plant and Kumthe Plant can be utilised for both agriculture as well as Industry as the accumulated capacity will be of 87.5 MLD. Even if NTPC is given In order to carry the water to industry we assume that we need to lay a pipeline of 20 km (to reach to Akkalkot Industrial area) and the water required to serve agriculture in the command area under Degaon plant can be directly released into canal for utilisation of farmers.

[5] Presently, we do not have the water demand data from industries situated in MIDC but we know that NTPC needs 96 MLD water to run its operation and Maharashtra Government has sanctioned 52.6 Million cubic meter fresh water from Ujani dam. We can think of supplying 50 MLD treated wastewater to NTPC and rest can be met from fresh water from Ujani dam. Public Heath Engineer revealed that SMC is constructing 3 other STPs in Solapur. Once they are in operation and the pipeline for recovering sewage from households is in place most of the industrial demand can be met from treated wastewater. In 2012, Solapur had a population of 1250000. Assuming a growth rate of 1 percent per year, in 2018 it is probably at the level of 1326900. If we assume that per capita water consumption is 150 litre per day, total waste water generated per day will be of 199 MLD. Therefore, after meeting the NTPC demand we will be left with a sizeable amount of water to cater t the need of agriculture and industry.

Cropping Pattern and Water Demand for Agriculture

Table 2 provides the cropping pattern and crop wise water requirement under Pratap Nagar plant command area. We are also assuming similar cropping pattern under Degaon plant command area as cropping pattern in a region doesn't vary substantially. It is to be noted that the fallow land could be utilised for agriculture provided there is sufficient water supply throughout the year and this is only possible when we supply wastewater treated at the tertiary level.

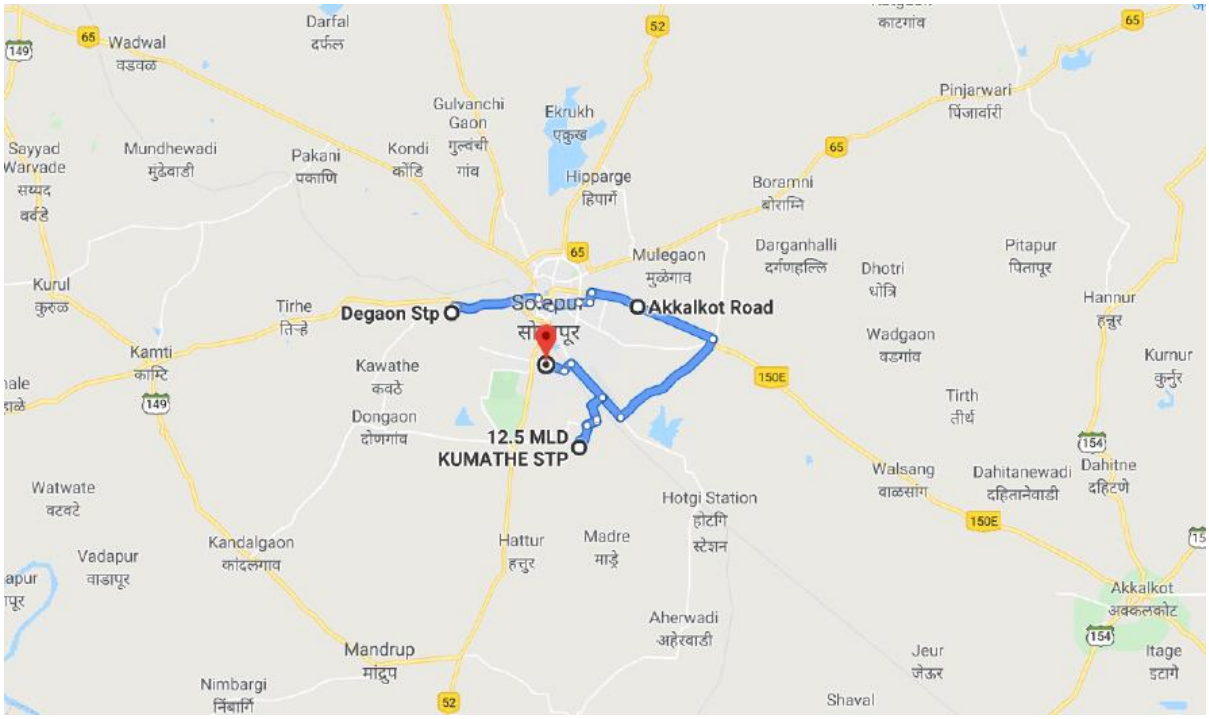


Figure 2. 1: Sewage Treatment Plants and their distance from Akkalkot Road MIDC

Table 2. 2: Cropping Pattern under Pratap Nagar plant command area

Command Area under Pratap Nagar Plant (acre): 1000		
Crops Grown	Area (%)	**Water Requirement(mm/day)**
Sugarcane	30	7
Groundnut	5	6
Mint	5	4
Maize	10	5
Ragi	10	3.26
Cucumber	2	7
Papaya	10	6
Pomegranate	2	4
Tur	5	3
Guava	5	3.5
Fallow Land	16	0

The requirement for tertiary treatment arises from the fact that water quality requirement for the use of wastewater in Industry and agriculture doesn't conform to the quality requirement. Recent

literature (2012-16) also suggests that inappropriately treated waste water used for agriculture significantly affects soil texture properties, and also causes possible alterations of the biomass and microbiota (Jaramilo & Restrepo, 2017). Moreover, wastewater treated at the secondary level cannot be used for most of the industries as it does not meet the water quality requirement, in particular Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Nitrate, and Phosphate levels are higher than the permissible level Table below shows the qualities of wastewater received from sewerage and Central Pollution Control Board (CPCB) norms for discharge of water.

Table 2. 3: Water Quality Characteristics of sewage and CPCB norms

Water Quality Characteristics	Untreated SEWAGE WATER	CPCB NNORMS	SBR	Tertiary Treatment
BOD	110-400	<30	<5	<10
COD	250-1000	<250	<50	<50
TSS	100-350	<20	<10	<2
Nitrates	20-85	--	<10	<10
Phosphates	4-15	--	<1.0	<1.0
Turbidity			16	<5
pH			6.5-7.5	<6.0-7.5
Total Hardness as $CaCO_3$(mg/l)			750	<300
Iron (mg/l)			0.63	<0.25
TDS (mg/l)			2100	<500
Manganese (mg/l)			0.12	<0.10

Water treated at the secondary level using various technologies meets the requirement of CPCB norms. It can be seen that water released through SBR technology meets the parameter requirement and can be used for Low end industrial activity. High end industrial use needs more refinement and that's where we need tertiary treatment of wastewater released through secondary treatment.

Methodology:

In order to carry out the financial feasibility study, we needed to understand ground realities of Solapur city i.e. the status of wastewater treatment, water demand for industry and agriculture surrounding the city. We met Public Health Engineer in SMC. Initially we went with the concern to supply the treated wastewater to National Thermal Power Corporation (NTPC) plant of 1320 MW established recently as it has become a controversial issue. Public Health Engineer claimed that the issue of supplying wastewater to NTPC power plant has been resolved and asked us to figure out if we could do something for agriculture and other industries. She facilitated us for the visit to operational Sewage treatment plants in Degaon, Pratap Nagar. Visit to these plants helped us getting data about the functioning of the STP and data of capital expenditure and operation and maintenance costs under various heads. To understand the demand for farmers we visited the farmers in the command area of Pratap Nagar Plant. Farmers told us their requirement and the problems with the currently treated wastewater. We had collected data about the cropping pattern in the region. To carry out the financial feasibility study we needed data for establishing pipeline, pumping stations, and cost of different tertiary treatment technologies. To collect the cost the cost of establishing pipeline and secondary treatment options we met officials of Bangalore Water Supply and Sewage Board (BWSSB) officials. Information about the cost of tertiary treatment and land

requirement was obtained from practitioners from Taru Leading Edge Pvt. Ltd. who have extensively worked on sewage treatment plants in the past. In addition to the primary survey, we have collected data from the secondary literature available on sewage treatment plants. Majority of the information has been obtained from the report published by Central Pollution Control Board study on performance of sewage treatment plants in India published in the year 2013.

Assumptions:

1. Tertiary treatment unit will be built inside the existing secondary treatment plant as there is sufficient space left out in the Degaon Plant.
2. There will be 10 percent loss of wastewater during processing.
3. The cost of laying 900 mm pipe to carry water will be Rs. 3 crore per kilometre.
4. The cost of laying pipeline to transport the treated water will be borne by ULB. Only maintenance cost and cost of pumping water will be borne by private entity.
5. We are assuming that cost of pumping 1 KL liter water over 10 km is Rs. 1.
6. Power tariff is Rs. 6.3/kwh which has been observed from electricity bill at Degaon plant in Solapur.
7. The capital expenditure for Filtration with Sand (Pressurised sand filters, Activated carbon filters) (4 Filters can be installed 2 of them will be standby) is Rs. 2 lakh per MLD.
8. The capital expenditure for Reverse Osmosis (Microfiltration+RO+Ultraviolet Treatment+Demineralisation) is Rs. 30 lakh per MLD.
9. We assume that operation and maintenance cost for tertiary treatment will be Rs. 562487.
10. Construction of storage facility will require Rs. 40 lkh per MLD.Land requirement for storage facility will be 12141 square meter.
11. Operation and maintenance cost for the storage facility will be 3 percent of total expenditure.
12. Land requirement for Sand filtration plant is 2000 square meter.
13. Land requirement for tertiary treatment plant with reverse osmosis is 4047 square meter.
14. Land cost per acre is Rs. 1.5 crore.
15. We assume that ULBs will provide land for construction of tertiary treatment plant inside secondary treatment facilities.
16. Operation and maintenance cost of secondary treatment using Sequencing Batch Reactor is Rs. 576480.
17. We are assuming 75 MLD waste water will be treated at the tertiary level.
18. Adoption rate in the first year of processing is 10 percent and thereby every year it will increase by 10 percent. Therefore, in 10 years we will be able to achieve 100 percent adoption.
19. Interest rate for borrowing is 8 percent which is the current rate of interest in India.
20. Social Discount rate is 15 percent as suggested for India by literature.
21. Corporate tax rate is 25 percent which is the existing tax rate in India.
22. We are assuming that operation and maintenance cost will go up by 2 percent every year for secondary and tertiary treatment.
23. We assume debt equity ratio will be 70:30.

Table 2. 4: Data Collected from field and secondary sources

Piping rates (Including cost of digging road-		Quantity	Source

laying pipe-closing the road)	Unit		
600-900 mm Diameter Pipe **(Main)**	INR/km	30000000	BWSSB
Length of pipeline for supplying water to Industry (km)	km	20	Assumed
Power Tariff - INR/kWh (Using Multiplying Factor of 30)	Rs/Kwh	6.3	Electricity Bill
Cost of carrying Treated Water using pipeline (Pumping cost)	INR/L/10 Km	0.00000000 758	Hingorani (2011)
Capital Cost of Tertiary Treatment			
Filtration with Sand (Pressurised sand filters, Activated carbon filters) (4 Filters can be installed 2 of them will be standby)	Rs./Liter	0.2	Expert Estimates
Reverse Osmosis (Microfiltration+RO+Ultraviolet Treatment+Demineralisation)	Rs./Liter	3	CPCB(2013)
O&M COST FOR TERTIARY TREATMENT			
Energy Cost for Tertiary Treatment Plant			
Average technology power requirement, kwh/d/MLD (Tertiary Treatment + Tertiary Sludge Handling)		1	CPCB
Average Non-technology Power required, kwh/d/MLD (Tertiary Treatment)		4.5	CPCB
Yearly Power cost for Tertiary Treatment per MLD	INR/MLD	12647	CPCB
Repair Cost/L			
Annual Repair Costs for tertiary treatment[Civil Works, E&M works]	INR/MLD	88000	CPCB
Chemical Cost for tertiary treatment	INR/MLD	445000	CPCB
Manpower Cost[Salary+Benefits] for Tertiary Treatment	INR/MLD	16840	CPCB
Construction Cost of storage (Excluding cost of Land)	Rs./Liter	4	Expert Estimates
Land Requirement for Storage Capacity	Sq meter	12141	Expert Estimates
Operation and maintenance of Storage facility		3%	Expert Estimates
Land Requirement for Tertiary Treatment Plant (Sand Filtration)	Sq meter	2000	Expert Estimates
Land Requirement for Tertiary Treatment Plant (Reverse Osmosis)	Sq meter	4047	Expert Estimates
Land Cost (INR/Acre)	INR/Acre	15000000	Assumed
Subsidy Given by Municipality	INR/Acre	15000000	Assumed
OPERATION & MAINTENANCE COST			
Yearly Power cost (INR/MLD) upto secondary treatment	INR/MLD	334000	CPCB
Annual Repairs cost (INR/MLD) upto secondary Treatment	INR/MLD	116000	CPCB
Annual chemical cost (INR/MLD) upto secondary treatment	INR/MLD	85000	CPCB
Annual Manpower cost(INR/MLD) upto secondary treatment	INR/MLD	41480	CPCB
Total O&M cost (including pre-treatment + primary treatment + secondary treatment using SBR)		**576480**	
Capacity of Secondary Treatment Facility	Liter/day	75,000,000	Stp capacity
Water Loss during processing	Percent	10%	Assumed
Adoption rate in first year	Percent	10%	Assumed
Increment in adoption rate each year	Percent	10%	Assumed
Water discharged by secondary (STP)	cubic meter/day	67500	Calculated

Water demand for Industry	cubic meter/day	49002	Calculated
Total Capital expenditure (Sand Filtration)	INR	915000000	Calculated
Total Capital Expenditure (RO)	INR	1125000000	Calculated
Interest Rate	Percent	8	Assumed
Discount Rate	Percent	15	
Income Tax rate	Percent	25	Assumed
Installment paid per year (sand Filtration)	INR	56893971.08	Calculated
Installment paid per year (RO)	INR	99030862.56	Calculated

Scenario Analysis for Solapur

We have conducted a financial feasibility analysis based on the assumptions mentioned above. (Financial model has been placed in the Annexure). Sensisivity analysis has been carried out with respect to parameters like adoption rate, Income tax rate, interest rate.

We have assumed that the initial adoption rate will be 10 percent for the first year as it takes time to create awareness. Then each year there will be increment by 10 percent so that in 10 years it is possible to sell the whole treated water. In this case the water demand for agriculture is met and then rest is supplied to the industry. Moreover, we are treating the whole 75 MLD water coming out of secondary treatment and out of which in the first year 10 percent of the wastewater adopted by industry and agriculture and thereby each year it increases by 10 percent. We are treating the whole water from the beginning otherwise installed capacity will remain unutilised and environment will be affected even if it is discharged in the canal due to lack of demand. With 10 percent adoption rate and 25 percent corporate tax rate if we choose sand filtration as the tertiary technique then farmers will have to pay Rs. 5/m^3 and industry has to pay Rs.17.15 /m^3. If we consider reverse osmosis as the tertiary treatment mechanism industry has to pay Rs. 24.00 /m^3. In this context it is worth mentioning that Vrishabhavathi Valley STP in Bangalore which operates under the supervision of BWSSB at a capcity of 60 MLD, supplies tertiary treated wastewater to a number of industries. Its cost of production is between Rs. 10-12 per kilo litre. Industrial tariff rate in Chennai industrial water tariff is Rs. 60/KL and household tariff is Rs. 4/KL. Delhi Jal Board (DJB) is planning to sell water form its sewage tretement plant located in Rithala to two power plants at approximately Rs. 8 per kilo litre. The estimate of Hingorani (2011) reveals that under both public and private arrangements should be within Rs. 4-14 and Rs.5-17 per kilo litre. Our tariff is little bit on the higher side as compared to others mainly because of two reasons. One possible reason is that in the span of 8 years our cost has increased. On the other hand, other studies didn't consider the capital expenditure made for setting up tertiary treatment plant. Hingorani (2011) considered only the capital expenditure incurred for transporting water to industry and its pumping and maintenance cost. The other possible reason could be they might have assumed full adoption in the beginning of the production. If the adoption rate is high obviously the cost will go down substantially. But as the adoption rate increases to 20 percent the cost of tertiary treated water goes down to Rs.14.95 /m^3 and Rs.22.70 /m^3 for sand filtration and reverse osmosis technologies respectively.

Table 2. 5: Tariff for Viable Operation according to Adoption Rate

SAND FILTRATION	**Tax Rate:25%**	**Tax Rate: 0%**

	AR: 10%	AR: 20%	AR:10%	AR:20%
Tariff Imposed on agriculture(SBR+SF)	5.00	5.00	5.00	5.00
Tariff Imposed on Industry(SBR+SF)	17.15	14.95	14.95	12.65
REVERSE OSMOSIS				
Tariff Imposed on agriculture (SBR+RO)	5	5	5	5
Tariff Imposed on Industry(SBR+RO)	24.00	22.70	21.20	19.35

In the baseline scenario we assumed the PPP venture will be taxed at the rate of 25 percent which is current corporate tax regime. But since this is development project PPP might be given exemption from paying corporation tax. In case of zero taxation rule if the adoption rate is 10 percent cost to the industry goes down to Rs.14.95 and Rs.21.20 for sand filtration and reverse osmosis process. Under the assumption of 20 percent adoption cost goes down further to 12.65 and 19.35 for sand filtration and reverse osmosis process respectively.

In the baseline scenario we have assumed that cost of borrowing is 8 percent. But the interest rate might fluctuate in future and if it rises to the level of 10 percent there will be marginal increase in the cost of treated water.

Table 2. 6: Tariff when interest rate changes from 8% to 10%

SAND FILTRATION	Tax-25%|adoption rate 10%|Interest rate 8%	Tax-25%| adoption rate 10%|Interest Rate 10%
Tariff Imposed on agriculture(SBR+SF)	5.75	5.00
Tariff Imposed on Industry(SBR+SF)	16.25	17.55
REVERSE OSMOSIS		
Tariff Imposed on agriculture (SBR+RO)	5	5
Tariff Imposed on Industry(SBR+RO)	23.25	24.95

Types of Public Private Partnership

Currently, there are five types of PPP models that exist in Indian wastewater sector. Those are Design Build and Operate (DBO) model, Build Operate and Transfer Model (BOT)-End User PPP, Build Operate and Transfer (BOT) Third Party Annuity, BOT Third Party PPP (User Charge). It has been observed that DBO and BOT-End User models are most successful in wastewater sector in India.

DBO

In this case the private entity will Design build and Operate (DBO) for the term of the project which is 30 years. In this case we assume that Municipal Corporation will fund capital expenditure, provide land for the tertiary treatment plant and it will build pipeline required for transferring water to industry and agriculture as deems convenient. If needed municipality will provide the land required for creation of storage capacity and build the storage capacity. Moreover, Municipality will also bear demand off-take and therefore revenue risk. Private entity will bear the risk of technology, construction, and operation and maintenance. In this case the ULBs will have the liberty to decide the tariff. But private sector will bear the risk of timely payment even though work is completed on time. This could be one possible option.

BOT End-user PPP

In this case the end user takes the risk of design, technology, construction and municipality ensures land required for construction and timely availability of sewage and its quality. This is not a feasible option for us as we intend not only to supply a particular firm but the industry as a whole and agriculture surrounding the cities. This requires operation at large scale and hence we discard this option.

BOT- Third Party Annuity

In this case the private agency will bear the risk of major capital expenditure, along technology, construction and operation and maintenance risk. Municipality takes the risk of partial funding for capital expenditure, and annuity payment to ensure expected returns of the private operator. Demand off-take and thereby revenue risk is borne by the ULBs. This is another feasible option.

BOT- Third Party PPP (User Charge)

In this case the risk of capital expenditure can be partially borne by municipality but majority of capital expenditure has to be borne by private agency along with technology, construction and operation and maintenance cost. But the major risk of demand off-take and revenue has to be borne by private agency. This is other possible option but has been the failure in most of the cases as demand off-take and revenue is often uncertain.

In case we consider the most successful options in wastewater sector in India we find those cases are successful when revenue risk is taken by government. When revenue risks are taken by government, often it translates into loss for the government and hence adds to the fiscal burden. It is a well known fact that ULBs have shortage of funds. Therefore adding burden on the government further cannot be called successful model at all. Therefore, we need to think of some alternative mechanism which doesn't add to the burden of government. We argue that there should be full cost recovery model for sustainability of the venture. Demand off-take is a problem as there are alternative resources available and present policy environment doesn't prevent entities from using those alternate resources and doesn't make sufficient provision. For example, either use of treated waste water is not mandatory and that induces industry to use fresh water or even though there is policy in place government doesn't make sufficient provision for treated wastewater for reuse by the industry. Therefore, a stringent policy should be in place and government needs to make provision for sufficient treated reusable wastewater.

Table 2. 7: Risk Sharing Pattern in different types of PPP

	Capital Expenditure	**Construction**	**Technology**	**Revenue**	**Land**
DBO	Govt.	Private	Private	Govt.	Govt.
BOT End-user PPP	Private	Private	Private	Private	Govt.
BOT- Third Party Annuity	Govt. & Private	Private	Private	Govt.	Govt.
BOT- Third Party PPP (User Charge)	Private	Private	Private	Private	Govt.

Since demand off-take is a problem, we can think of recovering operation and maintenance cost in the beginning, thus keeping the tariff rate low and after few years recovering capital expenditure through imposition of a fixed cost along with variable cost of production. Considering Solapur we see that if we adopt BOT-Third Party PPP (user charge) which will be self-sustainable the uniform tariff rate that is applied is Rs. 5 for agriculture and Rs. 23.10. If we adopt recovering O&M cost policy for first 5 year and recovering fixed cost in next 25 years, then in first 5 years agriculture sector has to

pay a tariff of Rs. 2 and industry Rs.5. Next a fixed tariff of Rs. 3 for agriculture and Rs. 17 for industry can be applied to make this project sustainable in future.

Table 2. 8: Tariff rate under O&M Plus fixed Tariff System

REVERSE OSMOSIS	BOT-Third Party PPP (User Charge)	O&M + FIXED COST 5 YEARS	O&M + FIXED COST 25 YEARS
Tariff Imposed on agriculture (SBR+RO)	5	2	5
Tariff Imposed on Industry(SBR+RO)	24.55	5	23.20

Viability Gap Funding (VGF)

The problem in this case may be tariff might be on the higher side which agriculture and industry might oppose. In that case govt. might fix the rate of supplying water to agriculture and industry. The cost of implementing subsidised rates needs to be borne by Govt. in terms of Viability GAP Funding (VGF). Assuming that the agriculture and industry will be charged at the rate of Rs. 2/m^3 and Rs.10/m^3 [6] respectively, let us find out the VGF fund required for sustainability of the project in Solapur.

In Solapur if we consider SBR technology with Sand Filtration and hold the rate at Rs.2/m^3 and Rs.10/m^3, then VGF fund required to be paid by government is Rs. 36 crore. In case of SBR technology with Reverse Osmosis the VGF fund increases to Rs. 70.5 crore under the assumption of adoption rate of 10 percent in the first year, income tax 25 percent and interest rate 8 percent.

[6] We are assuming this as it is comparable with the Industrial tariff in Bangalore.

Financial Feasibility Analysis of tertiary treated wastewater used for agriculture and Industry at Vijaywada

Introduction

Central Pollution Control Board (CPCB) report reveals that 38254 million litres of sewage is generated in India everyday considering both Class I cities and Class-II towns both (CPCB, 2013). Out of which only 30.8% is treated and rest flows into surface water bodies and that contaminates the fresh water bodies in and around cities. Vijaywada is also not an exception. There are four sewage treatment Plants in Vijaywada which are operating with Upflow Anaerobic Sludge Blanket Reactor (UASB) and Moving Bed Biofilm Reactor (MBBR) technology. The total capacity of these four plants taken together is 150 MLD. These plants are located at Ajithsingh Nagar, Jakkampudi, Ramalingeswara Nagar, and Auto Nagar. Currently, all the three plants discharge wastewater treated at the secondary level directly into the nearby canal or in Krishna River. Recent literature (2012-16) suggests that inappropriately treated waste water used for agriculture significantly affects soil texture properties, and also causes possible alterations of the biomass and microbiota (Jaramilo & Restrepo, 2017). Moreover, wastewater treated at the secondary level cannot be used for most of the industries as it does not meet the water quality requirement, in particular Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Nitrate, and Phosphate levels are higher than the permissible level.

It is a well-known fact that in India, urban local bodies are not obliged to treat water beyond secondary level. The burden of even secondary treatment plants remains with Urban Local Bodies (ULBs). Treating water at the tertiary level will impose another level of burden on ULBs. It is needless to say that ULBs do not have requisite funds for operation and achieve integrated wastewater management system. Therefore, the challenge to maintain wastewater systems and achieve resource recovery and reuse is technological, institutional (regulatory and policy framework) as well as financial. We are taking up only one aspect in this study the financial aspect (provided we have different set of technologies to achieve quality parameters for reuse). Therefore, if we add tertiary treatment facility to the existing secondary treatment plants and treated water is supplied to industry as well as agriculture what type of financial arrangements are needed and what are the possible ways of recovering the expenditures for a sustainable operation of the plant needs attention. In this paper, an attempt is made to find out the feasibility for supplying water treated at the tertiary level to the industry and agriculture in Vijaywada city. In other words, we are trying to figure out what could be the potential tariff rate for industry and agriculture that would help self-sustaining the system.

Industrial area and its proximity to Sewage Treatment Plants

There are 6 identified industrial areas with the total area of 956.65 acres which are existing in and around pilot mandals with 29 large scale industries located within them. In which noted major industries are Vijayawada Thermal power station, Hindustan petroleum, Lanco power, Bharat petroleum and Indian oil corporation.

There are no medium scale enterprises and there are two existing clusters (small scale enterprises) which area Vijayawada pharma cluster and Krishna food processing centre. Major exportable items are Mango and other fruits, pickles, fishes & prawns, limestone, pulses, boiled rice, Handlooms & handicrafts.

Table 3. 1: **Industrial Area in Vijaywada**

IP Name	Land Acquired (acres)	Percentage of land developed
AN KANURU (Phase I)	115.94	65.37
AN KANURU (Phase II)	32.34	100.00
IP GANNAVARA M	10.4	99.48
IP KONDAPALLY	438.19	80.21
IP VIJAYAWADA	53.93	58.90
SEZ GANNAVARAM	30.17	88.30
AN VIJAYAWADA	275.68	62.36

Table 2.2: Industrial water usage

	Vijayawada (Urban)	Vijayawada (Rural)	Gannavaram
Area (Ha)	477.89	438.19	40.57
Annual water usage MLD	870	800	70

Table 2 provides the water requirement for the industry in Vijaywada. Ground water has been the source for major source for the industrial purpose. For industries around the city VMC only supply water for drinking purposes. For the manufacturing and other industrial uses water is being drawn from the ground through borewells.

A **CETP** was established in kanuru to treat the wastewater from the Industrial - Vijayawada, Auto Nagar - Vijayawada, IDA - Kondapally, Coca cola plant – Atmakur, Priya foods – Poranki and the capacity of the effluents treated by the CETP is 200 KLD. Treated water is being used for the median plantation and Green belt plantation. The maintenance and other operations are taken care by Industrial Area Local Authority which is a

Sewage Treatment Situation in Vijaywada

In Vijaywada there are four secondary sewage treatment plants with total capacity of 130 MLD. Soon 20 MLD will be added to the existing capacity. In these plants two types of technologies are used for treating waste water, namely-UASB and MBBR. These plants are located in different parts of city. So we can think of accumulating water in one place and then distributing the water to agriculture and industry.

Table 3. 2: Secondary treatment plants in Vijaywada

Location	Capacity	Year of commission	Status	Technology
Ajithsingh Nagar	20 MLD	2011	Functioning	UASB
	40 MLD	Mar-17	Functioning	UASB
Ramalingeswara Nagar	10 MLD	2005	Functioning	UASB+EA
	20 MLD	2012	Functioning	UASB
Jakkampudi	20 MLD	Mar-17	Functioning	UASB
	20 MLD		Nearing completion	UASB
Auto Nagar	10 MLD	2004	Functioning	UASB+EA
	10 MLD	2019	Functioning	MBBR

Since Jakkampudi plant is very near to canal we can release water directly in canal. Water from the rest three plants needs to be accumulated. To carry water to storage facility and distributing water to industry we need to lay pipeline of around 50 km. To carry the water 900 mm pipe will be laid at the cost of Rs. 3 crore per kilometre. Cost of pumping 1 KL liter water over 10 km is Rs. 1. In this case we assume that capital expenditure for laying pipe will be borne by ULB and operation and maintenance cost of and the cost of pumping water will be borne by the private entity.

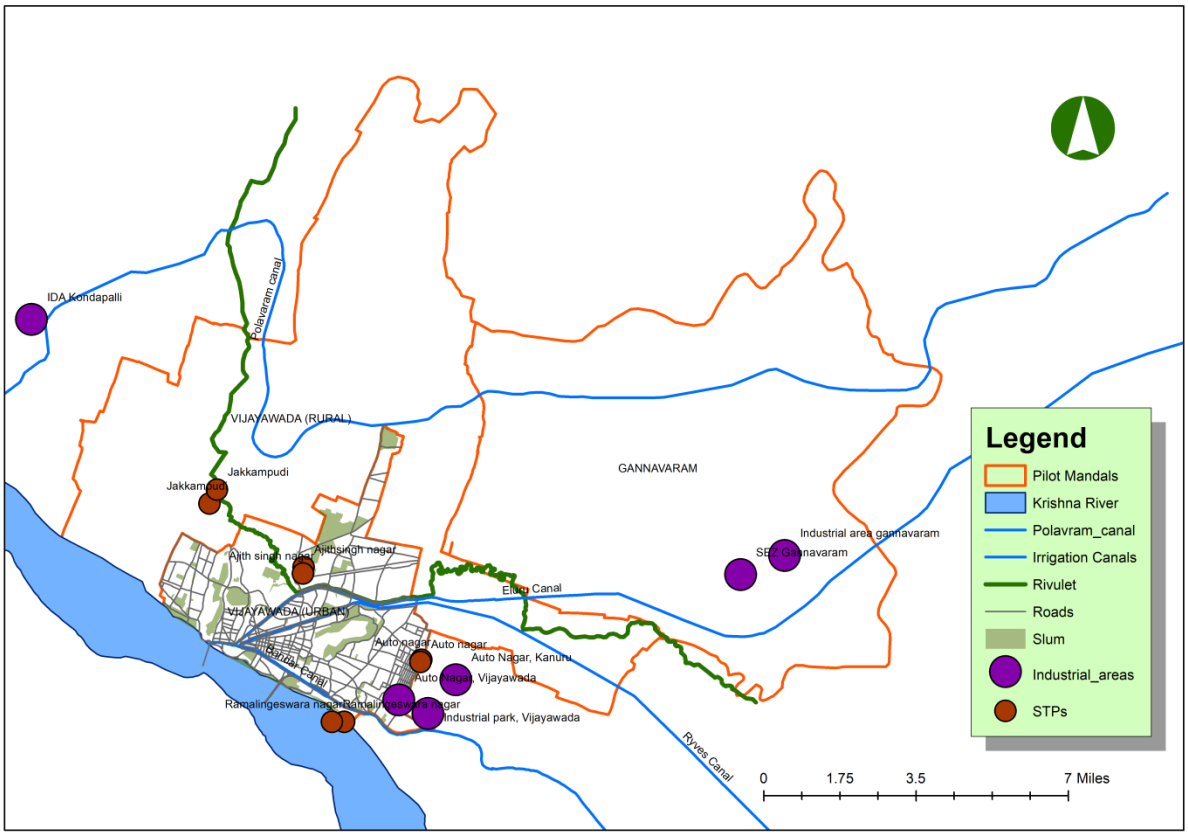


Figure 3. 1: Location of Sewage Treatment Plants and Industrial Areas on Vijaywada

Distribution of Minor and Major irrigation sources

From the table below it is evident that agricultural activity is practiced in Vijayawada rural and Gannavaram mandals. There are 7 Irrigation tanks in Vijayawada rural and 16 Irrigation tanks in Gannavaram which majorly provide water for the agricultural activities. In Vijayawada urban, irrigation canals and tanks which are surface water sources majorly serve 58 percent of agricultural requirement and rest 42 percent comes from ground water.

Table 3. 3: **Irrigated area in Vijaywada**

	Vijayawada (Urban)	Vijayawada (Rural)	Gannavaram
No. of MI Sources (Nos)	0	7	16
Regd. Ayacut (Ha)	0	3589.49	7351.03
Actual Area Irrigated (Ha)	0	3589.49	7110.93

Table 4, 5, 6, and 7 below provide the water requirement of agriculture and cropping pattern in Vijaywada during Khariff and Rabi. From the tables below it is evident that Paddy is the major crop in Vijaywada followed by Maize, Sugarcane, Greengram, Blackgram, Fruits and dryfruits, cotton and Tobacco.

Due to the scarcity of water in the Rabi season the area irrigated is less when compared to the kharif season. Most percentage of water from canals and rivers is diverted for agricultural activities as amount of rainfall is less in Rabi season as compared to Kharif.

Table 3. 4: Agricultural water usage

	Vijayawada (Urban)	Vijayawada (Rural)	Gannavaram
Area under agricultural activities (Ha)	481	10317	14517
Annual water usage MLD	1370	2940	4137
Surface water source MLD	800	1705	2400
Ground water source MLD	580	1235	1738

Table 3. 5: Crop harvesting

Kharif	**Vijayawada (Urban)**	**Vijayawada (Rural)**	**Gannavaram**
	Tonnes		
Paddy	297	4485	6340
Jowar	-	-	0
Maize	-	-	30
Greengram	-	-	1
Blackgram	-	-	63
Redgram	-	-	28
Condiments and spices	-	-	2
Total sugarcane	31	297	490
Fruits & dry fruits	-	2072	2077
Cotton	-	10	539
Rabi	**Vijayawada (Urban)**	**Vijayawada (Rural)**	**Gannavaram**
	Tonnes		
Paddy	184	3148	1510
Jowar	-	-	36
Maize	30	600	810
Greengram	-	20	450
Blackgram	-	50	510
Chillies	-	-	72
Condiments and spices	-	-	72
Total sugarcane	38	234	432
Fruits & dry fruits	-	-	15
Castor	-	-	20
Tobacco	-	-	131

The requirement for tertiary treatment arises from the fact that water quality requirement for the use of wastewater in Industry and agriculture doesn't conform to the quality requirement. Recent literature (2012-16) also suggests that inappropriately treated waste water used for agriculture significantly affects soil texture properties, and also causes possible alterations of the biomass and microbiota (Jaramilo & Restrepo, 2017). Moreover, wastewater treated at the secondary level cannot be used for most of the industries as it does not meet the water quality requirement, in particular Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended

Solids (TSS), Nitrate, and Phosphate levels are higher than the permissible level Table below shows the qualities of wastewater received from sewerage and Central Pollution Control Board (CPCB) norms for discharge of water.

Table 3. 6: Water Quality Characteristics of sewage and CPCB norms

Water Quality Characteristics	SEWAGE WATER	CPCB NNORMS	UASB+EA	MBBR
BOD	110-400	<30	<20	<30
COD	250-1000	<250		
TSS	100-350	<20	<30	<30
Nitrates	20-85	--		
Phosphates	4-15	--		

Methodology:

In order to carry out the financial feasibility study, we needed to understand ground realities of Vijaywada city i.e. the status of wastewater treatment, water demand for industry and agriculture surrounding the city. We visited Vijaywada Municipal Corporation to meet Public Health Engineer and commissioner. In spite of two days visit we could not meet any one of them. Then somehow we managed to get the contact met Public Health Engineer in SMC. In the next step we tried to get the contacts of the person in charge of Sewage Treatment Plants (STPs). We managed and visited four STPs We first visited Ajithsingh Nagar Plant which consists of two separate units- 20 MLD and 40 MLD and both these units use UASB technology. Thereafter, we visited Jakkampudi which also consists of two separate units-20 MLD and 20 MLD. Second unit is near completion and first unit is functional. Both the units run with UASB technology. Third plant we visited in Ramalingeswara Nagar which has two separate units-10 MLD and 20 MLD. 10 MLD unit runs with UASB plus EA technique, and other unit runs with UASB technology. The last plant we visited is in Auto Nagar. It consists of two units-10 MLD, and 10 MLD. One unit is running with UASB technology plus EA and another 10 MLD unit runs with MBBR technology. Currently, all of these plants discharge water in the canal except Ramalingeswara plant which releases water in adjacent Krishna River. There we collected data on capital expenditure, operation and maintenance expenditure, number of staffs, electricity expenditure etc. We have also collected data related to agriculture and industries surrounding the city. Data regarding cropping pattern, industrial activities and their respective water demands. To carry out the financial feasibility study we needed data for establishing pipeline, pumping stations, and cost of different tertiary treatment technologies. To collect the cost the cost of establishing pipeline and secondary treatment options we met officials of Bangalore Water Supply and Sewage Board (BWSSB) officials. Information about the cost of tertiary treatment and land requirement was obtained from practitioners from Taru Leading Edge Pvt. Ltd. who have extensively worked on sewage treatment plants in the past. In addition to the primary survey, we have collected data from the secondary literature available on sewage treatment plants. Majority of the information has been obtained from the report published by Central Pollution Control Board study on performance of sewage treatment plants in India published in the year 2013.

Assumptions:

1. Since there is very limited space inside most of the STPs except Ramalingeswara Nagar, we propose to build a separate tertiary treatment plant in such a place so that minimum distance needs to be covered to transport the treated wastewater to industry and agriculture. The capacity of the tertiary treatment plant should be of 150 MLD which will accommodate the all secondary treated wastewater in one place.
2. There will be 10 percent loss of wastewater during processing.
3. The cost of laying 900 mm pipe to carry water will be Rs. 3 crore per kilometre.
4. The cost of laying pipeline to transport the treated water will be borne by ULB. Only maintenance cost and cost of pumping water will be borne by private entity.
5. We are assuming that cost of pumping 1 KL liter water over 10 km is Rs. 1.
6. Power tariff is Rs. 6.3/kwh.
7. The capital expenditure for Filtration with Sand (Pressurised sand filters, Activated carbon filters) (4 Filters can be installed 2 of them will be standby) is Rs. 2 lakh per MLD.
8. The capital expenditure for Reverse Osmosis (Microfiltration+RO+Ultraviolet Treatment+Demineralisation) is Rs. 30 lakh per MLD.
9. We assume that operation and maintenance cost for tertiary treatment will be Rs. 562487 per MLD.
10. Construction of storage facility will require Rs. 40 lkh per MLD. Land requirement for storage facility will be 12141 square meter.
11. Operation and maintenance cost for the storage facility will be 3 percent of total expenditure.
12. Land requirement for Sand filtration plant is 2000 square meter.
13. Land requirement for tertiary treatment plant with reverse osmosis is 4047 square meter.
14. Land cost per acre is Rs. 1.5 crore.
15. We assume that ULBs will provide land for construction of tertiary treatment plant inside secondary treatment facilities.
16. Operation and maintenance cost of secondary treatment using UASB is Rs. 581400 and Rs. 743540 for MBBR.
17. We are assuming 150 MLD waste water will be treated at the tertiary level.
18. Adoption rate in the first year of processing is 10 percent and thereby every year it will increase by 10 percent. Therefore, in 10 years we will be able to achieve 100 percent adoption.
19. Interest rate for borrowing is 8 percent which is the current rate of interest in India.
20. Social Discount rate is 15 percent as suggested for India by literature.
21. Corporate tax rate is 25 percent which is the existing tax rate in India.
22. We are assuming that operation and maintenance cost will go up by 2 percent every year for secondary and tertiary treatment.
23. We assume debt equity ratio will be 70:30.

Table 3. 7: Data Collected from field and secondary sources

	Unit	Quantity	Source
600-900 mm Diameter Pipe **(Main)**	INR/km	30000000	BWSSB
Length of pipeline for supplying water to Industry (km)	km	20	Assumed

Power Tariff - INR/kWh (Using Multiplying Factor of 30)	Rs/Kwh	6.3	Electricity Bill
Cost of carrying Treated Water using pipeline (Pumping cost)	INR/L/10Km	0.00000000758	Hingorani (2011)
Capital Cost of Tertiary Treatment			
Filtration with Sand (Pressurised sand filters, Activated carbon filters) (4 Filters can be installed 2 of them will be standby)	Rs./Liter	0.2	Expert Estimates
Reverse Osmosis (Microfiltration+RO+Ultraviolet Treatment+Demineralisation)	Rs./Liter	3	CPCB(2013)
O&M COST FOR TERTIARY TREATMENT			
Energy Cost for Tertiary Treatment Plant			
Average technology power requirement, kwh/d/MLD (Tertiary Treatment + Tertiary Sludge Handling)		1	CPCB
Average Non-technology Power required, kwh/d/MLD (Tertiary Treatment)		4.5	CPCB
Yearly Power cost for Tertiary Treatment per MLD	INR/MLD	12647	CPCB
Repair Cost/L			
Annual Repair Costs for tertiary treatment[Civil Works, E&M works]	INR/MLD	88000	CPCB
Chemical Cost for tertiary treatment	INR/MLD	445000	CPCB
Manpower Cost[Salary+Benefits] for Tertiary Treatment	INR/MLD	16840	CPCB
Construction Cost of storage (Excluding cost of Land)	Rs./Liter	4	Expert Estimates
Land Requirement for Storage Capacity	Sq meter	12141	Expert Estimates
Operation and maintenance of Storage facility		3%	Expert Estimates
Land Requirement for Tertiary Treatment Plant (Sand Filtration)	Sq meter	2000	Expert Estimates
Land Requirement for Tertiary Treatment Plant (Reverse Osmosis)	Sq meter	4047	Expert Estimates
Land Cost (INR/Acre)	INR/Acre	15000000	Assumed
Subsidy Given by Municipality	INR/Acre	15000000	Assumed
OPERATION & MAINTENANCE COST of UASB+EA			
Yearly Power cost (INR/MLD) upto secondary treatment	273000	INR/MLD	CPCB
Annual Repairs cost (INR/MLD) upto secondary Treatment	156000	INR/MLD	CPCB
Annual chemical cost (INR/MLD) upto secondary treatment	85000	INR/MLD	CPCB
Annual Manpower cost(INR/MLD) upto secondary treatment	67400	INR/MLD	CPCB
Total O&M cost (includes O&M for pre-treatment+ primary treatment+UASB technology)	**581400**		
OPERATION & MAINTENANCE Cost of MBBR			
Yearly Power cost (INR/MLD) upto secondary treatment	487000	INR/MLD	CPCB
Annual Repairs cost (INR/MLD) upto secondary Treatment	122000	INR/MLD	CPCB
Annual chemical cost (INR/MLD) upto secondary treatment	85000	INR/MLD	CPCB
Annual Manpower cost(INR/MLD) upto secondary treatment	49540	INR/MLD	CPCB
Total O&M cost (includes O&M for pre-treatment+ primary treatment+MBBR technology)	**743540**		
Capacity of Secondary Treatment Facility	Liter/day	150,000,000	STP CAPACITY
Water Loss during processing	Percent	10%	Assumed
Adoption rate in first year	Percent	10%	Assumed
Increment in adoption rate each year	Percent	10%	Assumed
Water discharged by secondary (STP)	cubic meter/day	1350000	Calculated

Water demand for Industry	cubic meter/day	1332712	Calculated
Total Capital expenditure (Sand Filtration)	INR	6300000000	Calculated
Total Capital Expenditure (RO)	INR	10500000000	Calculated
Interest Rate	Percent	8	Assumed
Discount Rate	Percent	15	
Income Tax rate	Percent	25	Assumed
Installment paid per year (sand Filtration)	INR	391728981	Calculated
Installment paid per year (RO)	INR	1599152081	Calculated

Scenario Analysis for Vijayawada

We have conducted a financial feasibility analysis based on the assumptions mentioned above. (Financial model has been placed in the Annexure). Sensisivity analysis has been carried out with respect to parameters like adoption rate, Income tax rate, interest rate.

We have assumed that the initial adoption rate will be 10 percent for the first year as it takes time to create awareness. Then each year there will be increment by 10 percent so that in 10 years it is possible to sell the whole treated water. In this case the water demand for agriculture is met and then rest is supplied to the industry. Moreover, we are treating the whole 150 MLD water coming out of secondary treatment and out of which in the first year 10 percent of the wastewater adopted by industry and agriculture and thereby each year it increases by 10 percent. We are treating the whole water from the beginning otherwise installed capacity will remain unutilised and environment will be affected even if it is discharged in the canal due to lack of demand.

There are two types of secondary treatment technologies exist in Vijaywada namely, UASB and MBBR. With 10 percent adoption rate and 25 percent corporate tax rate if we choose sand filtration as the tertiary technique then farmers will have to pay Rs. 5/m^3 and industry has to pay Rs.13.95/m^3 and 19.05 for sand filtration and reverse osmosis process respectively with UASB technology at the secondary level. The cost of treated water will be slightly higher in case of MBBR technology which are 15.10 and 20.15 for sand filtration and reverse osmosis respectively.

In this context it is worth mentioning that Vrishabhavathi Valley STP in Bangalore which operates under the supervision of BWSSB at a capcity of 60 MLD, supplies tertiary treated wastewater to a number of industries. Its cost of production is between Rs. 10-12 per kilo litre. Industrial tariff rate in Chennai industrial water tariff is Rs. 60/KL and household tariff is Rs. 4/KL. Delhi Jal Board (DJB) is planning to sell water from its sewage tretement plant located in Rithala to two power plants at approximately Rs. 8 per kilo litre. The estimate of Hingorani (2011) reveals that under both public and private arrangements should be within Rs. 4-14 and Rs.5-17 per kilo litre. Our tariff is little bit on the higher side as compared to others mainly because of two reasons. One possible reason is that in the span of 8 years our cost has increased. On the other hand, other studies didn't consider the capital expenditure made for setting up tertiary treatment plant. Hingorani (2011) considered only the capital expenditure incurred for transporting water to industry and its pumping and maintenance cost. The other possible reason could be they might have assumed full adoption in the beginning of the production. If the adoption rate is high obviously the cost will go down substantially. But as the adoption rate increases to 20 percent the cost of tertiary treated water goes down to Rs.9.70/m^3 and Rs.15/m^3 for sand filtration and reverse osmosis technologies combined

with UASB secondary treatment technology. In case of MBBR it goes down to Rs.10.90/m^3 and Rs.16.20/m^3.

In the baseline scenario we assumed the PPP venture will be taxed at the rate of 25 percent which is current corporate tax regime. But since this is development project PPP might be given exemption from paying corporation tax. In case of zero taxation rule if the adoption rate is 10 percent cost to the industry goes down to Rs.12.40 and Rs.16.65 for sand filtration and reverse osmosis process combined with UASB technology. Under the assumption of 20 percent adoption cost goes down further to Rs.8.10 and Rs.12.55 for sand filtration and reverse osmosis process respectively combined with UASB technology.

In case of zero taxation rule when the adoption rate is 10 percent cost to the industry goes down to Rs.13.45 and Rs.17.70 for sand filtration and reverse osmosis process combined with MBBR technology. Under the assumption of 20 percent adoption cost goes down further to Rs.9.20 and Rs.13.65 for sand filtration and reverse osmosis process respectively combined with MBBR technology.

In the baseline scenario we have assumed that cost of borrowing is 8 percent. But the interest rate might fluctuate in future and if it rises to the level of 10 percent there will be marginal increase of 30 paisa in case of sand filtration technique with both the technologies and 70 paisa in case of reverse osmosis in the cost of treated water.

Table 3. 8: Tariff for Viable Operation according to Adoption Rate for UASB & MBBR technology

	UASB+EA		**MBBR**	
	Tax Rate:25%		**Tax Rate: 25%**	
SAND FILTRATION	**AR: 10%**	**AR: 20%**	**AR:10%**	**AR:20%**
Tariff Imposed on agriculture	5	5	5	5
Tariff Imposed on Industry	13.95	9.70	15.10	10.90
REVERSE OSMOSIS				
Tariff Imposed on agriculture	5	5	5	5
Tariff Imposed on Industry	19.05	15.00	20.15	16.20

Table 3. 9: Tariff for Viable Operation according to Adoption Rate for UASB & MBBR technology

	UASB+EA		**MBBR**	
	Tax Rate:0%		**Tax Rate: 0%**	
SAND FILTRATION	**AR: 10%**	**AR: 20%**	**AR:10%**	**AR:20%**
Tariff Imposed on agriculture	5	5	5	5
Tariff Imposed on Industry	12.40	8.10	13.45	9.20
REVERSE OSMOSIS				
Tariff Imposed on agriculture	5	5	5	5
Tariff Imposed on Industry	16.65	12.55	17.70	13.65

Table 3. 10: Tariff when interest rate changes from 8% to 10% in UASB Technology

	UASB+EA		**MBBR**	
	Tax Rate: 25% |AR: 10%		**Tax Rate: 25%| AR: 10%**	
SAND FILTRATION	**IR: 8%**	**IR: 10%**	**IR:8%**	**IR:10%**

Tariff Imposed on agriculture	5	5	5	5
Tariff Imposed on Industry	13.95	14.25	15.10	16.40
REVERSE OSMOSIS				
Tariff Imposed on agriculture	5	5	5	5
Tariff Imposed on Industry	19.05	19.75	20.15	20.85

Types of Public Private Partnership

Currently, there are five types of PPP models that exist in Indian wastewater sector. Those are Design Build and Operate (DBO) model, Build Operate and Transfer Model (BOT)-End User PPP, Build Operate and Transfer (BOT) Third Party Annuity, BOT Third Party PPP (User Charge). It has been observed that DBO and BOT-End User models are most successful in wastewater sector in India.

DBO

In this case the private entity will Design build and Operate (DBO) for the term of the project which is 30 years. In this case we assume that Municipal Corporation will fund capital expenditure, provide land for the tertiary treatment plant and it will build pipeline required for transferring water to industry and agriculture as deems convenient. If needed municipality will provide the land required for creation of storage capacity and build the storage capacity. Moreover, Municipality will also bear demand off-take and therefore revenue risk. Private entity will bear the risk of technology, construction, and operation and maintenance. In this case the ULBs will have the liberty to decide the tariff. But private sector will bear the risk of timely payment even though work is completed on time. This could be one possible option.

BOT End-user PPP

In this case the end user takes the risk of design, technology, construction and municipality ensures land required for construction and timely availability of sewage and its quality. This is not a feasible option for us as we intend not only to supply a particular firm but the industry as a whole and agriculture surrounding the cities. This requires operation at large scale and hence we discard this option.

BOT- Third Party Annuity

In this case the private agency will bear the risk of major capital expenditure, along technology, construction and operation and maintenance risk. Municipality takes the risk of partial funding for capital expenditure, and annuity payment to ensure expected returns of the private operator. Demand off-take and thereby revenue risk is borne by the ULBs. This is another feasible option.

BOT- Third Party PPP (User Charge)

In this case the risk of capital expenditure can be partially borne by municipality but majority of capital expenditure has to be borne by private agency along with technology, construction and operation and maintenance cost. But the major risk of demand off-take and revenue has to be borne by private agency. This is other possible option but has been the failure in most of the cases as demand off-take and revenue is often uncertain.

In case we consider the most successful options in wastewater sector in India we find those cases are successful when revenue risk is taken by government. When revenue risks are taken by government, often it translates into loss for the government and hence adds to the fiscal burden. It

is a well known fact that ULBs have shortage of funds. Therefore adding burden on the government further cannot be called successful model at all. Therefore, we need to think of some alternative mechanism which doesn't add to the burden of government. We argue that there should be full cost recovery model for sustainability of the venture. Demand off-take is a problem as there are alternative resources available and present policy environment doesn't prevent entities from using those alternate resources and doesn't make sufficient provision. For example, either use of treated waste water is not mandatory and that induces industry to use fresh water or even though there is policy in place government doesn't make sufficient provision for treated wastewater for reuse by the industry. Therefore, a stringent policy should be in place and government needs to make provision for sufficient treated reusable wastewater.

Table 3. 11: Risk Sharing Pattern in different types of PPP

	Capital Expenditure	**Construction**	**Technology**	**Revenue**	**Land**
DBO	Govt.	Private	Private	Govt.	Govt.
BOT End-user PPP	Private	Private	Private	Private	Govt.
BOT- Third Party Annuity	Govt. & Private	Private	Private	Govt.	Govt.
BOT- Third Party PPP (User Charge)	Private	Private	Private	Private	Govt.

Since demand off-take is a problem, we can think of recovering operation and maintenance cost in the beginning, thus keeping the tariff rate low and after few years recovering capital expenditure through imposition of a fixed cost along with variable cost of production. We see that if we adopt BOT-Third Party PPP (user charge) which will be self-sustainable the uniform tariff rate that is applied is Rs. 5 for agriculture and Rs. 19.05 for industry. If we adopt recovering O&M cost policy for first 5 year and recovering fixed cost in next 25 years, then in first 5 years agriculture sector has to pay a tariff of Rs. 2 and industry Rs.5. Next a fixed tariff of Rs. 3 for agriculture and Rs. 9.75 for industry can be applied to make this project sustainable in future with UASB plus EA technology. In case of MBBR the fixed tariff is marginally higher for industry by 35 paisa.

Table 3. 12: Tariff rate under O&M Plus fixed Tariff System using UASB + EA

REVERSE OSMOSIS	**BOT-Third Party PPP (User Charge)**	**O&M + FIXED COST 5 YEARS**	**O&M + FIXED COST 25 YEARS**
Tariff Imposed on agriculture	5	2	5
Tariff Imposed on Industry(SBR+RO)	19.05	5	14.75

Table 3. 13: Tariff rate under O&M Plus fixed Tariff System using MBBR

REVERSE OSMOSIS	**BOT-Third Party PPP (User Charge)**	**O&M + FIXED COST 5 YEARS**	**O&M + FIXED COST 25 YEARS**
Tariff Imposed on agriculture (SBR+RO)	5	2	5
Tariff Imposed on Industry(SBR+RO)	20.15	5	15.10

Viability Gap Funding (VGF)

The problem in this case may be tariff might be on the higher side which agriculture and industry might oppose. In that case govt. might fix the rate of supplying water to agriculture and industry. The cost of implementing subsidised rates needs to be borne by Govt. in terms of Viability GAP Funding (VGF). Assuming that the agriculture and industry will be charged at the rate of Rs. 2/m^3 and Rs.10/m^3 [7] respectively, let us find out the VGF fund required for sustainability of the project in Vijaywada.

In Vijaywada if we consider UASB technology along with Sand Filtration and hold the rate at Rs.2/m^3 and Rs.10/m^3, then VGF fund required to be paid by government is Rs. 42.23 crore. In case of UASB technology with Reverse Osmosis the VGF fund increases to Rs. 114 crore under the assumption of adoption rate of 10 percent, income tax 25 percent and interest rate 8 percent.

In Vijaywada if we consider MBBR technology along with Sand Filtration and hold the rate at Rs.2/m^3 and Rs.10/m^3, then VGF fund required to be paid by government is Rs. 59 crore. In case of MBBR technology with Reverse Osmosis the VGF fund increases to Rs. 74 crore under the assumption of adoption rate of 10 percent, income tax 25 percent and interest rate 8 percent.

[7] We are assuming this as it is comparable with the Industrial tariff in Bangalore.

Annexure 1

Study Area Description

Location & Geographical Area:

Solapur is a city located in the south-western region of the Indian state of Maharashtra, close to its border with Karnataka. Solapur is located on major Highway, rail routes between Mumbai, Pune, Bangalore and Hyderabad, with a branch line to the cities of Bijapur and Gadag in the neighbouring state of Karnataka. It is classified as A1 Tier and B-1 class city by House Rent Allowance (HRA) classification by the Government of India. It is the 5th biggest city in Maharashtra. It is also the 49th most populous city and 43rd largest urban agglomeration in India.

Solapur is located at 17.68°N 75.92°E. It has an average elevation of 458 metres (1502 feet). It is bordered by Ahmednagar district on the north; Osmanabad district on the north and northeast, Gulbarga district on the southeast and Bijapur Districts on the south of Karnataka State, Sangli district on the south and southwest; Satara district on the west, and Pune district on the northwest. It is situated at a distance of 410 km from the Maharashtra State Capital of Mumbai by road and train. Solapur is at a distance of 245 km from Pune and 305 km from Hyderabad. Solapur is situated on the Deccan plateau.

As per 2011 census of Solapur city, the population of Solapur in 2011 was 951,118, of whom 50.69 percent were male and 49.31 percent were female. Solapur's population, with the inclusion of its suburbs in 2012, increased to 1,250,000.

In 2011, the total literates in Solapur city are 710,180 of whom 390,335 are males while 319,845 are females. The average literacy rate of Solapur city is 74.66 percent of which male and female literacy was 80.94 and 68.20 percent respectively.

Hinduism is the majority religion in Solapur city with 75.73% followers. Islam is the second most popular religion, with approximately 20.64% following it. Buddhism 1.62% Jainism by 1.00%, Christianity 0.73%, others, no religion and not stated 0.28%.

The civic administration of the city is managed by the Solapur Municipal Corporation, which was established on the Maharashtra Day of 1 May 1964. The corporation oversees the engineering works, health, sanitation, water supply, administration and taxation in the city. The city is divided into 135 wards and 6 zones.

The district has good agricultural land and is mainly fed with river Bhima. Additionally, other sub-rivers - Neera, Mann, Seena, Bhogawati plays an important role in giving necessary water for the district.

Table A1: Financial Analysis and Sequential Batch Reactor (SBR) and Sand Filtration Technique

Profit Loss Statement (Figures are in Rs. Crore)

Year	0	1	2	3	4	5	.....	23	24	25	26	27	28	29
Capital Expenditure														
Cost of Sand Filters	1.5													
Cost of Establishing Reservoirs	30													
Cost of Establishing pipeline to supply water to Industry	60													
Cost of Land for Reservoir	4.5													
Subsidy given by Govt. for Land	-4.5													
Cost of Land for Tertiary plant	0													
Total Capital Expenditure	**91.5**													
Current Expenditure														
O&M cost for SBR		4.3	4.5	4.6	4.7	4.9		8.3	8.5	8.8	9.1	9.3	9.6	9.9
Energy Cost		0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1
Annual Repair Cost		0.7	0.7	0.7	0.7	0.7		0.7	0.7	0.7	0.7	0.7	0.7	0.7
Chemical Cost		3.3	3.3	3.3	3.3	3.3		3.3	3.3	3.3	3.3	3.3	3.3	3.3
Manpower Cost		0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1
Carrying cost of water (Variable cost)		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operation & Maintanance Cost of Storage Facility		0.9	0.9	0.9	0.9	0.9		0.9	0.9	0.9	0.9	0.9	0.9	0.9
Total Current Expenditure		9.4	9.6	9.7	9.8	10.0		13.4	13.7	13.9	14.2	14.4	14.7	15.0
Debt Servicing		2.0	2.0	2.0	2.0	2.0		2.0	2.0	2.0	2.0	2.0	2.0	2.0
Total Outflow	31.5	11.4	11.5	11.7	11.8	11.9		15.4	15.6	15.9	16.1	16.4	16.7	17.0
Revenue														
Revenue from Industry		3.1	6.1	9.2	12.3	15.3		30.7	30.7	30.7	30.7	30.7	30.7	30.7

Year	0	1	2	3	4	5	.....	23	24	25	26	27	28	29
Revenue from Agriculture		0.3	0.7	1.0	1.4	1.7		3.4	3.4	3.4	3.4	3.4	3.4	3.4
Total Revenue		3.4	6.8	10.2	13.6	17.0		34.0	34.0	34.0	34.0	34.0	34.0	34.0
Revenue														
Revenue from Industry		3.1	6.1	9.2	12.3	15.3		27.6	27.6	27.6	27.6	27.6	27.6	27.6
Revenue from Agriculture		0.9	1.8	2.7	3.6	4.5		8.0	8.0	8.0	8.0	8.0	8.0	8.0
Total Revenue		4.0	7.9	11.9	15.8	19.8		35.7	35.7	35.7	35.7	35.7	35.7	35.7
Net Profit	-31.5	-8.0	-4.7	-1.4	1.8	5.1		18.7	18.4	18.2	17.9	17.6	17.4	17.1
Corporate Tax		0.0	0.0	0.0	0.5	1.3		4.7	4.6	4.5	4.5	4.4	4.3	4.3
Profit After tax	-31.5	-8.0	-4.7	-1.4	1.4	3.8		14.0	13.8	13.6	13.4	13.2	13.0	12.8
Net Profit	-31.5	-7.4	-3.6	0.2	4.0	7.9		20.3	20.0	19.8	19.5	19.3	19.0	18.7
Corporate Tax		0.0	0.0	0.1	1.0	2.0		5.1	5.0	4.9	4.9	4.8	4.7	4.7
Profit After Tax	-31.5	-7.4	-3.6	0.2	3.0	5.9		15.2	15.0	14.8	14.6	14.4	14.2	14.0
NPV@10%	₹ 0.21													
NPV@20%	₹ 9.66													

Table A2: Financial Analysis and Sequential Batch Reactor (SBR) and Reverse Osmosis Technique

Profit Loss Statement (Figures in Rs. crore)

Year	0	1	2	3	4	5	.....	23	24	25	26	27	28	29
Capital Expenditure														
Cost of RO	22.5													
Cost of Establishing Reservoirs	30.0													
Cost of Establishing pipeline to supply water to Industry	0.0													
Cost of Land for Reservoir	4.5													
Subsidy given by Govt. for Land	-4.5													
Cost of Land for Tertiary plant														
Total Capital Expenditure	**52.5**													
Current Expenditure														
O&M cost for SBR		4.3	4.5	4.6	4.7	4.9		8.3	8.5	8.8	9.1	9.3	9.6	9.9
Energy Cost		0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1
Annual Repair Cost		0.7	0.7	0.7	0.7	0.7		0.7	0.7	0.7	0.7	0.7	0.7	0.7
Chemical Cost		3.3	3.3	3.3	3.3	3.3		3.3	3.3	3.3	3.3	3.3	3.3	3.3
Manpower Cost		0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.1	0.1	0.1	0.1	0.1
Carrying cost of water (Variable cost)		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operation & Maintanance Cost of Storage Facility		0.9	0.9	0.9	0.9	0.9		0.9	0.9	0.9	0.9	0.9	0.9	0.9
Total Current Expenditure		9	10	10	10	10		13	14	14	14	14	15	15
Debt Servicing		4.7	4.7	4.7	4.7	4.7		4.7	4.7	4.7	4.7	4.7	4.7	4.7
Total Outflow	52.5	₹ 14	₹ 14	₹ 14	₹ 15	₹ 15		₹ 18	₹ 18	₹ 19	₹ 19	₹ 19	₹ 19	₹ 20

Year	0	1	2	3	4	5	.....	23	24	25	26	27	28	29
Revenue														
Revenue from Industry		4.3	8.6	12.9	17.2	21.5		42.9	42.9	42.9	42.9	42.9	42.9	42.9
Revenue from Agriculture		0.3	0.7	1.0	1.4	1.7		3.4	3.4	3.4	3.4	3.4	3.4	3.4
Total Revenue		5	9	14	19	23		46	46	46	46	46	46	46
Revenue														
Revenue from Industry		4.3	8.6	12.9	17.2	21.5		38.6	38.6	38.6	38.6	38.6	38.6	38.6
Revenue from Agriculture		0.9	1.8	2.7	3.6	4.5		8.0	8.0	8.0	8.0	8.0	8.0	8.0
Total Revenue		5	10	16	21	26		47	47	47	47	47	47	47
Net Profit	-52.5	-9	-5	0	4	9		28	28	28	27	27	27	27
Corporate Tax		0	0	0	1	2		7	7	7	7	7	7	7
Profit After tax	-52.5	-9	-5	0	3	6		21	21	21	21	20	20	20
Net Profit	-52.5	-9	-4	1	6	11		29	28	28	28	28	27	27
Corporate Tax		0	0	0	2	3		7	7	7	7	7	7	7
Profit After Tax	-52.5	-9	-4	1	5	8		21	21	21	21	21	20	20
NPV@10%	₹ 0.03													
NPV@20%	₹ 8													

Annexure 2

Study Area Description

Vijayawada is a city on the banks of Krishna River, in Krishna district of the Indian state of Andhra Pradesh. It is one of the twelve urban local bodies and is a highly developed area in the Andhra Pradesh Capital Region. The city is the second largest city in the state by population and third most densely populated urban built-up areas in the world. The city has a population density of 16462 persons per acre.

Vijayawada has been described as commercial, political, media capital of Andhra Pradesh and is one of the rapidly growing urban areas in India. The city is the second most populous in the state with a population of more than one million. It was recognised as a "Global City of the Future" by McKinsey Quarterly, which expected an increase to GDP of $17 billion by 2025. In October 2018, it was awarded with ISO 37120 platinum level certification and has been added to the "Global Cities Registry". It is expected to be the India's 10th fastest growing economy in the world by 2035, a report published by Oxford Economics.

It also serves as an important national hub for rail traffic being one of the busiest railway station in the country and is also the largest railway junction on the South Coast Railway network. The city is home to the largest wagon workshops of Indian Railways. Anchored by Jawaharlal Nehru Auto Nagar Industrial Estate, Vijayawada in the eastern side, Vijayawada has been called both the most economically powerful city and the leading political centre of the state of Andhra Pradesh.

Distribution of population

Population explosion had been the major concern in the city as the city had become the part of the capital region witnessing the increase in migration during the recent years. Meanwhile predominant agrarian economy is transforming into service and industrial hub serving the capital region.

Table 1 below shows that the villages in the peripheral area of the municipal corporation i.e., Gollapudi, Rayanapadu, Paidurupadu, Nidamanuru, Amabapuram, Nunna and Ramavarappadu have a population density of 10000 and above persons per sq. Km

Table 1: Population density in Vijaywada

	Vijayawada (Urban)	Vijayawada (Rural)	Gannavaram
Area (Sq. Km)	62.00	181.00	207.00
Population	1021806	153591	87027
Density (Persons/ Sq. Km)	16462	846	421

Agricultural and allied activities

Table 2: Land utilisation pattern in Vijaywada

Category	Vijayawada (Urban)	Vijayawada (Rural)	Gannavaram
	Area in Ha		
Forest area	121.00	3424.00	600.00
Barren & Uncultivable Land	342.00	194.00	983.00
Land put to Non-Agricultural uses	5263.00	3503.00	4530.00

Category	Vijayawada (Urban)	Vijayawada (Rural)	Gannavaram
Cultivable waste	0.00	142.00	3.00
Permanent Pastures & other grazing lands	0.00	350.00	25.00
Misc. Tree crops & groves not included in net area sown	0.00	219.00	9.00
Other Fallows	100.00	2663.00	1356.00
Current Fallows	24.00	539.00	1885.00
Net Area Sown	357.00	7115.00	11276.00
Total area	6207.00	18149.00	20667.00

Table A1: Financial Analysis of UASB+EA and Sand Filtration Technique

Profit Loss Statement (Figures are in Rs. Crore)

Year	0	1	2	3	4	5	.....	23	24	25	26	27	28	29
Capital Expenditure														
Cost of Sand Filters	30													
Cost of Establishing Reservoirs	600													
Cost of Establishing pipeline to supply water to Industry	0													
Cost of Land for Reservoir	4.5													
Subsidy given by Govt. for Land	-4.5													
Cost of Land for Tertiary plant														
Total Capital Expenditure	**630**													
Current Expenditure														
O&M cost for UASB+EA		87.2	89.8	92.5	95.3	98.2		167.1	172.1	177.3	182.6	188.1	193.7	199.5
Energy Cost		1.9	1.9	1.9	1.9	1.9		1.9	1.9	1.9	1.9	1.9	1.9	1.9
Annual Repair Cost		13.2	13.2	13.2	13.2	13.2		13.2	13.2	13.2	13.2	13.2	13.2	13.2
Chemical Cost		66.8	66.8	66.8	66.8	66.8		66.8	66.8	66.8	66.8	66.8	66.8	66.8
Manpower Cost		2.5	2.5	2.5	2.5	2.5		2.5	2.5	2.5	2.5	2.5	2.5	2.5
Carrying cost of water (Variable cost)		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operation & Maintanance Cost of Storage Facility		18.0	18.0	18.0	18.0	18.0		18.0	18.0	18.0	18.0	18.0	18.0	18.0
Total Current Expenditure		190	192	195	198	201		269	274	280	285	290	296	302
Debt Servicing		46.78	46.78	46.78	46.78	46.78		46.78	46.78	46.78	46.78	46.78	46.78	46.78
Total Outflow	630	₹ 236	₹ 239	₹ 242	₹ 244	₹ 247		₹ 316	₹ 321	₹ 326	₹ 332	₹ 337	₹ 343	₹ 349
Revenue														

Year	0	1	2	3	4	5	.....	23	24	25	26	27	28	29
Revenue from Industry		69.3	138.6	208.0	277.3	346.6		693.2	693.2	693.2	693.2	693.2	693.2	693.2
Revenue from Agriculture		0.3	0.6	0.9	1.3	1.6		3.2	3.2	3.2	3.2	3.2	3.2	3.2
Total Revenue		70	139	209	279	348		696	696	696	696	696	696	696
Net Profit	-630	-167	-100	-33	34	101		380	375	370	365	359	353	348
Corporate Tax		0	0	0	9	25		95	94	92	91	90	88	87
Profit After tax	-630	-167	-100	-33	26	76		285	281	277	273	269	265	261
	₹ 2.55													

Table A2: Financial Analysis UASB+EA and Reverse Osmosis Technique

Profit Loss Statement (Figures in Rs. crore)

Year	0	1	2	3	4	5	…	23	24	25	26	27	28	29
Capital Expenditure														
Cost of RO	450													
Cost of Establishing Reservoirs	600													
Cost of Establishing pipeline to supply water to Industry	0													
Cost of Land for Reservoir	4.5													
Subsidy given by Govt. for Land	-4.5													
Cost of Land for Tertiary plant														
Total Capital Expenditure	**1050**													
Current Expenditure														
O&M cost for UASB+EA		87.2	89.8	92.5	95.3	98.2		167.1	172.1	177.3	182.6	188.1	193.7	199.5
Energy Cost		1.9	1.9	1.9	1.9	1.9		1.9	1.9	1.9	1.9	1.9	1.9	1.9
Annual Repair Cost		13.2	13.2	13.2	13.2	13.2		13.2	13.2	13.2	13.2	13.2	13.2	13.2
Chemical Cost		66.8	66.8	66.8	66.8	66.8		66.8	66.8	66.8	66.8	66.8	66.8	66.8
Manpower Cost		2.5	2.5	2.5	2.5	2.5		2.5	2.5	2.5	2.5	2.5	2.5	2.5
Carrying cost of water (Variable cost)		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operation & Maintanance Cost of Storage Facility		18.0	18.0	18.0	18.0	18.0		18.0	18.0	18.0	18.0	18.0	18.0	18.0
Total Current Expenditure		190	192	195	198	201		269	274	280	285	290	296	302
Debt Servicing		₹ 111.4	₹ 111.4	₹ 111.4	₹ 111.4	₹ 111.4		₹ 111.4	₹ 111.4	₹ 111.4	₹ 111.4	₹ 111.4	₹ 111.4	₹ 111.4
Total Outflow	1050	₹ 301	₹ 304	₹ 306	₹ 309	₹ 312		₹ 381	₹ 386	₹ 391	₹ 396	₹ 402	₹ 407	₹ 413
Revenue														
Revenue from Industry		97.29	194.58	291.86	389.15	486.44		972.88	972.88	972.88	972.88	972.88	972.88	972.88

Year	0	1	2	3	4	5	…	23	24	25	26	27	28	29
Revenue from Agriculture		0.13	0.25	0.38	0.50	0.63		1.26	1.26	1.26	1.26	1.26	1.26	1.26
Total Revenue		97	195	292	390	487		974	974	974	974	974	974	974
Net Profit	-1050	-204	-109	-14	81	175		593	588	583	578	572	567	561
Corporate Tax		0	0	0	20	44		148	147	146	144	143	142	140
Profit After tax	-1050	-204	-109	-14	60	131		445	441	437	433	429	425	421
	₹ 31.7													

Table A3: Financial Analysis MBBR and Sand Filtration Technique

Profit Loss Statement (Figures in Rs. crore)

Year	0	1	2	3	4	5	…	23	24	25	26	27	28	29
Capital Expenditure														
Cost of Sand Filters	30													
Cost of Establishing Reservoirs	600													
Cost of Establishing pipeline to supply water to Industry	0													
Cost of Land for Reservoir	4.5													
Subsidy given by Govt. for Land	-4.5													
Cost of Land for Tertiary plant														
Total Capital Expenditure	**630**													
Current Expenditure														
O&M cost for MBBR		111.5	114.9	118.3	121.9	125.5		213.7	220.1	226.7	233.5	240.5	247.7	255.2
Energy Cost		1.9	1.9	1.9	1.9	1.9		1.9	1.9	1.9	1.9	1.9	1.9	1.9
Annual Repair Cost		13.2	13.2	13.2	13.2	13.2		13.2	13.2	13.2	13.2	13.2	13.2	13.2
Chemical Cost		66.8	66.8	66.8	66.8	66.8		66.8	66.8	66.8	66.8	66.8	66.8	66.8
Manpower Cost		2.5	2.5	2.5	2.5	2.5		2.5	2.5	2.5	2.5	2.5	2.5	2.5
Carrying cost of water (Variable cost)		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operation & Maintanance Cost of Storage Facility		18.0	18.0	18.0	18.0	18.0		18.0	18.0	18.0	18.0	18.0	18.0	18.0
Total Current Expenditure		214	217	221	224	228		316	322	329	336	343	350	358
Debt Servicing		₹ 46.78	₹ 46.78	₹ 46.78	₹ 46.78	₹ 46.78		₹ 46.78	₹ 46.78	₹ 46.78	₹ 46.78	₹ 46.78	₹ 46.78	₹ 46.78
Total Outflow	630	₹ 261	₹ 264	₹ 267	₹ 271	₹ 275		₹ 363	₹ 369	₹ 376	₹ 383	₹ 390	₹ 397	₹ 404
Revenue														

Year	0	1	2	3	4	5	…	23	24	25	26	27	28	29
Revenue from Industry		75.40	150.80	226.19	301.59	376.99		753.98	753.98	753.98	753.98	753.98	753.98	753.98
Revenue from Agriculture		0.32	0.63	0.95	1.26	1.58		3.16	3.16	3.16	3.16	3.16	3.16	3.16
Total Revenue		76	151	227	303	379		757	757	757	757	757	757	757
Net Profit	-630	-185	-113	-40	32	104		394	388	381	374	367	360	353
Corporate Tax		0	0	0	8	26		99	97	95	94	92	90	88
Profit After tax	-630	-185	-113	-40	24	78		296	291	286	281	276	270	265
	₹ 17.12													

Table A4: Financial Analysis MBBR and Reverse Osmosis Technique

Profit Loss Statement (Figures in Rs. crore)

Year	0	1	2	3	4	5	…	23	24	25	26	27	28	29
Capital Expenditure														
Cost of RO	450													
Cost of Establishing Reservoirs	600													
Cost of Establishing pipeline to supply water to Industry	0													
Cost of Land for Reservoir	4.5													
Subsidy given by Govt. for Land	-4.5													
Cost of Land for Tertiary plant														
Total Capital Expenditure	**1050**													
Current Expenditure														
O&M cost for MBBR		111.53	114.88	118.32	121.87	125.53		213.70	220.12	226.72	233.52	240.53	247.74	255.17
Energy Cost		1.90	1.90	1.90	1.90	1.90		1.90	1.90	1.90	1.90	1.90	1.90	1.90
Annual Repair Cost		13.20	13.20	13.20	13.20	13.20		13.20	13.20	13.20	13.20	13.20	13.20	13.20
Chemical Cost		66.75	66.75	66.75	66.75	66.75		66.75	66.75	66.75	66.75	66.75	66.75	66.75
Manpower Cost		2.53	2.53	2.53	2.53	2.53		2.53	2.53	2.53	2.53	2.53	2.53	2.53
Carrying cost of water (Variable cost)		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Operation & Maintanance Cost of Storage Facility		18.00	18.00	18.00	18.00	18.00		18.00	18.00	18.00	18.00	18.00	18.00	18.00
Total Current Expenditure		214	217	221	224	228		316	322	329	336	343	350	358
Debt Servicing		₹ 111.38	₹ 111.38	₹ 111.38	₹ 111.38	₹ 111.38		₹ 111.38	₹ 111.38	₹ 111.38	₹ 111.38	₹ 111.38	₹ 111.38	₹ 111.38
Total Outflow	1050	₹ 325	₹ 329	₹ 332	₹ 336	₹ 339		₹ 427	₹ 434	₹ 440	₹ 447	₹ 454	₹ 462	₹ 469
Revenue														

Year	0	1	2	3	4	5	…	23	24	25	26	27	28	29
Revenue from Industry		102.2	204.3	306.5	408.6	510.8		1021.5	1021.5	1021.5	1021.5	1021.5	1021.5	1021.5
Revenue from Agriculture		0.3	0.6	0.9	1.3	1.6		3.2	3.2	3.2	3.2	3.2	3.2	3.2
Total Revenue		102	205	307	410	512		1025	1025	1025	1025	1025	1025	1025
Net Profit	-1050	-223	-124	-25	74	173		597	591	584	577	570	563	556
Corporate Tax		0	0	0	19	43		149	148	146	144	143	141	139
Profit After tax	-1050	-223	-124	-25	56	130		448	443	438	433	428	422	417
	₹ 20.33													

Annexure 3

For the reuse projects to be viable, the tariff of the treated water should be cost-competitive when compared to the alternative options available to the industries. The main sources of water for industries include municipalities, tankers, and extraction of groundwater. However, with regulation on use of groundwater in different cities, water supply from the municipalities are the most reliable option for industries.

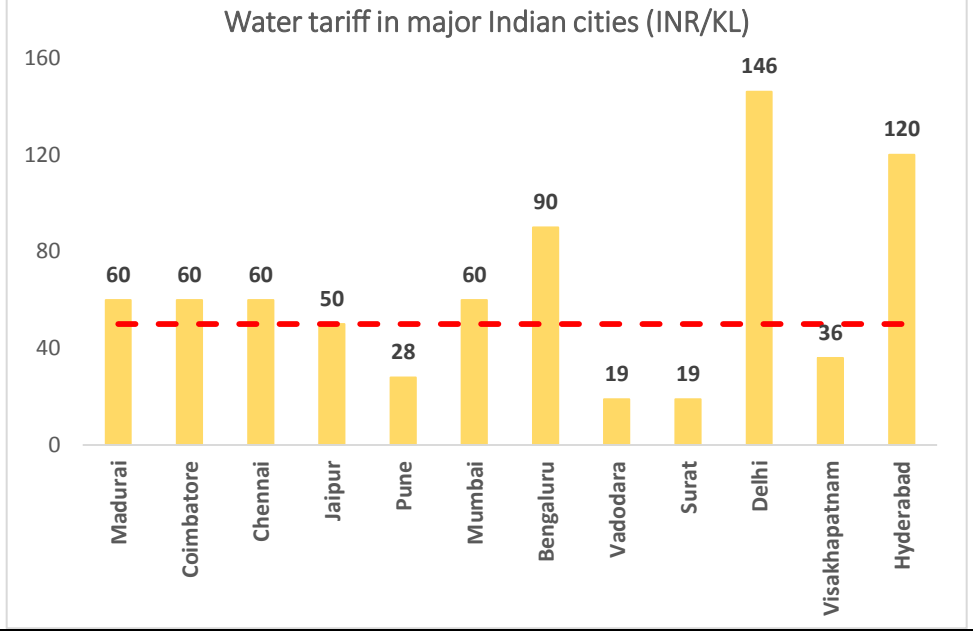


Fig A: Water tariff in Major Indian Cities
Source: PwC, 2016

As can be gleaned from the above table, industrial water tariff in most of metropolitan cities and industrial towns ranges between 19 Rs./m^3 to 146 Rs./m^3. The weighted average of industrial water tariff is estimated to be 50 Rs./m^3 which can be considered as a competitive price for setting the tariff for industrial water. This estimation is in line with the costs of wastewater treatment where the treatment process can be established to cover most of the industries (i.e. Grade III) which costs 40 Rs./m^3.

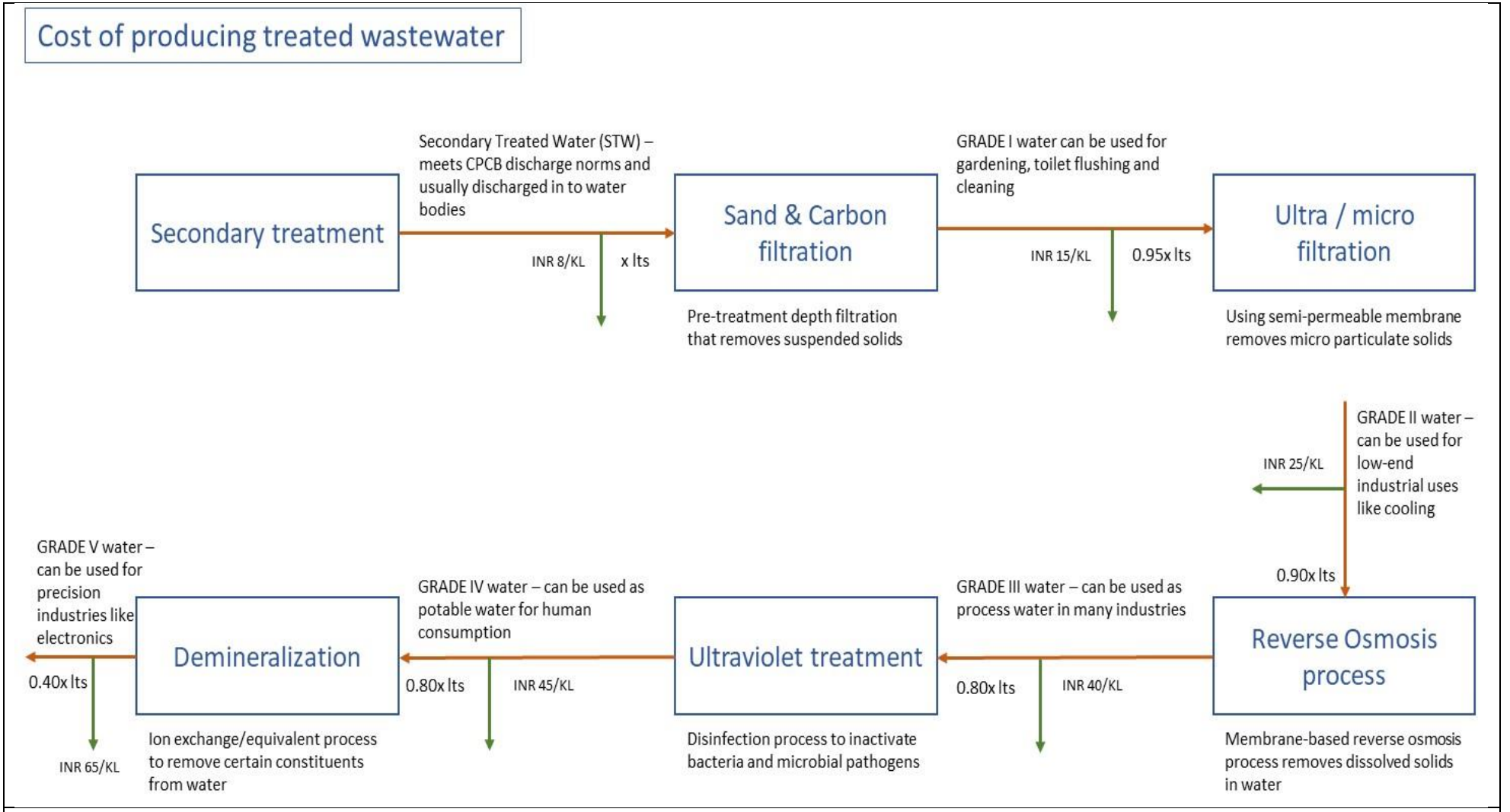


Fig B: Cost of producing treated wastewater

Source: PwC, 2016

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