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HYBRID ANNUITY MODEL(HAM) -AN EMERGING TOOL FOR URBAN INFRASTRUCTURE DEVELOPMENT UNDER PUBLIC PRIVATE PARTNERSHIP EXPERIENCE OF SETTING UP OF WASTE WATER PLANTS UNDER NAMAMI GANGE MISSION PROGRAMME (NGMC), GOVERNMENT

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ABSTRACT: The basic aim of this research paper is to address the framework of Contract management on how this is aligned with **Public-Private Partnership** (**PPP)** under **Hybrid Annuity Model(HAM)**model ,as to why thewastewater capital project development is best suited under HAM to execute, under the existing waste utility agency at the local level and its current wastewater tariff practices. What has been the lessons learned from waste-water plants constructedin Uttarakhand and how enabling institutional framework is being developed under thecapacity building program of the "**National Missionof Conservationof Gange**"**(NMCG)**

1. INTRODUCTION TO NAMAMI GANGE PROGRAMME

Namami Gange Programme (**NMG**) is an Integrated Conservation Mission approved as a 'Flagship Programme' by the Union Government in June 2014 to accomplish the twin objectives of effective "**abatement of pollution"**, as well as, to "**conserve and rejuvenate"**

our National River- **Ganga**. It is being operated under the Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti.

The program is being implemented by the National Mission for Clean Ganga(**NMCG),** and its respective state's counterpartorganizations viz., State Program Management Groups (**SPMGs**). **NMCG** is the implementation wing of the National Ganga Council that wassetup in 2016, replacing the **National Ganga River Basin Authority –NRGBA**.

This program has been evolved in the backdrop of the **Ganga Action Plan (GAP)** followed by the **National River of Conservation Directorate (NRCD)** under **GAP phase –II** and later **NGRBA,** that finally manifested into**NMCG. NMCG program** was mindfully evolved, since all the earlier programshadlimited success and impediments without a verifiable and quantifiable outcome in cleaning and conservation of sacred Ganga river in past.

The present paper deals with one of the main pillars of the program, out of the eight distinct pillars. Theplanned interventions under **NMCG**has a budget of Rs. 20,000-crorethat iscentrally-funded- non-lapsable corpus consisting of nearly 288 projects. This paper deals **HAM module** as a tool vis a vis contract management for building **Sewerage Infrastructure development & Industrial Effluent monitoring**.

2. PUBLIC-PRIVATE PARTNERSHIP AND THEIR INTERRELATIONSHIP UNDER CONTRACT MANAGEMENT FRAMEWORK FOR PROJECTDEVELOPMENT UNDER HAM

The contract management framework has been evolved with previousexperiences in **Ganga Action Plan**(GAP) and **NRCD**. Under this **GAP phase –I &II**program; sewerageinfrastructure assets that were built witnessed uncertainty in-terms of matching the capital contribution from states, as well as the **O&Missues,** since its planning & inception. Thus, it made the GAP program ineffective and unsustainable.

Lessons learnt from GAP–I &IIafter analyzing thelife cycle cost, effectiveness of O&M and **gaps in achieving**assuredcapital out-lay, has become the essence for an effectiveproject structuring under NMCG- capital project development. Encouraging experiences ofsuccessful private participation in road sector under HAM model of EPC contract was mooted because the road projects achieved assured operation and state funding. The capital mobilization challenge is mitigated throughan effectivestructuring under a **15-year HAMmodel** with EPC embedded contract management system.

A concessionaire will be provided 40 % of the project cost after financial closure of agreement and submission of Bank Guarantee for the same amount, remaining 60 % of contract cost is paid quarterly over 15 years of the life cycle of the project which includes CAPEX and OPEX both. This model address fundamentally two basic issues:

i. Assurance of Operation of Sewerage Infrastructure on agreed benchmarks.
ii. Assurance and availability of fund allocation(CAPEX& O&M) with Central Government, due to non-lapsable resource allocation in an escrow account.

3. WASTE WATER CAPITAL PROJECT DEVELOPMENT UNDER HAM – A BEST SUITED UNDER EXISTING INSTITUTIONAL FRAMEWORK OF STATE UTILITY AGENCY AND ITS CURRENT TARIFF PRACTICES

The most important aspect is the capital availability for wastewater plants because of their increasing demand. The uncertainty of capital recovery in case of the Waste-water plantand that of the O&M cost during its life cycle period, is taken care.

if we go back to the history of GAP I &II, thecontribution of the state share in capital project development of wastewater plants have been dismal. Thus, **HAM embedded on EPC format**(as discussed above) is an innovative & appropriate model. The projects under the abovesaid new modelhas been successfully implemented by the concessionaire under the Namami GangeProgramme (NGP). The best examples are the Waste water plants under HAM are implemented at **Gothi** (120 MLD),**Dinapur**(140 MLD), **Ramana** (50 MLD)and that of at **Varanasi** that includes the Interception and diversion networks for 5kms.

The private sector is assured of capital cost payment through escrow account along with indexed operation and maintenance cost paid on sixty quarterly installments during the 15 year concession period.This model ensures a long-term commitment of cash flow supply becausethe concessionaire has to maintain the plants on agreedbenchmark parameters (BOD, COD, SO2) which confirms the effluent quality from the wastewater project development.There has been encouraging participation of private sectorin the construction of large plants at Patna (Bihar), Jagjitpur in Haridwar, as well as, the cluster-based SME investors role inthe construction of plants atSrinagar,Rudraprayag, and Badrinathin Uttarakhand.

The HAM model has emerged as an appropriate model in the domestic wastewater plants segment also under the Public-Private Partnership (PPP), which provides assured capital from the Government and indexed O&M payment with reducing the risk of cash flow for up-keeping of plants during the concession period;Thus, leveraging cash flow quarterly under HAM model is an attractiveproposition for receivingfinancing from commercial and development banks. The return is modest but less risky and attractive for long-term business development in wastewater business across India – an opportunity sector for exploring green funding for resilient urban infrastructure development.

4. EXISTING CAPACITY VIS A VIS REQUIRED CAPACITY ASSESSMENT

A summary analysis has been presented herewith regarding theexisting status of **Sewage TreatmentPlants (STP)**under the National Mission of Conservation of Gange in the states of Uttarakhand,Uttar Pradesh, Bihar, and West Bengal.The Ganga flows only 48 km in Jharkhand,that too in Shaibjanjis town where a single sewage plant has been proposed under **HAM**by Jharkhand Urban Infrastructure Development Corporation Ltd – apublic executing agency of Jharkhand State. It has been found that the **sewage treatment plants** have been classified and bundled with technical and commercial due diligence in terms of I)**scale of business** II**) technological alignments of assets** III) **One City one Operator approachbased ontechnical and financial sustainability**.

The wastewater recycling business has emerged from a small and medium operator to alarge and integrated sewage plant operator.There has been agrowingdemand for an assured market for wastewater treatment plants across towns of Ganga states of north and east India. The intuitional

framework under **HAM** is also assuring case to case basis on long-term availability of resources for investment in network, interception &diversion, waste recycling plants under CAPEX and OPEX cash flow model. This will certainly leadto a new emerging green sustainable wastewater business development in the future.

It is a point to reckon that India's first Municipal Corporation Ghaziabad has successfully listed the country'sfirst green municipal bond on the Bombay Stock Exchange (BSE) on April 8, 2021. The Corporation raised Rs150 crore for setting up tertiary wastewater treatment plants and supplying piped water via water metered in Ghaziabad.

S.N	Town, State	Existing STP Capacity	Proposed STP Capacity	Remarks
1	Haridwar (Uttarakhand)	Jagjitpur – 27 and 18 MLD Sarai – 18 MLD CETP 4.5 MLD	Jagjitpur enhanced to 62 MLDand 6MLD Sarai, refurbishment of 18 MLD & add. 8 MLD by 2028. Concession agreement to enhance 9.0 MLD	Rehabilitation & Brownfield, O&M of existing STP, New STP, I&D
2	Rishikesh (Uttarakhand)	18 MLD at Sarai. Swarg Ashram -3.0 MLD Lakharghat 6.0 MLD	14 MLD at Sarai.	Rehabilitation & Brownfield, O&M of existing STP, New STP, I&D.
3	Ganga Upstreams towns (Uttarakhand)	Srinagar (3.5 MLD) Devprayag (1.4) Gyanshu (2.0)	Reh. –Brownfield, O&M of existing STP, New STP, I&D.	Cluster-based approach for small & medium scale players.
4	Moradabad-Bareilly, Uttar	No existing	STPs with the capacity of	The benefit of economy of scale due to multiple

	Pradesh		• 25 MLD • 41 MLD • 20 MLD • two 1 MLD	assets.
5	Allahabad, Uttar Pradesh	343 MLD	Reh. –Brownfield, O&M of existing STP, New STP, I&D & Septage management	Opportunity for integrated bidder of scale
6	Kanpur, Uttar Pradesh	475 MLD	Rehabilitation &Brownfield, O&M of existing STP, New STP, I&D & Septage management	Opportunity for integrated bidder of scale
7	Farrukhabad-Fatehgarh, Uttar Pradesh	Existing STP of 2.7 MLD oxidation pond	STPs with the capacity of- • 28 MLD • 5 MLD • 2 MLD	A good entry platform for small & medium scale players.
8	Mirzapur-Ghazipur, Uttar Pradesh	Existing STP of 14 MLD UASB	STPs with the capacity of- • 21 MLD • Two 8.5 MLD each • 1 MLD (onsite treatment)	A good entry platform for small & medium scale players.
9	Digha and KakarBagah Patna Bihar	150 MLD		Network (CAPEX&0&M) New STPs and Septage Management
10	Meerut, Uttar Pradesh	All New Assets	STP with the capacity of 200 MLD; decentralized STPs with a cumulative capacity of 14 MLD No existing Rehabilitation Brownfield, O&M of existing STP,	The largest capacity of a single STP amongst NMCG projects.

			New STP, I&D	
11	Agra, Uttar Pradesh	• Existing STPs of 220 MLD • 75 MLD	• 3 STPs with the capacity of 166 MLD • 10 MLD decentralized STPs • 9.38 MLD	Large single STP with a sizeable number of brownfield assets.
12	Budhana Muzaffarnagar Uttar Pradesh	Existing STP of 32.50 MLD based on WSP technology; to be augmented to 65 MLD.	STPs with the capacity of- • 10 MLD • 22 MLD	A good entry platform for small & medium scale players.
13	Hooghly-Chinsurah&Maheshala, West Bengal	Existing STP of 4.2 MLD oxidation pond	STPs with the capacity of • 26 MLD, • 29.3 MLD, • 2.13 MLD (onsite treatment)	A good entry platform for small & medium scale players.
14	Asansol-Durgapur-Burdwan, West Bengal	online treatment of 18.06 MLD for 39 drains treatment in Asansol.	• 8 STPs with a cumulative capacity of 95 MLD inAsansol; • 50 MLD in Burdwan; • Two 25 MLD each • 30 MLD in Durgapur	Opportunity for bidders to bid along with other projects in West Bengal
15	Kolkata, West Bengal	183 MLD	Rehabilitation, Brownfield, O&M of existing STP, New STP, I&D & Septage management	Opportunity for integrated bidder of scale
16	Howrah, West	187 MLD	Rehabilitation Brownfield, O&M	Opportunity for

	Bengal		of existing STP, New STP, I&D & Septage management	integrated bidder

4.1 TECHNOLOGICAL OPTIONS:

Broad technical parameterscombination is used in municipal waste recycling plants across Ganga states of India. A short brief technical description is presented of wastewater recycling technology to align withthe **HAM model** of **contractcompliance**.

S. No	Technological Options	Advantages	Disadvantages
1	Activated Sludge System	• The system itself does not costmuch, it produced high-quality water, as long as the sewage is of a uniform type and volume and the activated sludge stays activate • It does not require large space and odor and pest are limited, convenient, and easy. • The process is efficient and little loss of pressure	• Capital outlay may be low, but ongoing operating costs of aerating and recycling the sludge can be high. These costs will add up over time • Sludge can be recycled back into the processsludge will need to be removed and disposed of after a while, and this can cause difficulties, as well as additional costs. • Activated sludge may not remain activated and aerated at all times, which will severely affect the performance of the process, manpower cost & supervision required attention.
2	Submerged Aerated Filter (SAF)	• Modular design allows easy installation. • Low & stabilized sludge production eliminating the need for sludge digestion. • SAFF process was able to achieve a 95-98% BOD	• High reliance on external energy input. • Clogging of the reactor due to the absence of primary sedimentation. • Requires skilled manpower. • Reliance on proprietary filter media.

S. No	Technological Options	Advantages	Disadvantages
		reduction. • High MLSS – Less Space required for the treatment. • Maintenance requirements are simple	
3	Trickling Filter	• Low power requirements, do not need large power-hungry aeration blowers, motor-driven rotary distributors are powered by fractional horsepower electric motors. • The cost to operate a trickling filter is very low. • efficient in Removal of ammonia from wastewater • Modest skill manpower required • Appropriate for small- to medium-sized communities	• Additional treatment may be needed for the effluent to meet strict discharge standards • Generates sludge that must be treated and disposed of, high incidence of clogging • Limited flexibility and control in comparison with activated sludge process • high maintenance costs of rotary distributor center mechanisms require a crane for complete guy rod and arm removal • Potential for vector and odor problems.
4	Sequencing Batch Reactor (SBR)	• Equalization, primary clarification, biological treatment, and secondary clarification can be achieved in a single reactor vessel. • Operating flexibility and control. • Minimal footprint. • Potential capital cost savings by eliminating clarifiers and other equipment.	• A higher level of sophistication is required (compared to conventional systems), especially for larger systems, of timing units and controls. • Higher level of maintenance (compared to conventional systems) associated with more sophisticated controls, automated switches, and automated valves. • Potential of discharging floating or settled sludge during the DRAW or

S. No	Technological Options	Advantages	Disadvantages
			decant phase with some SBR configurations. • Potential plugging of aeration devices during selected operating cycles, depending on the aeration system used by the manufacturer. • Potential requirement for equalization after the SBR, depending on the downstream processes.

4.2 PERFORMANCE INDICATORS

Based on the experiences of Wastewater treatment plants commissioning under the **HAM model** of lifecycle embedded cost for operation of 15years, the **Sludge Blanket Reactor (SBR**) is only the selected technological option on undisputed merit align with Key Performance Indicators at various levels (**KP1, KP2, KPI 3….**) under the concessionaire agreement of across Indian states in **NMCG program**.

Key Performance Indicator

- **KPI 1 –** Availability of the Facilities and the Associated Infrastructure during the O&M Period – should be 100% (95% during Scheduled Maintenance)
- **KPI 2** – Compliance of the Treated Effluent as per the requirements specified in the Concession Agreement below:

Parameter	Unit	Value
pH		6.5-9.0
BOD_5 at 20^0C	mg/L	< 10
TSS	mg/L	< 10
TN	mg/L	< 10
NH4-N	mg/L	< 5
COD	mg/L	< 50
TP	mg/L	< 2
Fecal Coliform	MPN/100 mL	<100

- **KPI 3** - Compliance of the Digested Sludge as per the requirements specified in the Concession Agreement below:

Units	Digested Sludge Consistency
Outlet Concentration of dewatered sludge	Not more than 20% of solids
Fecal Coliform Limit	Less than 20,00,000

4.3.1 TECHNICAL AND OPERATIONAL CHALLENGES:

Review of Hybrid Annuity Model (HAM) Contract Document of STPs development under National Mission of Clean Ganga (NMCG) Programme, summary and challenges are presented below:

S. No	Technical Challenges	Operational Challenges
1	Failure to complete the construction by the expiry of the Grace Period.0.1% of the Performance Security per day till 6 months	construction Payments due to the Concessionaire for Payment Milestones completed and certified by the Executing Agency.
2	Failure to achieve successful timely completion of Trial Operations	failure to cure the Third breach of performance KPIs within 20 days of the Third Breach Notice or a failure to comply with the discharge standards results in the occurrence of a Third Breach more than 3 times in a continuous 12-month period
3	Failure to achieve the KPIs for 2 consecutive days, 32 times in a continuous 12-month period	suspension of construction/O&M for a continuous period of 60 days
4	Failure to achieve the KPIs for 1 day, 64 times in a continuous 12-month period	failure to cure non-compliance with availability default within 3 days of the notice.

Note: CETPs Contract documents developed under NMCG are beyond the scope of the present paper.

4.4 ABUSINESS MODEL WITH INNOVATIVE PERFORMANCE-BASED CONTRACTING PROCEDURES

The paper has broadly covered the following aspects to explore and design an innovative business model for contact management

- Financial Analysis, Financial status, and sustainability of the existing business models
- Administrative and collaborative issues
    - Review the tender documents
    - Propose PPP Structures for implementation

4.4.1 COSTING AND COST RECOVERY FROM MUNICIPAL WASTEWATER

Waste Water recycling has been considered public health enterprise business which is also known as a green business and embedded with affirmative local action & climate change issues.

National Green Tribunal (NGT) of India has made mandatory benchmarks-basedeffluentsdischarge protocol as given under the NGT guidelines, failure todo so will lead to punitive financial and criminal action. All efforts are being made to explore technical and business models to construct and operate STPson sustainablebusiness models across Ganga states of India. **HAM model** under CAPEX and OPEX are based on benchmark based (K1, K2, K3, etc.) 40% paid on financial closure after concessionaire agreement is signed and the remaining contract amount is paidon sixty quarterlybasis during the 15 years of the concession agreement period.

Against this backdrop, a review ofthe capital costs, revenue streams (tariffs, taxes, collection efficiency, etc.) operations and maintenance costs towards network and treatment facilities and disposal mechanism (electricity, salaries, consumables, repairs,etc.) have been carried.

Based on the review of existing reports and information already available, the template fordata collection from each plant has been designed. In the case of Uttarakhand and Uttar Pradesh (KAVAL towns - Kanpur, Allahabad,Varanasi, Agra, and Lucknow), **Jal Sansthan** and Bihar local body is responsible for sewerage charge &tariff collection for operation maintenance of sewerage systems. It is important to reveal here that **JalSansthan** or ULB agency is currently under revenue deficit which is currently being met through other sources ofincome or transferred fromrespective state'sgovernment. The electricity charge is directly reimbursed by the state government to the power supplying agency.

This is an generic broad share of about 50 % electric charges, Manpower 30 %, and remaining in chemical & other cost expenses of STP plant.This cost data of O&M at the plant level is difficult to obtain becauseof a lackofdata and verifiable sources. However,this O&M cost share is based on historical plant level cost derived underGIZ sponsored study in Uttarakhand. It will be an inputfor assessing technological option, exploring cost control model under the HAM model of Public-Private Partnership.

One of the main challenges during the study was the access to sufficient and verifiable data on

the ground, which required the experts to complete the findings and recommendations with direct observations.
Poorsewer network coverage and a lesser number of connections are major concerns of **Jal Sansthan** or local agency due to which they are currently unable to increase the direct revenue through user charges.

The wastewater recycles use (as an example reuse of wastewater case is established in IOC OILrefinery,Mathura,Uttar Pradesh) and sale of bye products as compost or Gas (under the industrial gasapplication inJagjitpurplant Haridwar)etc., are helping towards financial sustainability of wastewater plants in future.

4.5 Risk Mitigation under HAM model of Contract Management

Risk mitigation is the most important component in any business proposition. It decides whether to begin or not to begin a particular business based on the risk associated with it. The construction and operation of sewage treatment plant as a concessionaire onperformance-basedbenchmark has leadto various kind of identified risk and categorized under **Hybrid**

Annuity Model (HAM)

An attempt has been made through the innovative architecture of project structuring to minimize the embedded risks of wastewater treatment plants because of public health issues and externalities associated with the waste recycling business. The present paper is classifying the recycling of wastewater risks based on experiences and lessons learned under Public-Private Partnership in general and Hybrid Annuity Model (HAM) in particular. It is advisable to review following broad strategy points under risk mitigation measures.

RISK MANAGEMENT STRATEGY

- Identifying Risk
- Monitoring Risk
- Mitigating Risk

CONTRACTUALLY ALLOCATED RISK

- Site Risk
- Land Acquisition Risk
- Statutory Clearance Risk
- Environmental Risk

RESIDUAL RISK

- Design and Engineering Risk
- Contractor Risk
- O&M Risk
- Financial Risk
- Concessionaire Management Risk
- Take back Risk

CONTRACT VARIATION RISK

- Change in Scope Risk
- Change in Law or Policy Risk

UNIDENTIFIED OR UNRESOLVED RISK

- Social Risk
- Force Measure Risk

REPORTING MECHANISM

An integral part of Contract Management Activity - will give the status of activity like - whether the concessionaire adhering to timelines and performance standards.

Regular Reporting:

- Operations to Supervisory Level
- Supervisory Level to Decision Making Level

ESCALATION MECHANISM-

Managing Issues and Disputes either by Contractor's default or by Authority's default Developing Contract Management Plan is required to ensure:

- Track the performance of the contractor
- Ensure the quality standards requirements
- Taking care of all financial matters related to project
- Need Assessment Contract Management Plan
- Present Status of the Contract Management System
- Prepare Draft Contract Management Plan
- Develop and Implement Contract Management Plan
- Review and Update the Contract Management Plan

5 INSTITUTIONAL DEVELOPMENT AND WAY FORWARD FOR WASTE WATER SECTOR DEVELOPMENT

The Ministry of JalShakti hassigned on 17/ 12/2019 under a bilateral agreement with USAID - promoting water management, water quality issues, and wastewater recycling and re-use through innovative concession arrangement and wastewater recycling and re-use through innovative concession arrangements of a bilateral agreement on 26/6/17 with the Netherlands Government. Both bilateral agreements will facilitate wastewater private sector development and also embrace **SDG agenda 9 and 11.**

SDG AGENDA 9:Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation

SDG AGENDA 11:Make cities and human settlementsinclusive, safe, resilient and sustainable

Risk transfer in public-private partnerships (PPPs) may not always be conducive to efficient management
due to the principal-agent problem. This paper identifies three parameters: (i) competition, (ii) monitoring (iii) incentives, for transferring risks in a principal-agent relationship.

The findings illustrate that competition determines the private sectors' ability to bear risks, monitoring reduces ex-post information asymmetry and incentive ensures that risks are efficiently managed. The lessons learned from the case studies illustrated above guide governments in transferring risks efficiently in PPP wastewater treatment projects.

The National Mission of Conservation of Ganga (NMCG) has proposed a long-term durable and business-oriented approach as a Hybrid Annuity model for assured revenue and a sustainable business model for wastewater to facilitate input-based tariff increase anduser's connection in the future. This adheres principle of marginal cost pricing, and the recent success of Green Municipal Bonds issued by local bodies in Uttar Pradesh will further facilitate and strengthen the HAM model as a tool for urban infrastructure development in India.

REFERENCES:

- Capinkero Samuel, Ole H. Petersen " Risk Allocation in Public-Private partnership (PPP) Projects for waste Water Treatments Plants" International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering Vol: 9, No -6,2015.
- Capacity Building Report for Support for Gange Rejuvenation Project,Gopa Infra GIZ, 2018.
- Economic Assessment of STPs & CETPs in Uttarakhand 2016, Infrastructure Development Corporation Limited, GIZ Gmbh.
- Govind Gopa Kumar, "Transforming Water Supply Regimes in India: Do Public Private Partnership have a role to play", Water Alternatives, Volume -3 / issues -3, 492 – 511.
- National Mission for Clean Ganga, Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India. www: nmcg.nic.in/nammegange/aspx
- RFP (Bid Document Part–I &II) for Development of Sewerage Treatment Plants on PPP basis at Haridwar, Jalnigam Uttarakhand, 2017.
- Vatsyayan Aloke, Pricing Costing and Cost recovery of water and sewerage services – A case study of Kanpur Jalsansthan in Uttar Pradesh, International Workshop on India Urban Infrastructure – HUDCO, IHS, The Netherlands, 1997, 486 -493