NATIONAL URBAN INNOVATION STACK

STRATEGY & APPROACH

National Institute of Urban Affairs

Ministry of Housing and Urban Affairs
Government of India

Smart City
MISSION TRANSFORMATION

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Message from Mission Director, Smart Cities Mission, MoHUA

India's cities are driving economic growth of the country. By 2030 urban India will contribute more than 70% of India' GDP and house at least 40% of national population. They already are home to the most innovative companies and organizations and a vibrant ecosystem of actors including government, industry, academia, and civil society. In order to capitalize on the potential of India's cities and their ecosystems, it is important to drive greater collaboration between ecosystem actors.

Smart Cities Mission is focused on driving economic growth and improving the quality of life of India's urban residents through many different means, crucial among those being harnessing of the power of technology. Thus, it is well placed to catalyze transformative collaboration in the urban ecosystem through establishing a shared digital infrastructure in the form of the National Urban Innovation Stack (NUIS).

NUIS will strengthen the capacity of the urban ecosystem to solve complex programs at speed and scale by unlocking the power of urban data, build capacity among all actors of the quadruple helix, driving discoverability and collaboration between urban stakeholders, and enabling responsive and data driven governance. It will provide participants with the digital tools and platforms, standards, specifications and certifications, and enable greater coordination and integration amongst them.

NUIS will support several key programs including the India Urban Data Exchange, India Urban Connect, SmartProcure, Research and Innovation for Urban India, National Urban learning Platform, SmartCode and Smart Governance to name a few. MoHUA is working towards establishing the digital and physical backbone as a foundational institution to catalyze the ecosystem, consolidate existing resources and drive innovation across India.

I urge you to treat this strategy and approach paper as an invitation to participate in these programs and join us in our journey to developing a best-in-class digital public good for urban India. Your comments/ suggestions/ remarks are invaluable for us. I strongly believe the NUIS will have a revolutionary impact on urban governance in the country and become the cornerstone of our urban governance and innovation ecosystem for many years to come.

Kunal Kumar

Mission Director, Smart Cities Mission, MoHUA

Executive Summary

India's exponential urban population growth, coupled with the growing challenges of urban governance in India, requires strengthening of capacity in the urban ecosystem across the quadruple helix of society, government, academia and industry, at every level. With the strengthening of institutions, it is imperative that we recognize the need for urban transformation at speed and scale.

The urban ecosystem currently struggles with poor capacities, inadequate coordination, weak planning, execution and monitoring, fragmented responsibilities and accountability. This results in a lack of citizen-centric service delivery and reduces the ease of doing business. Cities need strong collaboration between ecosystem actors to capitalize on the exponential growth they will continue to experience in the coming years. It is imperative that governments, civil society, citizens, academia and industry have the tools they need to manage the inherent complexity and dynamism of India's cities and towns.

To address this need, Ministry of Housing & Urban Affairs (MoHUA) intends to develop the National Urban Innovation Stack (NUIS) as a layered digital infrastructure to strengthen the capability of the ecosystem, to identify urban challenges and solve them at speed and scale. This paper lays out the strategy and approach including guiding principles and key components of the NUIS.

The NUIS is planned to be designed taking into cognizance the ongoing efforts of multiple stakeholders in driving and managing various programs and efforts towards urban transformation. India's vibrant ecosystem of civil society, governments markets, and academia can leverage the NUIS to co-create urban initiatives in keeping with local needs and priorities. The NUIS is built as a public good which is interoperable through Open Source code and Open APIs, keeping in mind data privacy, extensibility and scalability.

The NUIS will support the urban ecosystem in improving the ease-of-living, doing business in India's cities and in the process, building world-class cities. The NUIS is highly-configurable and scalable to meet the varied needs of diverse cities across the nation. The NUIS will address both current and future needs of urban India through an evolutionary design that will provide the latest technological advances and innovations to the ecosystem as they are developed and incorporated into the stack.

As a shared digital infrastructure, the NUIS will bridge the digital divide between cities enabling them to leapfrog the urban development curve.

By empowering decision makers and administrators with real-time standardized data on the performance of their agencies and departments, the NUIS will lead to more responsive and data-driven decision making, effective utilization of scarce resources and unlock collaborations between multiple stakeholders in the urban ecosystem.

As India is poised to face a massive influx into its towns and cities in the next decade, it is important that our cities are prepared to deal with the increased demand on services and infrastructure. The NUIS is crucial to ensuring that our cities meet the aspirations of Indians and in helping cities to fulfil their role as the vanguard of India's growth story in the 21st century.

List of Abbreviations

ACR	Annual Confidential Report
AEPS	Aadhar Enabled Payment System
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APB	Aadhar Payment Bridge
API	Application Programming Interfaces
BBPS	Bharat Bill Payment System
DEPA	Data Empowerment and Protection Architecture
ERP	Enterprise Resource Planning
GDP	Gross Domestic Product
GIS	Geographic Information System
GoI	Government of India
GSTN	Goods and Services Tax Network
HRIDAY	Heritage City Development and Augmentation Yojana
IT	Information Technology
JAM	Jan Dhan Aadhar Mobile
JDY	Jan Dhan Yojana
LAN	Local Area Network
MeitY	Ministry of Electronics and Information Technology
MoHUA	The Ministry of Housing and Urban Affairs
NIUA	National Institute of Urban Affairs
NMAM	National Municipal Accounting Manual
NOC	No Objection Certificate
NULM	National Urban Livelihoods Mission
NUIH	National Urban Innovation Hub
NUIS	National Urban Innovation Stack
OSS	Open Source Software
PMAY	Pradhan Mantri Awas Yojana
RWA	Resident Welfare Association
SBM	Swachh Bharat Mission
SLA	Service Level Agreement
UAF	Urban Analytics Framework
ULB	Urban Local Bodies
UPI	Unified Payment Interface

1. Background and Context

1.1 Urban India: Challenges and Opportunities

By 2030, India's urban population is expected to grow to 590 million or 40% of the national population. This population chooses urban life because cities provide opportunities for growth and self-actualization. This is particularly true of the post-industrial city and Indian cities are particularly representative of the new economy because industrialization was only concentrated in a few of the bigger metropolitan centres and older industrial townships, whereas most of urban India is engaged with other forms of economic activity. Because of the concentration of trade and commerce, knowledge-based industries and a vast informal sector, urban India has become the fulcrum of India's growth, with 70% of National GDP expected to come from urban areas. It is expected that if current growth trends prevail, India will become a 7 trillion-dollar economy by 2030.

Urbanization is inherently complex, with a variety of social, economic and governance priorities interacting through a wide range of institutions, including multiple levels of governments, industries, social groups and civil society institutions. Urban Governance is an evolving space in India with formal local self-governments being established through the 74th Amendment to the Constitution of India, 1992. The act envisaged the devolution of funds, functions and functionaries to the 'third tier' of governance in cities. The Urban Local Body (ULB) is the entity responsible for development, management and upkeep of cities and towns across India; however, it is severely constrained to fulfill its responsibilities and promise. The ULB suffers particularly because of a legacy of gaps in infrastructure and services and the capacity constraints that prevent it from augmenting resources and overcoming gaps. The ULB engages in symptomatic solving of immediate problems rather than addressing root causes through planned interventions and sustained investment.

There is rapidly growing acknowledgement, at all levels of leadership and public and private sector enterprise, that cities are the centres of India's future growth and have deep links with their regional contexts and the larger footprint of development such as energy infrastructure, water sources, transportation and food production. The Union and State governments in India are actively investing in urban development and housing through the MoHUA, which works in partnership with the State-level departments and agencies to execute its programmes and missions. MoHUA also invests in municipal reform and various aspects of urban quality of life and livelihoods.

While Indian cities are the location of its financial institutions and economic drivers, they are also centres of learning and creativity, offering a rich matrix of life to their citizens. While rural India has had a long a history of innovation, enterprise has been uniquely associated with urban India. It is predicted that the next generation of urban enterprises will be most likely dependent on digital technologies, data sciences, human ecologies mediated by advanced knowledge systems, new material sciences and new ways of managing resources and doing business. Enterprises require appropriate and vibrant ecosystems to flourish, and ecosystems require a variety of human actors, supportive environments and enabling technologies and catalysing knowledge resources. Increasing the number of new enterprises and encouraging such 'startups' to flourish

in Indian cities is an economic as well as social imperative, given the demographic dividend that India wishes to reap from having the largest working age population pool in the world.

The Government of India recognises that the enablement and support of ecosystems for innovation must be a national priority. While such a goal has been easier to realise in the science and technology realms, or in the space of arts and culture, the urban sector has been largely deprived of investment in innovations. However, with the huge investments that are being devoted to this sector over the past few years, it is both possible and desirable that innovation can be enabled and supported. Due to more frequent home-grown experiences as well as greater exposure to the experiences of other countries, the urban sector actors, institutions and organisations in India have now evolved a better understanding of the potentials in the sector and there is a growing ecosystem that has emerged with focus on supporting urban development through capacity building, research, service and infrastructure innovations and citizen engagement. It can be said with confidence that urban India is poised for incremental improvements and sustained growth powered by deep collaboration between multiple stakeholders.

1.2 Systemic Challenges in Urban India

Currently, urban India faces several capacity deficits in the ecosystem, preventing it from resolving urban challenges, which consist in building infrastructure and delivering services to fill legacy gaps as well as to accommodate emerging and future needs and demands. In its current form, urban India is a roadblock in achieving our aspiration of becoming a 7 trillion-dollar economy that is secure from risk and hence resilient and sustainable. Despite the significant investment and effort invested by various actors in the urban ecosystem, there is a large gap between the actual outcomes achieved and the quality of life and other outcomes and aspirations of the programs and efforts of ecosystem actors. While some of these capacity deficits relate to governance, a significant part is related to lack of capacity to implement successful projects – i.e. well designed and planned, adequately financed and funded, and sustainable projects. the others are fueled primarily by a lack of effective coordination and collaboration. Some of the underlying problems are:

- **Poor Urban Governance Capacities**

  The pace of growth and changing circumstances that affect urban development are forces that compel the urban manager to engage in lifetime learning. However, there is limited penetration of learning opportunities, which need to be easily available where and when required, because most city managers and municipal functionaries are unable to leave their duty stations for sufficient durations to undergo traditional training programmes.

  The existing nationwide resources and infrastructure for capacity building in the urban sector are overly directed towards classroom training and perform uncoordinated activities that do not satisfy the stakeholders and thus lie underutilised in most Indian states. Even though the governments of India's 4041 cities face significant capacity issues, with low levels of staffing and a paucity of key urban management and governance skill sets, they are unable to find the appropriate training resources or delivery methods that they prefer. The absence of sufficient tools and information adds to this sense of being unprepared for the urban transformation and as a result, they feel consistently

overwhelmed by the demands of citizens, industry, state and their subordinates and superiors. The fragmentation of city management across multiple agencies and departments has further resulted in a lack of convergence and coordination with inefficient city systems that are not robust or evolutionary in serving citizens and businesses.

- **Absence of Trust, Accountability and Participation**

There is a general lack of data that can form the basis for decision-making in the ULBs, beyond the most basic data that emerges from financial records and other routinely maintained records. Even these are not digitised in most ULBs, thus becoming unwieldy for analysis. The unavailability of data that justifies actions further creates a general environment of distrust. Seeming opacity of decision-making breeds distrust and alienates stakeholders and lack of evidence-based decision-making tends to result in poor planning and execution of projects, which in turn causes dissatisfaction with outcomes and reduces faith in governance. Poor governance outcomes, quality of life and ease of doing business combine to lead to an absence of trust and accountability between urban stakeholders. This in turn leads to lower participation in addressing urban challenges from ecosystem actors despite the shared acknowledgment that sustainable solutions require greater participation and coordination between the various urban stakeholders. A vicious cycle plagues the urban sector.

- **Limited Penetration and Harnessing of Innovation**

The urban sector also suffers from the preponderance of business-as-usual approaches and formulaic solutions. Constrained functionaries and outmoded systems within the urban sector lead to an inability for cities to effectively spur and harness innovations around urban challenges. there are not enough incentives for interorganizational collaboration and the incubation of innovative ideas and practices in the urban development space. As a result, while our cities continue to attract talent and spawn enterprises that have transformed entire sectors of industry, they are yet to realize the potential of this talent and innovation for their own ongoing development.

- **Low level of rigour in planning, design, execution and monitoring**

Decisions that are based on evidence, analysis and research are more likely to be perceived as rigourous. Information and insight are the necessary conditions for achieving rigour and urban insight is founded on data analysis. India's cities generate significant amounts of data every day through the actions and interactions of various urban stakeholders. However, this data is often siloed and inaccessible, and when publicly available, is often outdated. In the absence of systems and processes for urban stakeholders to exchange and collaborate with real-time data, it is challenging to build a coherent view of the problems and to coordinate actions for maximum impact. This is particularly problematic when it afflicts the planning and design of infrastructure and housing projects, which are supposed to produce durable assets but often produce burdensome legacies. The paucity of data in the planning and design phases of projects extends into the near total lack of monitoring.

1.3 Catalyzing the Urban Ecosystem to deliver results

The urban sector in India is in urgent need of whole-of-system innovation. Identifying and removing systemic bottlenecks, blind spots and inefficiencies are imperatives that cannot be ignored any more, especially because they have proliferated across a vast geography of more than 4000 cities and the diverse geographical and cultural contexts of India's states and UTs. In order to address the need for scale and speed, it is therefore essential that the country should use the transformational force of digitalisation in all aspects of the urban sector.

An urban transformation has been unleashed in India. MoHUA has focused its investments on driving urban transformation through the Swachh Bharat Mission (SBM), Pradhan Mantri Awas Yojana (PMAY), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Smart Cities Mission, National Urban Livelihoods Mission (NULM) and the Heritage City Development and Augmentation Yojana (HRIDAY). Through these missions, it has invested over Rs. 7 Lakh Crores during 2014-2018 in urban areas across the country to enable ULBs to upgrade their infrastructure, service delivery and governance. A significant portion of these funds is earmarked for capacity building and skills upgrade for the urban local government employees, but even this is suboptimally utilised because of a lack of coherent and suitably scaled vision. It is necessary to create a strategic view and interventionist ideology for transforming the sector.

It is a significant that the key tenets and approaches that inform the urban missions are: convergence, integration, result and outcome orientation, demand-based and responsive to peoples' needs, and directed towards sustainability (social, environmental, financial). These are conducive to the conception of an innovation ecosystem. MoHUA recognizes that there is already a growing ecosystem of institutions, businesses, citizens, experts and other stakeholders within and outside government focusing on these challenges, driving investments and making programmatic interventions.

The GoI and state governments have created a vast infrastructure of institutions and organisations across the country that have direct relevance for the urban sector. Human resources that are needed for addressing the urban transformation are also scattered across the country and operating in public and private spheres, as well as residing abroad yet focused on India's needs. This global capacity is latent and underutilised and can be catalysed for servicing the urban transformation. This can be only achieved by creating a unified ecosystem that can respond to the geographical scale, the intellectual scope and the need for speed that the sector demands—and this would be best served through a digital presence. It is critical to ensure that this ecosystem is better coordinated to drive combinatorial innovation between ecosystem actors and to amplify the impact that they have. Based on these engagements, as well as the need to rapidly increase the speed and scale at which the ecosystem can drive urban transformation, it is critical to enable all actors in the ecosystem to collaborate and to drive lasting change. There is a clear need for a new approach and solutions to create the capacity to solve problems at speed and scale across the urban sector. In order to unleash the latent potential of the ecosystem described above, a foundational Institution is required to catalyze population-scale problem-solving at speed. This institution is being called the National Urban Innovation Hub.

2. National Urban Innovation Hub

MoHUA intends to establish the National Urban Innovation Hub (NUIH) as a Foundational Institution that can coordinate a nationwide ecosystem for identifying and solving problems at scale and with speed. The NUIH will catalyze the urban ecosystem in India, consolidate existing resources and expand the footprint of innovation development and capacity building.

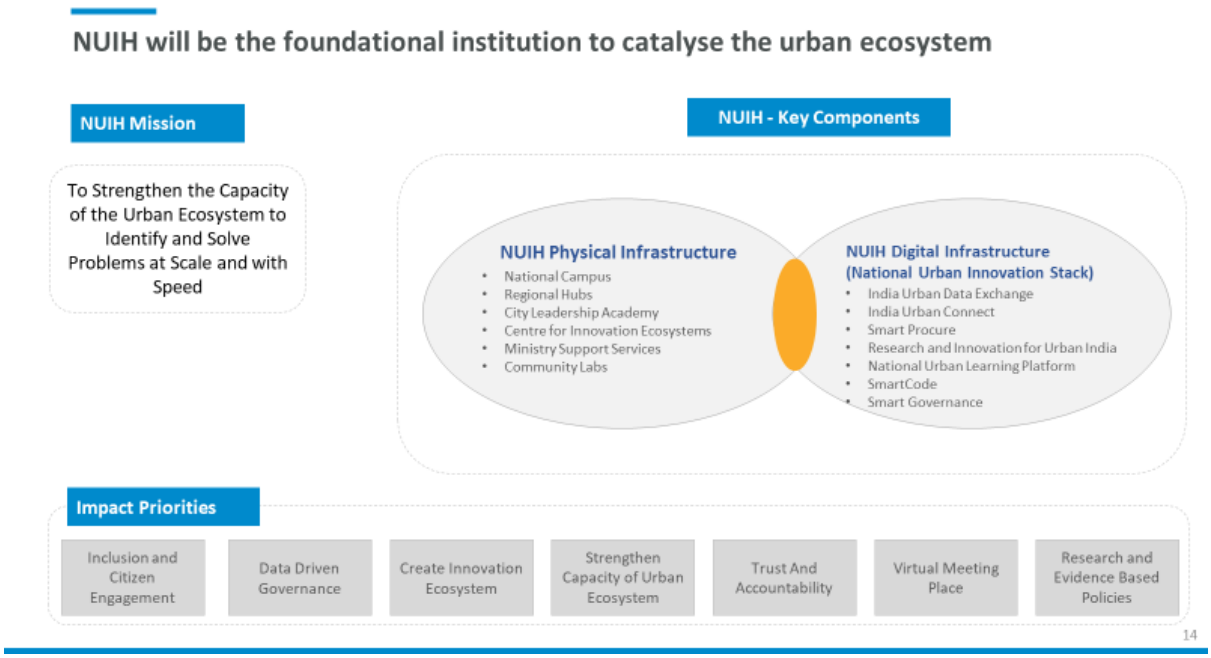

Figure 1: NUIH Mission, Key Components & Impact Priorities

2.1 Priority Areas of Focus

The NUIH will focus on catalyzing solutions in key urban sectors like Smart Mobility, Water and Sewerage, Solid Waste Management, Affordable Housing, Safety and Clean Energy. The Impact Priorities for the NUIH will be:

- Strengthen the capacity of urban local bodies
- Catalyze city-level Innovation
- Enable data-driven governance
- Create a Partnership Marketplace for Collaboration Between Stakeholders
- Enable Evidence-based Policies
- Engender enhanced Trust and Accountability in the ecosystem
- Enable Citizen Participation and Collaboration

2.2 NUIH Strategy and Approach

The NUIH will drive greater coordination and alignment of urban stakeholders to solve urban challenges across the country. In order to guide the activation of a nationwide ecosystem and the

initiatives of various urban missions, programmes and projects, the NUIH will abide by the following foundational principles:

1. Openness – making it easier for stakeholders to coordinate, communicate and participate
2. Trust – building trust between stakeholders to improve the quality of outcomes achieved
3. Data-Driven – advancing a culture of data-driven decision-making amongst stakeholders

The NUIH will identify and partner with different stakeholders in the ecosystem including:

1. **Governments and Agencies**
    - National
    - State
    - Urban local body
2. **Business and Industry**
    - Private Sector
    - Public Sector
    - Incubators and Accelerators
3. **Research and Academic Institutions**
    - Urban Planning, Architecture, Design
    - Engineering
    - Science and Technology
    - Social Science
    - Public Policy & Management
    - Finance and Economics
4. **Civil Society**
    - Non-Profit Organizations
    - Social Enterprises
    - Resident Welfare Associations
    - Citizen Collectives
    - Foundations
5. **Global networks**
    - Multilateral Institutions
    - Bilateral relationships

2.3 Need for a National Urban Innovation Stack

The NUIH will focus on addressing some of the key challenges in the urban ecosystem including data and information asymmetries, data exchange and interoperability, archaic procurement processes, poor utilization of research and innovations, long project and development timelines, poor capacity and skills in the urban ecosystem and limited digital governance.

In order to harness the vast amounts of data generated by India's cities, it is imperative to eliminate organizational and systemic siloes. NUIH will foster the development of an Indian Urban Data Exchange to evolve standards, specifications, certifications, systems and tools for urban stakeholders to share data for closer coordination and improved planning, decision making and execution. The IUDX will enable authenticated, secure and consented data access between different organizations and digital systems in the urban ecosystem.

In addition to breaking down data siloes, it is important to eliminate information asymmetries between ecosystem actors and improve data driven discoverability along key themes and sectors. The India Urban Connect platform will be designed as a network for urban ecosystem stakeholders to share relevant information including data, knowledge, urban development plans, strengths, capabilities and resource information. IUC will provide stakeholders with relevant networking and meeting tools as well as data and information catalogs to drive engagement between stakeholders. This will enable city governments, academics, sector experts, businesses, startups and investors, to connect with one another on topics of interest with a focus on data driven discussions and collaboration.

In order to harness the potential of India's vibrant startup ecosystem to drive innovation in urban India it is important to overcome the challenges posed by archaic procurement processes. SmartProcure will be a program of the NUIH to assist city governments on identifying fit for purpose innovations for urban challenges and to connect easily with the startup and innovation ecosystem. SmartProcure will reduce barriers to participation and engagement between city governments and startups through providing discovery and matchmaking tools and services.

Despite boasting a large number of high-quality academic institutions in India, there has traditionally been a disconnect between academia and urban policy and practice. The research and innovation program of the NUIH will focus on establishing partnerships with leading national and international academic institutions to address key areas of concern for MoHUA and city governments. In addition, the Smart Cities Mission will establish the SPIRIT program to drive innovation around urban challenges in partnership with Atal Innovation Mission and Startup India. Through this program Smart Cities will become Living Labs to study, design and evaluate policy and practice innovations in real world contexts. Over time the evidence and innovations generated through these programs will be channeled back into making data driven improvements

in the quality of urban governance and service delivery, while enabling new market opportunities for ecosystem actors.

In order to ensure that city governments and urban ecosystems are well equipped to drive urban transformation, NUIH will also anchor the capacity building efforts of MoHUA missions and other ecosystem stakeholders through a National Urban Learning Platform that will address the training and skill development needs of different ecosystem actors. The NULP team will work with various stakeholders to ensure that the knowledge they possess can be digitized and made available to ecosystem actors to access in a streamlined manner. The NULP will also enable the delivery of training programs and certification courses in a targeted manner. Over time, the NULP will host content from a large variety of stakeholders, making it the primary source for urban training and development for government employees, civil society, business and industry actors.

These efforts will culminate in an increased capacity within the urban governance ecosystem to manage urban infrastructure provisioning and service delivery. In order to streamline their operations, the NUIH will also provide a Smart Governance Platform with priority applications focused on revenue generation and enhancement, digital citizen service delivery and improved planning and execution within urban government agencies. This platform will facilitate the rapid development of urban governance applications and systems as well as the rapid digitalization of India's 4041 ULBs.

In order to successfully deliver these initiatives, the NUIH needs to catalyze the quadruple helix of governments, citizens, industry and academia to address the complex and dynamic nature of these programs. It requires an approach that can evolve and be extensible. This involves eradicating siloes, driving interoperability and reducing friction to engage, for the ecosystem actors. The network of actors needs to come together and have the capabilities to build solutions, that can be leveraged by urban programs dealing with different urban challenges.

This can be achieved through a stack-based approach, wherein complex multifaceted challenges are unbundled and abstracted into specific micro-problems. These micro-problems can be addressed through processes, people or technological innovations that equip actors with the micro-capabilities required. Solving a large challenge will require a logical arrangement of these micro-capabilities within the context of the specific challenge. This promotes reusability of the underlying innovations, as well as speed in building and implementing new solutions.

While the approach is applicable to people, processes and platforms, this strategy paper aims to elaborate the approach for digital platforms in the context of urban programs.

The NUIS is envisioned as a shared digital infrastructure that fosters innovation and collaboration in the ecosystem by unlocking the collective imagination to create novel solutions. The NUIS is predicated on the empowerment of people and enablement of processes in the ecosystem to drive solutions at scale and with speed.

3. The 'National Urban Innovation Stack' (NUIS)

3.1 Overview

The NUIS is designed to provide the foundational components that are required across various urban programs in India. The NUIS is a nationally-shared digital infrastructure usable by the Union and State across public and private sectors. The stack is designed to bring a holistic view across multiple urban verticals and enable rapid creation of diverse solutions in the urban development sector.

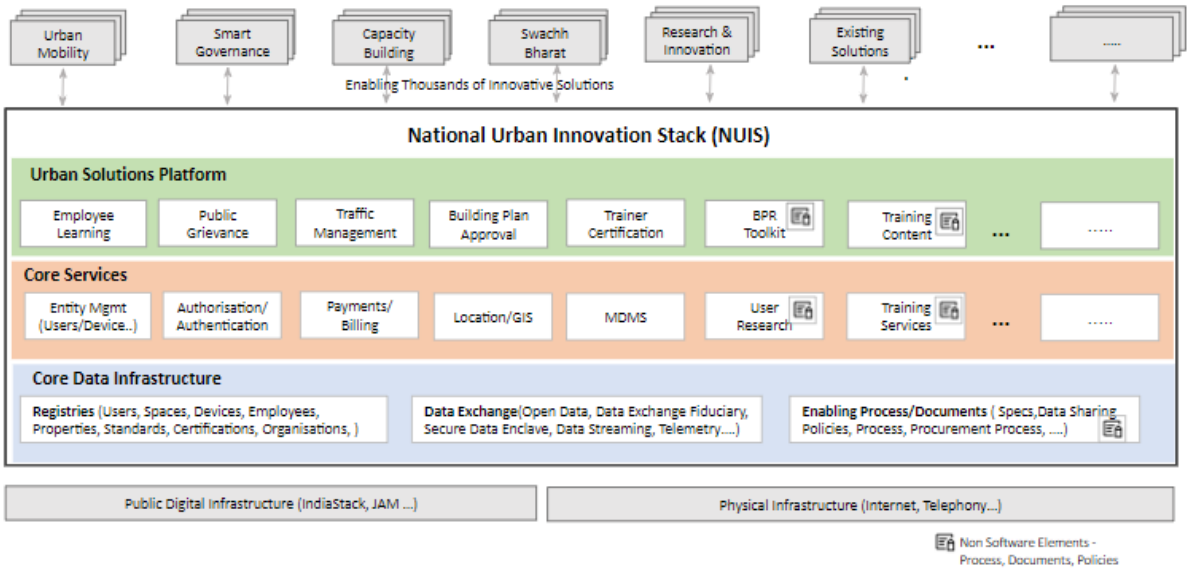

Figure 2: NUIS Overview

The NUIS is a collection of cloud-based services. Each service efficiently provides a single capability across multiple urban services, accessible through using simple, open APIs compatible with global standards. In addition, it provides a set of open standards and specifications that enable the ecosystem players to innovate on the stack. Together, these services and standards create a powerful framework to drive convergence and a faster implementation cycle for any urban initiative.

Urban initiatives, irrespective of their complex and diverse nature, share certain key building blocks. For example, whether it is a citizen filing an application or lodging a complaint, the ability to register it for that program, tag it and be able to process it, remains common. However, the actual solution may differ across programs, actual user journeys may be different, and the user interactions may be different. Monolithic solutions struggle to adapt to such a diverse set of use cases. NUIS therefore needs an architecture that is built of many small pieces, that can be extended and assembled to compose a particular solution. NUIS provides such key building blocks 'out of the box', and enables

extending their functionality. This provides flexibility and choice to the adopters to customize the platform for their own programs, without reinventing the wheel.

Naturally, when the domain and context vary significantly, the generic building blocks should not become a constraint and need to remain abstract enough to be applicable across sectors and domains. The NUIS will need to constantly maintain the balance between the applicability of these building blocks while reducing the need for customization. NUIS builds on this philosophy to create an architecture for micro-functional services. Each functional service is small, atomic, and complete in its conceptualization.

3.1.1 Guiding Design Principles for the NUIS

In order to distribute the problem-solving ability, the NUIS must provide guiding principles for ecosystem actors as they develop solutions to urban challenges. The principles result in the evolution of the necessary standards, specifications and certifications in the contexts of people (for example, policy standards and working methodologies), processes (for example process standards and compliance certificates) and the underlying digital platforms (for example, open standards, open APIs and open reference applications).

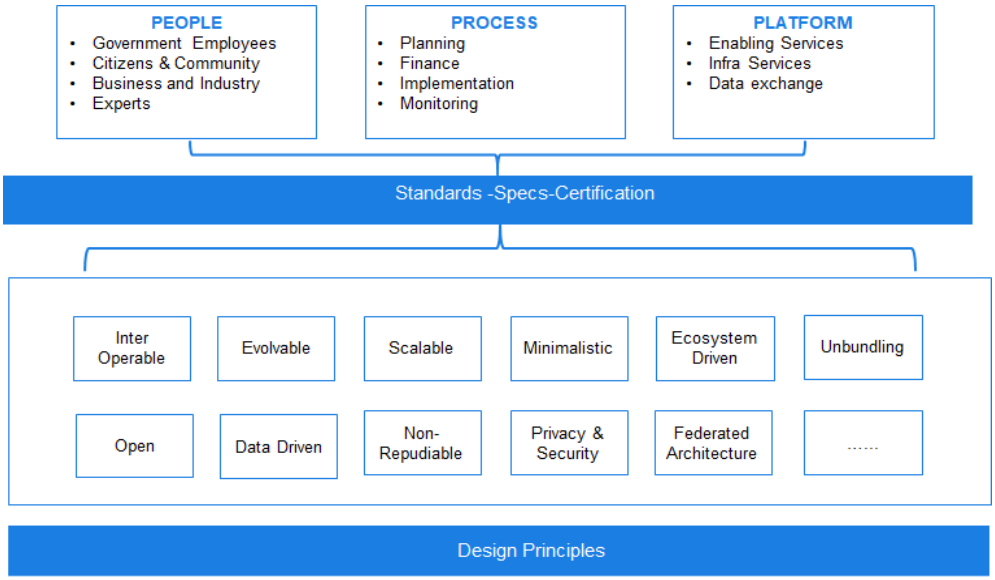

Figure 3: Stack Approach

Adherence to the design principles and the standards, specifications and certification processes, ensures increased access and lowers barriers to participation. Thereby, the approach allows all the actors across the whole ecosystem to collaborate and to solve urban challenges at scale and with

speed while ensuring the quality of outcomes by working toward achieving clearly established benchmarks.

The key guiding principles for the NUIS are:

1. Ecosystem Driven

The NUIS will foster a vibrant ecosystem of urban actors and respond to their needs by enabling effective collaboration for the purpose of devising solutions that are relevant to the contexts of each urban challenge.

2. Interoperability through Open APIs and Open Standards

Interoperability is essential for NUIS to be able to support a large number of diverse use cases. NUIS must be built using open standards and avoid dependence on specific platforms or software frameworks that become a barrier to the participation of any actor in the ecosystem. In addition, the components of the stack would be loosely coupled using open interfaces (APIs). Adoption of open and vendor-neutral APIs and open standards and, wherever appropriate, choosing open source frameworks and components over proprietary ones, will help achieve the goal of interoperability. NUIS will integrate with all relevant open platforms of the government including Aadhaar, GSTN, UPI, BBPS, and BharatQR.

3. Inclusive

Different instances of NUIS should be able to configure, extend or customize applications to cater to their specific needs as long as they meet the open standards and specifications laid out by the NUIS.

4. Minimalistic

The goal of the stack is to enable relevant solutions; hence it is important that the stack remains minimal and allows innovative solutions to emerge rather than forcing a particular type of solution. It may provide reference implementations to seed the imagination of the ecosystem, but should remain minimalistic to allow actors to respond to context and complexity.

5. Unbundling

Platforms achieve scale and flexibility by unbundling complex challenges into micro solutions and services and subsequently allowing their re-bundling in specific contexts. These layers rise from context-neutral bottom layers to more context-sensitive layers — similar to LEGO™ building blocks. Unbundling promotes reusability, lowers the barrier for new solutions and enhances participation by abstracting complexity under simple interfaces.

6. Designing for Evolvability and Scale

The NUIS will need to keep pace with India's urban challenges as they evolve over the years. It will have an architecture that can easily accommodate new capabilities that will be needed as the ecosystem evolves and to incorporate new technologies as they emerge. The stack will be able to scale horizontally to hundreds of millions of users in the urban ecosystem and to handle trillions of data records. All components, including computer, network and storage resources, must be capable of scaling horizontally. Being cloud-ready and using commodity hardware will ensure that capital investments on the stack will be minimal. This will also give a choice of infrastructure to the actors and users and enable systems to evolve heterogeneously.

7. Transparency and Accountability through Data

The verified registry of all the entities and the non-repudiable transaction trails shall lead to higher trust and stronger accountability. NUIS will be data-driven and will use data generated through transactions for reporting and analysis. Public Open Data shall be made available via APIs for transparency. The access to open data will ensure high-quality analytics, accurate fraud detection, shorter cycles for system improvement and, most importantly, high responsiveness to user needs.

8. Non-Repudiable

The stack would enable the verifiability of data and its provenance and thereby ensure trust and accountability within the ecosystem. All data would be non-repudiable and verifiable In order to energize the ecosystem for collaboration and interaction between actors.

9. Domain Modeling

Since NUIS must balance between abstraction, for wider adaptability, and context-specific solutions, the data specifications would remain generic without making concrete assumptions about the purpose for which the data is used. The data specifications would be extensible, allowing programs to model their own domain by adding new data attributes on top of available specifications.

10. Privacy and Security by Design

Managing security and privacy of data is crucial to building and maintaining trust between ecosystem participants and thus will be a critical design principle. All data access must be through API calls to ensure appropriate security controls. NUIS will provide standards and certification for data privacy and security. Except for open data, direct access to data will be prohibited and use of APIs will be mandated. NUIS will ensure privacy, data encryption and

data integrity and will disseminate data only to authenticated and authorized stakeholders (both internal and external) through data fiduciaries.

11. Federated Architecture

To resolve for scale and ensure agency, the ability to solve must be distributed, empowering stakeholders to overcome the challenges they face. Hence the NUIS will have a federated architecture enabling actors to retain agency and choice in solutions.

12. Ensuring extensibility through the use of layered design

The design of NUIS will be modular, with clear separation of data storage, software services and APIs. Components will be minimalistic, independently replaceable and extensible. This will allow different components to be loosely coupled when building applications, thereby enabling application diversity. Different instances of the stack will be able to customize and create contextual solutions to serve their specific purpose.

13. Multi-Channel Access

With the rapid growth of net connectivity and the variety of electronic devices available in the market, it is important that the end user's access points and access interfaces are kept in mind while enabling access channels — Citizen Service Centres, PCs, Tablets, Smartphones, Offline — and ensuring an engaging user experience on all of these channels to enable rapid adoption and ease of operation by the end users.

3.1.2 Standards, Specifications and Certifications

The NUIS will promote openness and collaboration while ensuring high quality of outcomes by providing standards, specifications and certifications to act as guardrails for the ecosystem as different actors build solutions across space and time. This allows the NUIS to provide flexibility and choice to ecosystem actors while enabling effective coordination through a common vocabulary across various areas. It also enables trust by effectively measuring the capabilities of ecosystem actors across the dimensions of people, processes, technology and data.

Open standards and specifications enable increased interoperability between solutions and systems. The use of open standards reduces the barriers to participation by ecosystem actors and enables them to avoid vendor lock-ins. Standards and specifications cover people, processes, data, interfaces and APIs.

Certifications act as an effective mechanism to create trust in the ecosystem. They enable participants to rapidly assess the capability of people, processes and systems. Certifications aid in facilitating the collaboration between the appropriate actors and components to build and deliver solutions.

3.2 Components of NUIS

At a broad level, the NUIS components are grouped into three layers:

1. CORE DATA INFRASTRUCTURE layer

Forms the base of the stack and comprises of data services.

2. CORE SERVICES layer

Houses context-neutral functional services which can be leveraged to build urban solutions.

3. SOLUTIONS PLATFORM layer

Provides context-sensitive solutions required to implement large-scale urban programs.

In order to accelerate the overall development and operationalization of the NUIS, the various components of the India Stack, which are immediately available with the Government of India, will be utilized. These are described below.

India Stack and existing open stacks

The NUIS builds on the India Stack, a set of digital public goods which collectively make it easier for innovators to introduce digital services in India across a range of sectors.

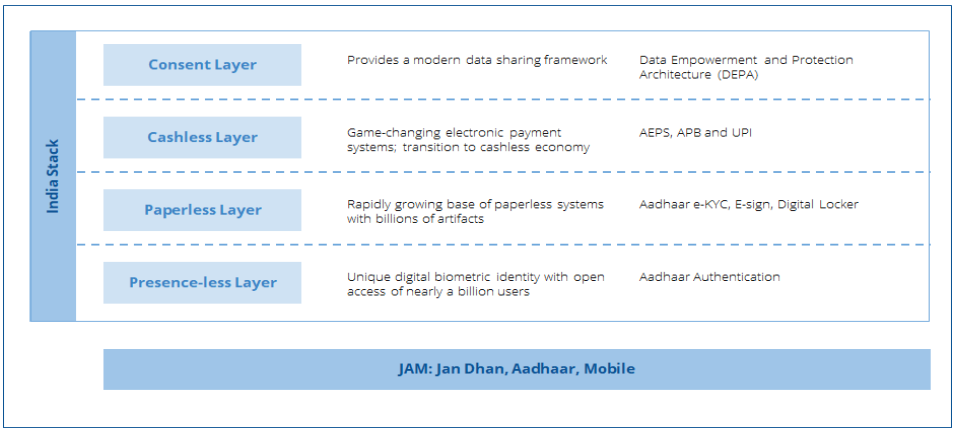

Figure 4: Layers of the India Stack

India Stack has four essential layers:

1. **Presence-less layer,** which enables removal of barriers to people's participation in formal services through digital identities and remote authentication mechanisms.

Authentication will be a core service in multiple solutions built on NUIS, therefore Aadhaar verification can be used wherever possible.

2. Paper-less layer, which enables digital records to be moved with an individual's digital identity. Urban solutions and services have enormous paperwork and need to store templates and documents for the same. Use of e-sign and DigiLocker provide a simple solution to this problem.

3. Cashless layer, which includes a set of payments services to ease monetary transactions. Since there will be various transactions between actors in the urban ecosystem, solutions built in NUIS can use UPI as a default technology for payment services.

4. Consent layer, which empowers individuals to share their data in a safe and secure manner, thus enabling access to better financial, governance, healthcare, and other services. This aspect of India Stack enhances the guiding principle of privacy and empowers the users of the NUIS to safely share data.

In addition, the NUIS will leverage other existing open stacks like Telephony, Internet and Global Positioning System (GPS).

3.2.1 Core Data Infrastructure

The Core Data Infrastructure layer is made up of two key components: registries and data infrastructure. This layer contains data standards, specifications and data services that will be leveraged by all programs built on top of NUIS.

Electronic Registries

A lack of reliable and easily-accessible master data is a core problem that affects urban India. Each organization tends to maintain its own copy of data that is difficult to update and restricts the data sharing across ecosystem actors. This in turn, makes it difficult to get a holistic view of urban issues. To overcome these challenges, the NUIS will incorporate a layer of electronic registries, that will form the base layer of the stack. Registries provide from the "root of trust" and a shared infrastructure to enable authorized agencies to publish digital data about users/entities and other agencies to access this data (for verification or usage). Registries enable decision makers across organizations to have access to common sets of data that are logically organized and act as a shared source of truth, to improve collaboration and decision-making in the ecosystem. The registries will

be backed with a common data ontology that will enable sharing of data across functions and creation of dashboards and analytics at various levels.

Registries in the NUIS will be developed with the following guiding design principles:

Self-Maintainability

Entities listed in the registry should be able to view their information and appropriate workflows should exist to enable entities to update their information in a verifiable and trustable manner. For example, the attributes of property records change over a period of time. If the ownership of the property changes at the registration department, a workflow will be initiated that will end with the updated ownership of the property record in the registry. Administration can view this data to verify the actual ownership change to issue the mutation certificate and also update records for future transactions related to property tax.

Non-Repudiable Data

The source for each attribute in the registry should be visible. Viewers should be able to view the attribute trail; that is, who added which information and when. All attributes should be digitally signed by the authorized updater. This leads to higher trust and strong accountability.

Data Provenance

A non-repudiable audit trail must also exist for all changes made to entries in the registry. In general, it will not be possible to delete data from registries, though in certain circumstances, the registry owner may choose to mark certain data objects as obsolete. For example, when the ownership of the property record is changed in the above example, the record will be digitally signed by the approving authority and will be viewable by everyone. All changes in the property records over a period of time will be viewable to all the authorized stakeholders. This helps to build trust in the data by the registry users.

Incentive-aligned design

The registry design must naturally cater to the incentives of the ecosystem actors. Registry owners must enact mandates that require the entities listed by the registry to register and keep up-to-date information. Where mandates are not possible, the registry owner must create aligned incentives for updation. For example, ensuring the ACRs of field employees include Key Performance Indicators (KPIs) and performance data

generated by the system, ensures that the field employee has an incentive to ensure real-time updates of the task list.

Extensibility and Flexible Schemas

Electronic registries will serve many stakeholders. Registry owners need to set up a process to accept feedback, extend information fields and help enrich the registry over time. Registries must also be able to store complex hierarchies of information and be able to link with other registries. For example, the license department may link to the property registry and store additional information with respect to the category of trade operating on the given property and issuing license.

Open APIs

Creation, updation and retrieval of data must be possible using open APIs. For some APIs, entity authentication mechanisms must be implemented in order to ensure data security.

Controlled Data Visibility and Consented Data Sharing

Registries will offer fine-grained control and visibility over any attribute. Attributes can be public or private, masked, encrypted, and so on. Sharing of private attributes to a requestor will require consented access.

A property registry is a good example in the urban context. Property is central to many urban needs - tax services, No Objection Certificates (NOCs)s, licenses, connections (electricity, water, sewerage), mobility solutions and need for public urban spaces, are some examples. A holistic and shared registry of properties provides an opportunity to reduce revenue leakages and plan proper public amenities. Given that property is an asset and details related with it can reveal many aspects about the owner, also qualifies it for access via data fiduciaries using consented access mechanisms.

Data infrastructure

Data in NUIS can mainly be categorized as follows -

1. *Master data*: Metadata about entities in the system a.k.a. Registry.
2. *Transaction data*: Transactional data like payments, expenses and workflows.

3. *Stream data*: Interaction events, sensor data, telemetry data, alerts, messages and commands (consisting of both live data streams as well as archived records).
4. *Derived data*: Computed by analytics pipelines using data products (such as calculators, etc).

Data in the first three categories typically enters the platform through APIs. Data infrastructure in NUIS will provide capabilities for injecting, storing, processing and accessing the data in conjunction with higher layers of the stack.

NUIS architecture conceptualizes data products as microservices for data processing. Data products are small atomic routines that aggregate or summarize the data. They take raw stream feeds or other derived data as input, and produce derived data as output. As new, higher order data products are built, newer analytical questions can be answered. In line with the microservice architecture, the data architecture in NUIS will allow adopters to customize NUIS by developing new data products, and assembling them for higher order insights. Outputs of data products are made available through APIs or exhausts. Based on the nature of output data, these APIs/exhaust may be access-controlled.

Following the NUIS principle of 'Privacy by Design', sensitive data will either remain anonymous or use virtual profiles where necessary. No sensitive or personally identifiable data will be captured unnecessarily by the system. However, if and when sensitive details like email addresses or phone numbers are captured (e.g. in the 'User Profile' for password reset), they will be stored in an encrypted manner.

NUIS will ensure privacy and data integrity and will disseminate data to authenticated and authorised stakeholders only. Sensitive data about individuals will be encrypted at rest. Mechanisms will be implemented for user consent, using the 'MeitY Electronic Consent Framework' to enable applications to share data about users in a safe manner. Finally, tools will be available to enable audit and to investigate breach. Each adopter of NUIS would need to define their own data manifesto, articulating policies around data gathering, usage, and sharing.

The NUIS philosophy is to enable an ecosystem that promotes data-driven innovation with the right balance between security and privacy of data. Some of the key attributes of the data infrastructure layer are:

Data Specifications

In order to achieve its objective of seamless data exchange to enable data driven innovation, it is important that there are well defined but extensible data specifications. These include Taxonomies, Ontologies, Categorization, Data Models, Open APIs, message structures, exchange protocols and, processing standards. This use of a common data language is key to allow interoperability, reduce barriers to innovation and avoid vendor lock-ins.

Since NUIS will balance between abstraction for wider adaptability, and specific solutions, the data specifications would remain generic without making concrete assumptions about the purpose for which the data is used. NUIS data specifications will also include best practices for ensuring privacy, security and informed use of data to enable data-driven innovation.

The data specifications will be extensible, allowing stakeholders and programs to model their own domain by adding new data attributes on top of available specifications. These changes can be incorporated into the main specifications based on a standard process.

Open Data

Open data is the idea that some data should be freely available for general public good. It helps researchers, academicians and other public actors to enhance their data innovation capabilities. NUIS data infrastructure will provide users with the ability to define the specifications for open data and provide mechanisms (Open APIs, Open Data Exhausts) to access anonymized and aggregated data as public goods.

Data Exchange Fiduciary

To enable smooth exchange of data, NUIS enables the establishment of Data Exchange Fiduciaries with the following key functions -

Data Discovery

Ability to create and search data catalogues to find relevant data sets, APIs and their access permissions.

Consented data access

Facilitating consent-driven interaction between the actor that produces the data and the actor that wants to consume it. A meaningful producer-controlled data exchange infrastructure, made possible via Data Exchange Fiduciaries, will help create trust between actors. It allows data producers to effectively become a data information exchange in their own context. Also,

the federated structure of NUIS can facilitate authorized access to data in a consented manner for multiple purposes.

Secure Data Enclaves

While open data and data exchange through access-controlled APIs will cover a large part of data exchange needs, there still remains a class of information and insights that cannot be derived either via open data or using consent-based data that is accessed through fiduciaries. In such cases, the data consumer has a need to look at a large data set and ask questions that may involve calculations on sensitive fields, but does not need these sensitive values in the response. An example of such a question is: “How many people in a city were born before January 1, 1980?” In order to calculate the response, it is important to know the date of birth but the response does not need to contain the sensitive data linked to each of the “people”. To enable exchange of such information and insights while balancing security and privacy, NUIS includes Secure Data Enclaves. Each data producer will need to set up such secure data enclaves where data consumers can send in their queries. The data producers will then process these queries in the secure data enclaves and validate the absence of any sensitive data in the response before responding.

3.2.2 Core Services

Apart from the Data Exchange Services mentioned in the Core Data Infrastructure layer, NUIS will have other services which will be used to build urban solutions. These reusable functional services will enable the creation of urban solutions form the Core Services layer. The services consist of fundamental building blocks of reusable APIs and libraries. Some of the services may be seeded by NUIS as open source services or already available open source components. Other services may come from different actors in the ecosystem and be adopted as open standards by the NUIS. A few examples of core services:

- ***Entity Management Service***: manages the primary data of entities amongst different programs in conjunction with corresponding registries (e.g., user, device and so on). It will help ecosystem actors in resource management. It can also provide various user administration and security functions, including creating new users, managing user passwords, editing the profile, enabling or disabling certain users.
- ***Authentication and Authorization Service***: provides various authentication mechanisms, resource access rules and user roles. In conjunction with user registries, this service also acts as a single-sign-on layer for multiple urban programs. Every urban solution will use it for access control.

- ***Localization***: enables a solution to adapt to the needs and preferences of users in different regions. Every service needs to communicate with the user in the language that is understandable by the user. Localization service will provide the capabilities to serve multilingual content to the users.
- ***Reporting***: provides a framework that allows different stakeholders to define their KPIs and generate specific reports. Every program has desired objectives and decision makers need to monitor the outcomes in the form of reports. For example: a ward-wise property tax collection report will provide an overview of wards with high and low levels of tax collection. This will help commissioners in ward-wise prioritizing of actions and targets.
- ***Master data management Service***: provides an effective management of shared master data assets. This will ensure that data throughout various programs is accurate, up-to-date, and consistent. For example: the trade licenses master data will contain a list of all trades and licenses that can be issued for the trades.
- ***Payments and Billing Service***: This service uses the relevant business parameters to generate bills and demands in the system followed by enablement of the relevant payment collection options. Collections can be done through payment gateways or may happen offline and then get updated in the system for audit purpose. For example: a payer can pay cash at the counter and an employee will update the details in the system.
- ***Location Service***: This service will provide the additional layering of geo-spatial data in the urban context to drive targeted actions and decisions. For example: while allocating tasks, it should be possible to assign the task to the last-mile employee assigned to that area.
- ***User Research Templates***: In the early stages of any program, one needs to focus on understanding user behaviors, needs and motivation. This can be done through observation techniques, task analysis, and other feedback methodologies. Standardized templates will help researchers gather consistent, structured and specific data for the program. For example, all user personas can have a structured template comprising of personal details, goals, targets, skills and problems faced.
- ***Training Service Templates***: Most programs and actors will need to deliver training to improve employee capability, productivity and performance. Standardizing this process will increase ease and efficiency of training programs. Standard templates, documents and steps will be published for training.

As various programs begin to unfold, a large number of similarly context-neutral core services can be added to this layer to power multiple urban solutions.

3.2.3 Solutions Platform

The Urban Solutions Platforms layer consists of context-aware reusable services (API's), tools and libraries. This layer leverages the first two layers of the NUIS — Core Data Infrastructure and Core Services — and builds functional solutions that can be assembled to achieve the goals of various programs. For example, an urban mobility program may use traffic management and grievance redressal solutions to complete a feedback loop. The strength of the microservice-based stack approach is that each new program will create reusable services that can be used by future programs, thereby increasing the speed of solutioning. Examples of a few such solutions are:

- ***Building Plan Approval***: A system with automated building plan scrutiny will help eliminate the need to physically visit an office for approval. This will give cities the ability to provide single-window services to acquire building permits, NOCs and clearances from multiple agencies. Standardization of the approval process will make it easier for citizens, ULB officials and stakeholders to submit and track applications in real-time and obtain approvals digitally.
- ***Public Grievances Redressal System***: This system will provide a transparent, accountable and trackable mechanism to solve public grievances. Citizens will be able to file their complaints via various channels like mobile apps, web and IVRS (Interactive Voice recognition service) which will be routed to the respective agency. For an example, view Appendix 3.

Other possible solution platforms could include Traffic Management, Content Management, Employee Learning and Water Management. As the ecosystem uses and repurposes stack elements to address different challenges, a large number of urban solutions platforms will proliferate.

4. Key Programs of NUIH enabled through NUIS

In order to realize the full potential of the NUIH, it is essential that the NUIS become a vehicle for activating several key programs that can accelerate the ecosystem for urban transformation across India's geography. These programs will provide urban ecosystems with the resources and support needed to address systemic challenges such as the lack of evidence-based decision-making, information asymmetry between ecosystem stakeholders, archaic procurement processes, barriers to research and innovation, avoidably long project schedules, lack of capacity in the urban local bodies and poor digital governance. The NUIS will be the underpinning for all the programs by and will guide the initial development of the NUIH, which will build on the early gains and the ecosystem developed through the digital programmes and establish a hub-and-spoke network of stakeholders across rhe country. The NUIH will establish dedicated teams to support these programs and these teams will be located on a physical campus that will be the nerve centre for the NUIS and the meeting place for its stakeholders, used for incubation & acceleration and for knowledge-sharing and capacity building.

Over time, through its digital and on-site programs, and tempered by its support to MoHUA's schemes and missions, the NUIH will establish itself as the premier and foundational institution for state and city governments to engage with on their urban development agendas. The NUIH will assist the state governments and ULBs with adoption of their own customised platforms using the building blocks offered by the NUIS. Thus, NUIH will continually evolve new programs and govern the evolution of the NUIS to meet the needs of the ecosystem. The NUIS will become a public good that is accessible to all ecosystem stakeholders and leveraged for their urban development initiatives. The NUIH will evolve processes and tools to enable and manage this access, as well as to manage ecosystem feedback and inputs regarding the NUIS.

The key programs supported by the NUIS are:

1. India Urban Data Exchange (IUDX)
2. India Urban Connect (IUC)
3. Smart Procure
4. Research & Innovation for Urban India
5. National Urban Learning Platform
6. SmartCode
7. Smart Governance

4.1 India Urban Data Exchange - IUDX

Cities around the world are becoming increasingly data-driven across the entire value-chain, from policy formulation, choice of projects, project design, implementation and service delivery. Cities have learnt that the data generated by their various departments and agencies and by other public and private entities within their boundaries is a valuable new asset that needs to be carefully protected and leveraged. It is therefore extremely critical for Smart Cities to adopt an appropriate data strategy. The India Urban Data Exchange (IUDX) is a pivotal enabler of each smart city's data strategy. IUDX will support cities with unleashing the power of data and fostering effective policies around the creation, use and governance of urban data for the public good. By enabling better policies and mechanisms for efficient collection and consumption of data, the IUDX program will strengthen all other solutions built on the NUIS.

IUDX is being created as an open-source and collaborative effort, involving contributions and support from a wide variety of stakeholders in industry, academia and community organizations. A collaborative ecosystem ensures that this critical piece of national infrastructure is best-of-breed, responsive to the needs of cities and immune to being captured or controlled by a single commercial entity.

The need for the IUDX is driven by the fact that, by nature, city data originates from a wide variety of sources. Some of it consists of streams of IOT data from installed sensors (e.g. air quality, traffic, etc.) while other data is demographic or geographical. Some data may come from municipal tax or property records, while other data is derived from legal documents and registrations. A large amount of data is historical and derived from archival sources. Each set of data has its own security and privacy consideration, as well as commercial, monetary or subscription aspects which must be observed. However, due to organizational inertia or friction or other reasons, the data often resides in a number of independent silos, without standardization of software components, their interfaces, or the underlying data models. Data created by a specific siloed system (e.g. a vendor's streetlight management platform) is usually available only to that system and cannot be leveraged more broadly. Sharing data between systems or building a new application that uses data from different systems is usually not feasible.

IUDX solves the interoperability and data connectivity issues that have perpeatuted within the urban ecosystem in such a manner that it complements existing deployments and does not require any replacement of existing systems. Instead of breaking existing systems or moving data en masse into

a central repository, this approach chooses to keep the data where it resides naturally, and to interconnect the disparate and distributed systems through a common data 'exchange'. This provides a way for accessing data in a unified, common format, allowing for sharing of data between different departments in a city, as well as opening up data for third party developers to create innovative new applications and citizen services. The data from each different vendor platform is translated into the common IUDX format through a specially designed IUDX 'adaptor' that masks the difference between vendors and enables increased flexibility in vendor selection. In addition, there is an opportunity for third party providers of data, or third party providers of data analytics or data annotation, to participate in what effectively performs as a data marketplace.

The IUDX is a win-win solution for all stakeholders. Within each of the cities, the citizens and the community benefit from the availability of better, more innovative, and cheaper applications and services. The cities benefit from the reduced development cost and faster development times enabled by a standard platform, together with the ability to choose vendors freely and avoid vendor lock-in. They will be able to identify new sources of revenue by unlocking of data assets, and will unleash innovation from entrepreneurs and community, without any cost to themselves. Industry will benefit enormously through the improved ability to find skills and rapidly ramp up projects. They will also see reduced development expense enabled by a standardized and open-source platform, and be able to focus on innovation and differentiated value rather than design basic platform software. Start-ups, in particular, will benefit from the decrease in heterogeneity. Third party sources of data (such as private apartment complexes) will have a new opportunity to share and monetize their assets. Academic institutions and research labs will be able to conduct more meaningful research by having direct access to a wide variety of data. A simplified picture of the IUDX architecture is shown below.

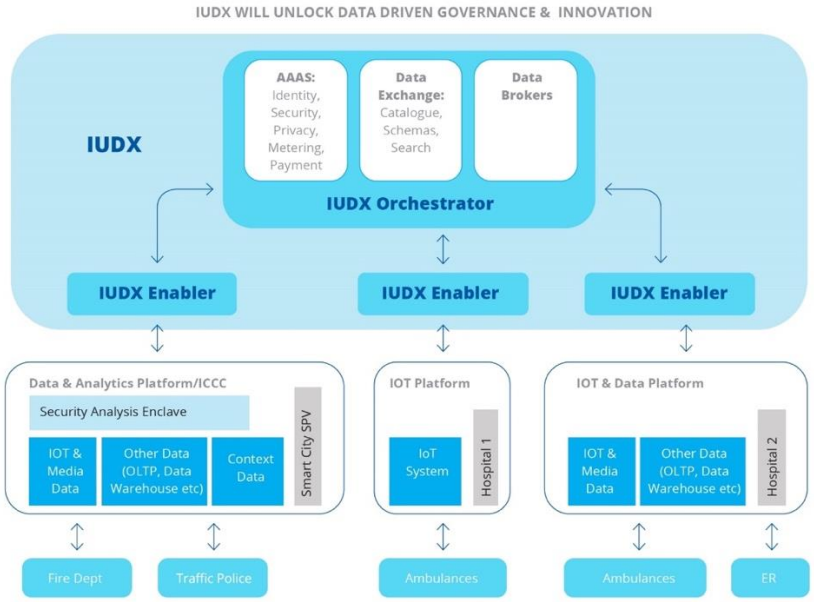

Figure 5: India Urban Data Exchange Architecture

IUDX is an open source software platform that enables the following key capabilities:

- **Finding data:** A comprehensive data catalog enables users to locate data of interest and to determine how to access it.
- **Connecting data:** Through suitable adaptors it will facilitate secure, authenticated and managed exchange of data amongst various data platforms, third-party authenticated & authorized applications and other data sources, data producers and consumers.
- **Control and security:** The platform will provide full control to the data owners as to what data to expose and to whom.
- **Enabling monetization:** Built-in accounting mechanisms will enable connect with payment gateways which will form the foundations for a data marketplace.
- **Application development:** The whole platform will be developer friendly, via definitions of open APIs (application program interfaces) and data schema templates (formats for interpreting data), so that a whole new application ecosystem gets created.

An illustrative use case is the real-time street-by-street women's safety map that is being evaluated by the city of Chennai. Currently, a diverse set of data is collected from a wide variety of sources related to the safety of the city residents. Police records contain the recent history of street crime in different parts of the city as well as information on police patrols and police cars. Smart street-light sensors and controls show which parts of the city are well-lit and which parts may be in darkness. This data comes from different vendor platforms as the city has multiple street-light vendors. For non-smart street-lights, this data comes from the citizen redressal systems, from flagged complaints about streetlights that have failed. Anonymized location data from mobile phones (from various mobile carriers) show whether a particular area is crowded or empty. Traffic sensors show the

density and frequency of vehicular traffic. And property records show the occupancy and category of the buildings on a particular street, allowing one to tag the vacant lots and to evaluate possible threats. Each source of data was implemented at a different time, is owned by a different department, and has not been installed with any thought to openness or interoperability. As a result, despite the availability of vast amounts if data, the city governments and their varied departments and agencies are unable to make coherent and consistent decisions about citizen safety and security based on holistic analysis. The IUDX platform can connect the diverse systems, providing the analytic framework to combine and evaluate the various data and enabling a citizen mobile application to provide real-time indication of whether a particular street corner is considered safe at that particular time.

IUDX: Women's safety use case

Problem Statement: The City Commissioner of Chennai wants to improve safety for women walking within the city. Safety data is available from a number of sources. However, all this data is in separate systems with no easy way of interconnecting or integrating them, particularly in real-time. With UDUX all sources of safety data can be combined and analyzed, to give citizens and law-enforcement a real-time view into citizen safety.

Step 01: Data Collection

Police: Historical geo-tagged street crime data. Police patrol and police car routes and locations. **Smart street-lights:** Data from different vendor platforms provides information about lighting levels; **Citizen compalints:** Data on which regular streetlights may have failed; **Mobile phone locations:** Various carrier data on anonymized phone locations to show people density; **Traffic sensors:** Density of nearby vehicular traffic; **Property Records:** Information on occupancy and cartegory of nearby buildings

Step 02: IUDX integration

All Data Sources: Create adaptors to "IUDX enable" their systems. Using the IUDX open API's with standardisation of the data formats, an application developer can locate and access relevent safety related data, without having to worry about the complexity of accessing heterogeous data sources. Also the ability to connect analytic engines to IUDX enables sophisticated statistical analysis and other computations.

Step 03: Women's Safety App

City Command Center: Using IUDX analytics add-ons, it is possible to compute a safety index based on the heterogenous data sources related to safety. This can be displayed on a City Heat map for pro-active law enforcement. **Citizen App:** Similar data can be displayed in a mobile app or superimposed on an existing navigation applcation (e.g. Google Maps). Allows a citizen to ask the navigation app to provide a "safe" path to walk home.

Outcome: IUDX enables women to be safer in Chennai.

Figure 6: Creating a real-time street-by-street Women's Safety Map

NUIS COMPONENTS USED

1. Core Data Infrastructure	
1.1 Registries	Users, Organisations, Devices, Certifications etc
1.2 Data Infrastructure	**1. Data Specifications**: Source Taxonomy, Sensor Specs, Telemetry Specs, Message Specifications etc **2. Open Data**: Data production Summary, Source Summary , Open source data, Device Usage data etc **3. Data Fiduciaries**: Sensor Reports, Individual Usage, Individual Certificates
Enabling Processes or Documents: Sensor Specifications, Device Registration Process	
2. Core Services	
Authentication, Authorisation, Entity Management (Users , Devices), Search, Localisation service, Ontology tools,	
3. Urban Solution Platform	
Analytics Platform, Data Visualization Tools, Big Data Platform	

4.2 India Urban Connect (IUC)

Urban India is currently a vast and disorganised ecosystem with numerous stakeholders, minimal cross-learning between stakeholders even if they have common concerns, and a vast diversity caused by geography, socio-economic conditions and cultural specificities. This causes low levels of awareness about peer groups and potential collaborators, human resources and expertise. As a result, Indian cities tend to develop in relative isolation and unable to learn from their peers and to internalise the lessons learnt from experience because of disconnect between different players within the ecosystem. Across the entire urban ecosystem, stakeholders continually 'reinvent the wheel' and perceive their problems as unique even when they can share ideas and thoughts and find insights derived from common experiences.

India Urban Connect will help eliminate information asymmetries between urban stakeholders by enabling intuitive discovery in the urban ecosystem across the country and beyond. India Urban Connect will be a data-driven networking platform, offering single-click access to virtual meeting solutions, discussion forums, data catalogs, query-based and geolocated registries and contact information. Different stakeholders may discover each other as a result of shared analytics. They can post information regarding their strengths, capabilities and requirements and find ways to collaborate and share.

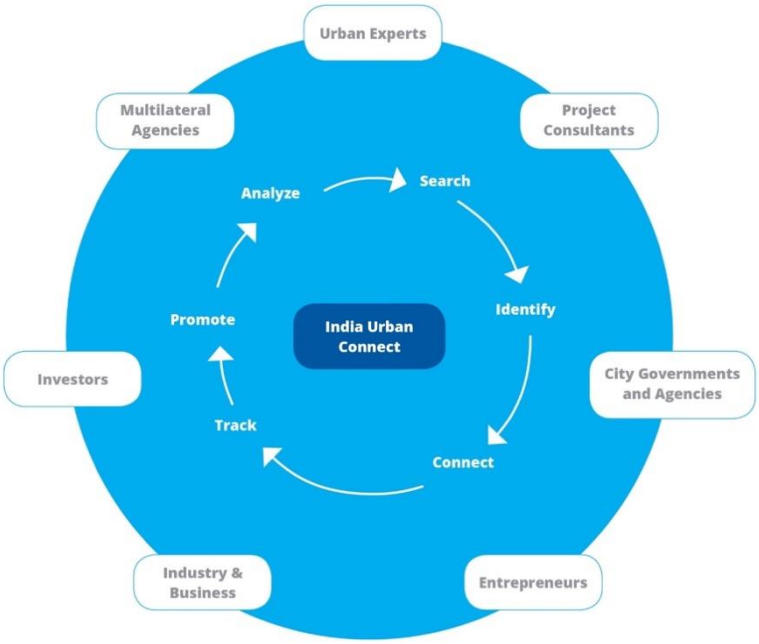

Figure 7: India Urban Connect

City Governments will be able to share their challenges, urban development plans and envisaged projects, invite feedback from ecosystem stakeholders and access the best possible set of options

available. In addition, city governments can identify and engage with sector experts to advise them on their challenges, upcoming projects and help them select the most relevant partners and technologies. They can also access research and white papers on topics of interest. They will be able to engage with investors to help design funding programs and options for these projects leveraging a range of methods including debt financing, equity financing, and value capture financing,

Industry, entrepreneurs, and vendors will be able to present their solutions and participate in discussions on upcoming projects and opportunities. They will also be able to promote their solutions and services through product catalogues, case studies and customer testimonials in print and video formats. Investors will benefit from having access to information and data on urban issues, ongoing and upcoming investable projects, the ability to effectively assess project risks through information on all project stakeholders and the ability to track project implementation against milestones and timelines. Academia and researchers can engage with urban problems using data shared by different stakeholders on platform. They can connect with city administrators and the industry to validate their research in real world conditions and help improve urban policies, initiatives and projects through evidence-based analysis.

India Urban Connect will actively lower barriers for industry participation in urban development and make it easier for India's cities to harness the best skills and capabilities available in the market to drive urban transformation. The India Urban Connect team will actively work to onboard new participants and evolve new features to meet participants needs.

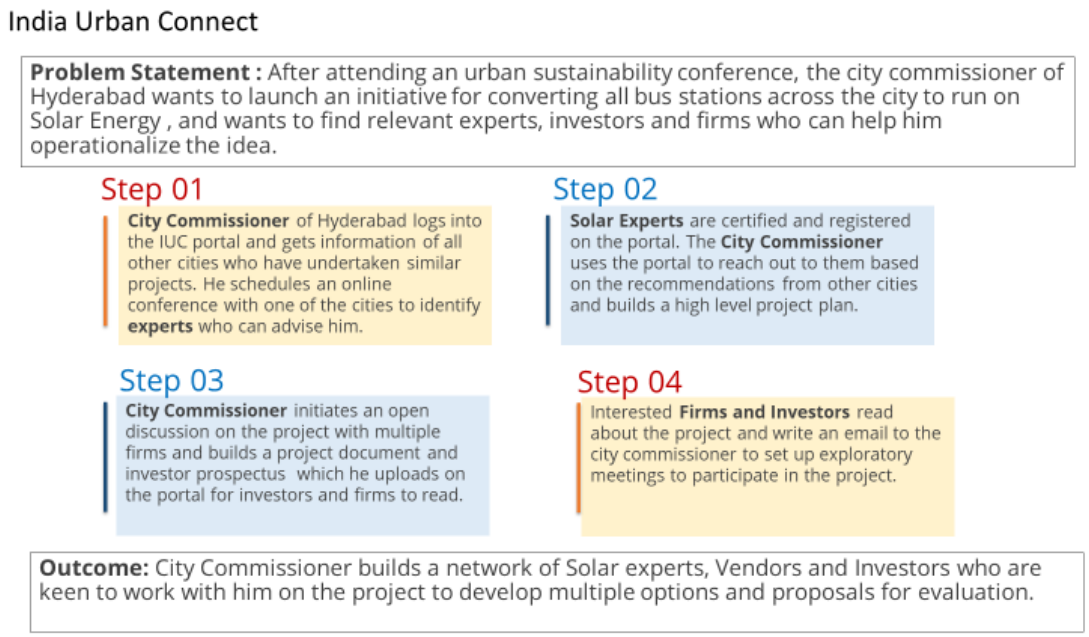

Figure 8: Developing a Solar Energy Project through India Urban Connect

NUIS COMPONENTS USED

1. Core Data Infrastructure	
1.1 Registries	Users, organisations, projects, transactions, innovators, certifications, and inventory
1.2 Data Infrastructure	**1. Data Specifications:** Sector taxonomy, policy taxonomy, project specifications and telemetry specifications. **2. Open Data:** Fund distribution summary, projects summary and platform activity summary. **3. Data Fiduciaries:** Project reports, individual usage and individual certificates. **4. Secure Data Enclave:** The Community Recommendation needs access to users private data to identify topics of relevance from each community. This cannot be provided and hence fiduciaries need to provide the ability for secure data enclave.
Enabling Processes or Documents: Expert certification process	
2. Core Services	
Authentication, authorisation, entity management (Users, organisations, etc.), search and localisation service	
3. Urban Solution Platform	
Virtual meeting solutions, contacts management solution and forum discussion application	

4.3 SmartProcure

While India has creating an enabling environment to foster startups and building innovative solutions for various challenges, the urban ecosystem has been unable to speed up the absorption of these innovations in its development efforts because of the inordinate delays caused by procurement procedures that discourage the interaction between cities and innovators, often forcing them to pursue discovery through non-transparent methods. Transparency in public procurement can be substantially improved by creating better flow of information and allowing for greater automation through single-windows and ease-of-living reforms.

Figure 9: SmartProcure Key Offerings

The SmartProcure platform creates a level playing field for all vendors to participate and discover information. The aspiration is to build a matchmaking platform between city project creators and the providers of the most optimal and innovative solutions. Resources and information will be distributed through simple tools which can be accessed by small and large vendors alike. Participating city governments will be able to access knowledge resources and advisory services to structure their procurement in a manner that is suited to the scale and complexity of the project for which the procurement is being made. Based on their special conditions, they can broadcast the project to a wide audience of vendors.

Businesses, industry actors and startups participating in SmartProcure will benefit from increased visibility of urban development and housing-related opportunities, transparent sharing of information on procurement processes, alerts on projects matching their skills and offerings and

visibility into payment timelines for purposes of financial planning as well as the ability to provide feedback on upcoming procurements.

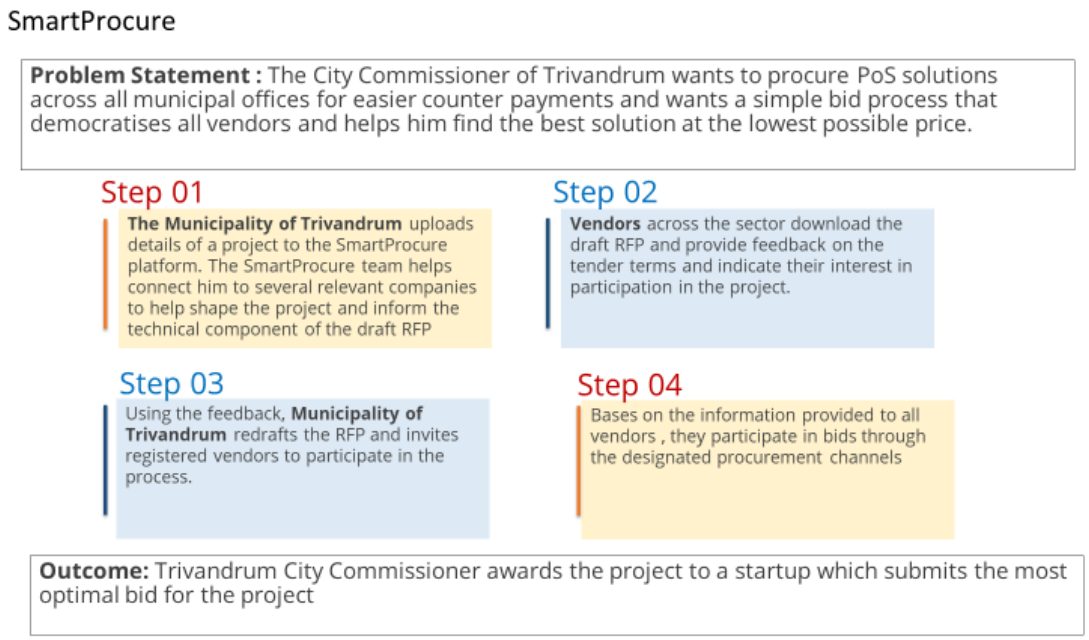

Figure 10: Simplifying procurement of PoS solutions

NUIS COMPONENTS USED

1. Core Data Infrastructure	
1.1 Registries	Users, employees, vendors, certifications and services.
1.2 Data Infrastructure	**1. Data Specifications:** Product taxonomy, certification specifications and telemetry specifications. **2. Open Data:** Government transaction summary and open government projects. **3. Data Fiduciaries:** Bid submissions, vendor profile and individual certificates. **4. Secure Data Enclave:** The Vendor Recommendation function needs access to private data of vendor usage and transactions. This cannot be provided and hence fiduciaries need to provide the ability for secure data enclave.
Enabling Processes or Documents: RFP templates and vendor certification process.	
2. Core Services	
Authentication, authorisation, entity management (users, employees, vendors.), workflow management, search, localisation service and payments	
3. Urban Solution Platform	
Procurement platform, vendor management solution, bidding application and contract management solutions	

4.4 Research and Innovation for Urban India

Urban India generates enormous amounts of data and produces the live urban conditions across a vast geography and diversity that can produce insights if subjected to analysis and inquiry. However, while Indian cities have been the subject of research over the years, the production of new knowledge and insight has been sparse, sporadic and restricted to a few disciplinary areas and fields. Most of the sites and actors engaged in urban policy and practice in India have historically been disconnected from research and innovation activities. As a result, cities do not benefit from the analysis of local potentials, problems and challenges and the production of innovative solutions that are appropriate to their conditions and needs. Innovators lose the opportunity to deal with problem statements that are grounded in reality. A deep rift has developed because of the lack of mechanisms and an ecosystem that can support the constant generation and exchange of ideas, insights and solutions.

In the developed economies of the world, government grants and private philanthropy have nourished, over many decades and, in some countries, over centuries, the research centres and university laboratories that have produced the new knowledge and innovative solutions that have spurred the economic growth of those countries, many of which have become knowledge economies on the basis of such innovation. India cannot afford to invest such large amounts of funding immediately; however, it does have the human resources and the institutional contexts that can be leveraged through an innovative and creative ecosystem. By creating the National Innovation Hub and activating its 'virtual' avatar immediately, India can begin to harness the unique opportunity to make the urban sector into a vast laboratory for evolving and testing cutting-edge solutions, especially by leveraging the 100 smart cities as the test beds for innovation. This will require the ecosystem to be activated through connections and collaborations.

Data analytics and sharing of information and analyses about the smart cities will produce the first generation of the new research and innovation, which will get disseminated throughout the country through the IUC platform and other functionalities of the NUIS. The process will originate with identification of problem statements either through crowdsourcing – especially in the case of commonly occurring phenomena such as waste or pollution or behaviour – or through the analysis of historical and archived data about any phenomenon like transportation and urbanization trends. These problem statements will be fed into a network of institutions and organisations that have the interest and wherewithal to engage with the problem statements, possibly from different disciplinary perspectives. Over several cycles of such engagement, the institutions and organisations

can even be formed into a consortium or association that can formulate rules and protocols for engagement, in order to accelerate the processes and even to manage cost-reduction and fund-raising. Cities can also form associations and networks that create a systematic engagement in the research and innovation ecosystem.

NUIH will foster research collaborations between leading national and international academic institutions across the world and Indian cities to develop process, policy and technological solutions to urban challenges in key areas including governance, mobility, environment, and economic development. Smart Cities will act as living labs to foster context relevant innovations and these will be disseminated in an organised manner through regular networking and showcasing activities such as conferences, workshops, webinars and publications, both online and printed. The archives of such research and innovation will reside on the NUIS and will be tagged in numerous ways such that users can locate and access the material with ease, intuitively and accurately.

Figure 11: Harnessing the power of Research and Innovation for Urban India

NUIS will provide researchers with access to urban data and data products, analytics workbenches and interactive 'spaces', in a secure and consented manner, with all communications and transactions recorded such that intellectual property and other aspects can be dealt with efficiently.

This will build greater trust and lower the barriers to participation by all actors, thereby attracting more new researchers to find fulfilling research experiences and – in best case scenarios – to reverse their tendency to join a brain drain that views only foreign environments as conducive to innovation. The greater the number of interactions that occur on the research and innovation ecosystem, the greater the knowledge and analysis that will be generated for future use by the ecosystem. A virtuous cycle will be created and the NUIH will be able to curate and provide key topics and areas of research based on the real world priorities that get established by the actors on the platform, such as city managers, technology providers, local communities and practitioners of all kinds.

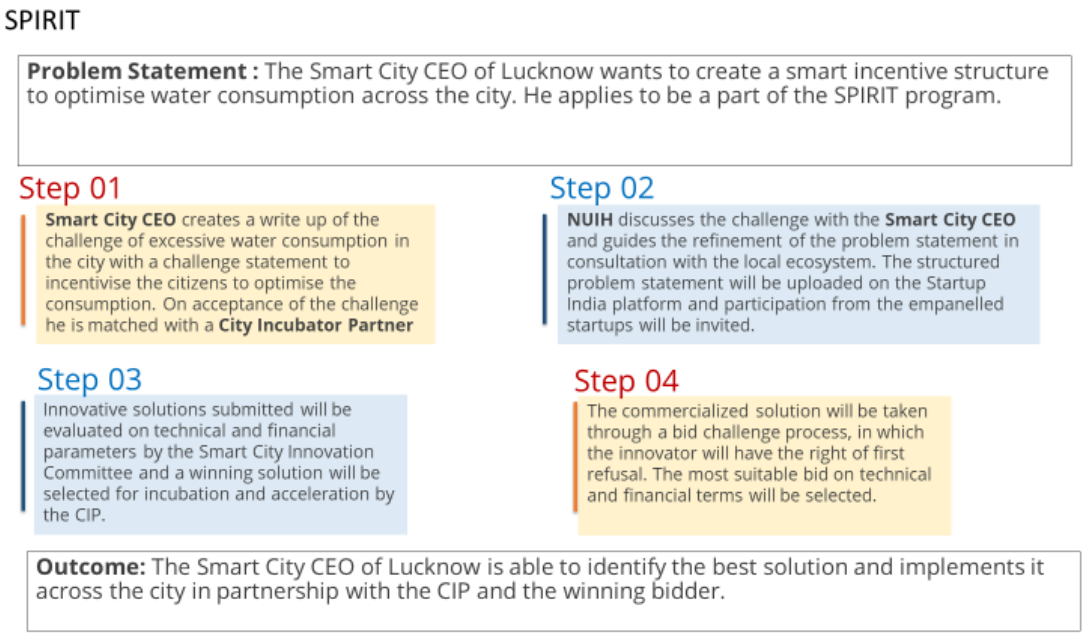

Figure 12:Optimizing water consumption in Smart Cities through Smart incentives

The NUIS will start its activities by enabling the expansion of the SPIRIT program established by the Smart Cities Mission to drive urban focused innovations in partnership with leading Government of India programs like the Atal Innovation Mission and Startup India. Through this initiative, cities will be able to identify critical innovations needed by them and contribute their problem statements into a challenge process that will begin with problem articulation and culminate with the demonstration and testing of a prototype. Winning ideas will be incubated and fostered through the provision of mentorship, seed funding and access to Smart Cities for prototyping and refining the solutions identified. Through the collaboration with the Startup India program, proven solutions will be commercialized and accelerated to make these available to cities for pilot implementation. The SPIRIT programme will utilise the entire spectrum of features of the NUIS in a self-reflexive manner, such that the performative aspects of the NUIS will in themselves be subject to scrutiny for potential problem identification and continual improvement.

NUIS COMPONENTS USED

1. Core Data Infrastructure	
1.1 Registries	Users, institutions, reports and certifications.
1.2 Data Infrastructure	**1. Data Specifications:** Sector taxonomy, certification specifications and telemetry specifications. **2. Open Data:** Open research repository and public institutions data. **3. Data Fiduciaries:** Individual research reports, individual usage and individual certificates. **4. Secure Data Enclave:** Topic Recommendation function needs access to users private data to identify topics of relevance from usage. This cannot be provided and hence fiduciaries need to provide the ability for secure data enclave.
Enabling Processes or Documents: Expert certification process and patent process	
2. Core Services	
Authentication, authorisation, entity management (users and devices), search, localisation service and report publication tool	
3. Urban Solution Platform	
Analytics platform, research community management and program management	

4.5 National Urban Learning Platform (NULP)

Urban India needs a variety of key skills and capacities to be developed speedily in the ecosystem in order to urgently address urban challenges, improve service delivery and unlock urban potential. These include skills like data driven decision making, urban planning, financial management, project management, resilience management and geographical information systems among others. However, these capacities and skills are scarce in the ecosystem with traditional channels of education, training and capacity building. All urban actors need to develop new skills and capacities in a timebound and on-demand manner to meet mission critical goals. New methods and strategies will need to be employed and new modes of training and capacity building will need to be made available to the urban ecosystem.

The National Urban Learning Platform is envisioned as a means of digitally consolidating key skills and knowledge required by urban stakeholders and making these available to all actors on the channel of their choice. The NULP will include tools to enable and streamline content creation, content organization and management, course building, course management, assessment and certification. These tools will enable the ecosystem of training institutions, urban experts and academia to rapidly digitize their existing course materials while creating new interactive and engaging types of content as well. The learning platform will enable the creation of multilingual content to ensure that language does not form a barrier to learning. The NULP will actively engage with and enroll training institutions, schools, civil society and other knowledge creators in India and abroad to ensure that there is a variety of content on a wide range of topics available on demand. The NULP team will also work closely with these stakeholders to help align their programs with and scale their reach.

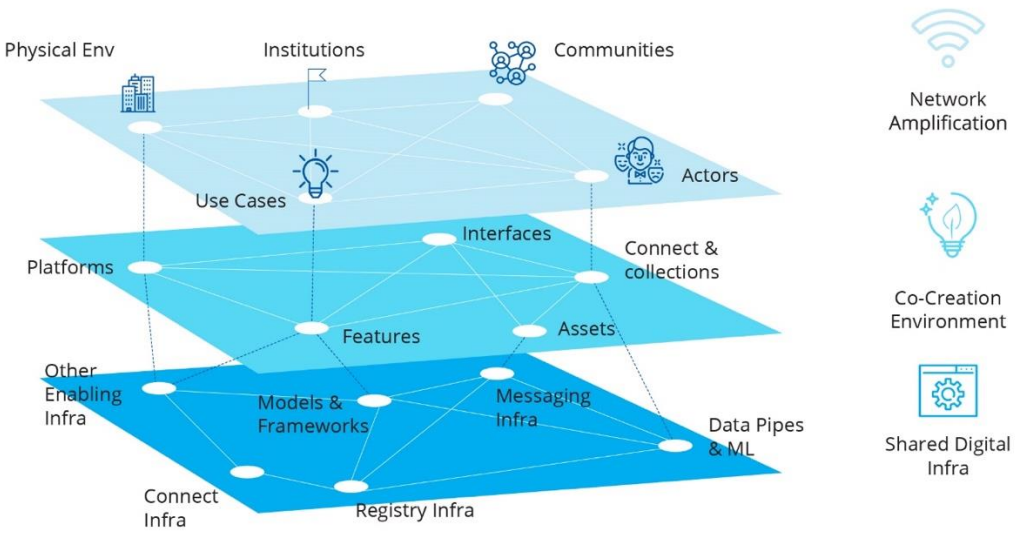

Figure 13: National Urban Learning Platform Architecture

The NULP will enable users to discover relevant materials and content on topics of interest and relevance and enroll in benchmarked and certified courses of varying durations and levels of effort to develop the related skills and capacities. Due to the dynamic nature of learning demand, the NULP will place agency and control over training in the hands of the users by making available a variety of options for self-directed learning and training. This will ensure that users are able to engage in lifelong learning and can access training and knowledge at a time that is most useful and relevant to them. Thus, for example, a city administrator can undertake a self-directed course on innovative financing in order to equip himself/herself to deal effectively with the financial demands of upcoming projects without having to wait for such a course to be made available at a local training institute. The NULP will also enable the creation of certification programs and will assist in the digital issuance and verification of certificates needed by functionaries in their respective roles. This will drive transparency on the skill levels and capacities available in the urban ecosystem and assist in matching functionaries to the roles that they are qualified to perform.

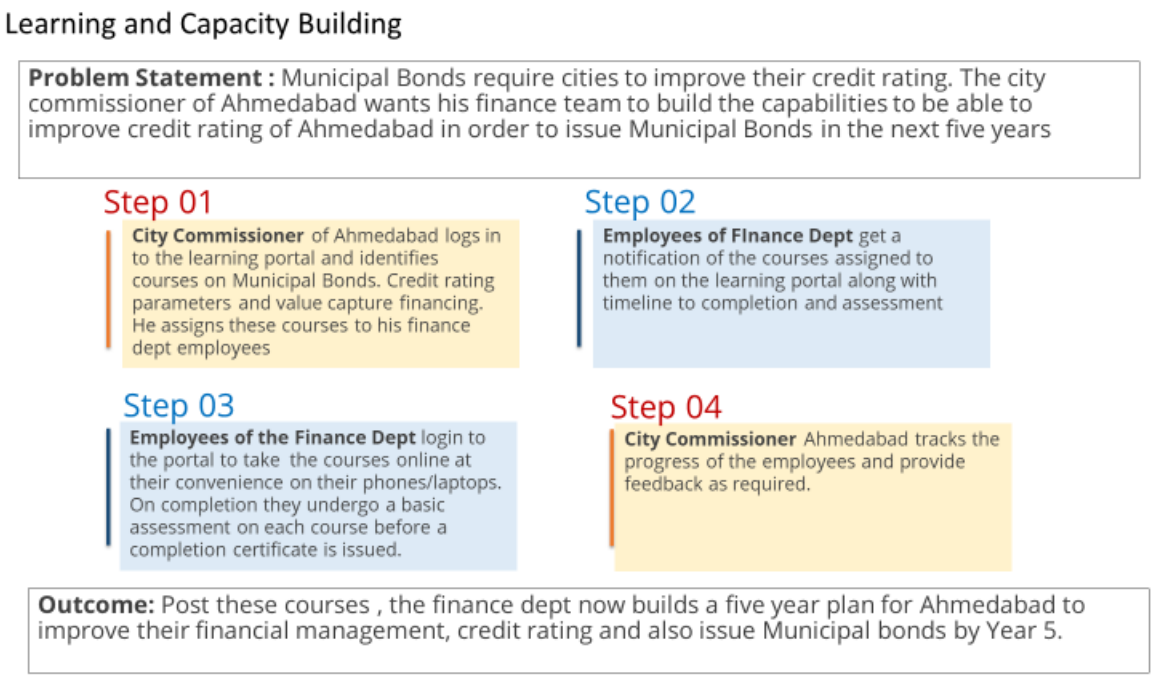

Figure 14: Improving financial management capacities in city governments

The NULP will provide the required telemetry frameworks, assessment mechanisms and tools to measure the usage of content and the engagement and completion levels achieved across specific pieces of content – this will enable content creators to assess the effectiveness of their content and enhance it as needed and will inform users about relevance and effectiveness of course content based on user ratings and feedback. Users will rate content and courses on parameters like relevance and quality to enable the easy discovery of high-quality content.

The NULP team will also engage with MoHUA missions and their existing capacity building ecosystems to ensure that the content available is aligned to the practical needs of various missions and to enable certifications obtained through the NULP to be counted as mandatory training requirements of the missions. The NULP will synergize the capacity building institutions empaneled with MoHUA to converge their training mandates and targets with the content and courses.

The NULP will empower India's urban functionaries, administrators, elected representatives, civil society, industry actors and other ecosystem players to build smart, inclusive, sustainable and resilient cities.

NUIS COMPONENTS USED

1. Core Data Infrastructure	
1.1 Registries	Users, organisations, standards, certifications, qualifications, etc
1.2 Data Infrastructure	**1. Data Specifications:** Curriculum taxonomy, roles taxonomy, policy taxonomy, certification specifications, content specifications and telemetry specifications. **2. Open Data:** Topic usage summary, content availability matrix, content usage data and engagement matrix. **3. Data Fiduciaries:** Individual reports, individual usage and individual certificates. **4. Secure Data Enclave:** The Employee Learning Recommender system needs access to private data of individual employees' learning and assessment from multiple NUIS instances from across cities. This cannot be provided and hence fiduciaries need to provide the ability for secure data enclave.
Enabling Processes or Documents: Course specifications and expert certification process	
2. Core Services	
Authentication, authorisation, entity management (users, organisations), content management and content workflows.	
3. Urban Solution Platform	
Citizen services assistant, employee learning assistant, employee assessment service, training partner certification service, content creator certification service and urban best practices knowledge base.	

4.6 SmartCode

A massive infusion of software innovation is required by Indian cities, given the current demand for digital applications and systems for urban solutions. These requirements are currently met by a concentrated ecosystem of software vendors and consultants. The development process is slow and often results in poor quality software products due to the lack of standards and protocols. It is critical to ensure that cities are able to leverage the country's talent in digital technology and IT-enabled services in a more effective manner through streamlined engagement processes and the digital infrastructure provided by NUIS.

SmartCode is a platform to create a vast network of developers across the country focused on serving the software development demands of cities and setting standards for requirement submissions and development cycles. This initiative will lower the barriers of participation and access, making it possible for freelancers and startups to actively engage in solving urban challenges across the entire urban geography. NUIH will create standards and certifications for coders and companies to participate in the process. It will also supply the incubation and acceleration facilities that are needed by the ecosystem, such that solutions can be made available at lower costs while maintaining performance standards. The platform will ensure faster development cycles and increase the opportunities for faster prototyping and decision making. ULBs will also be able to discover innovative solutions for the problem statements that they submit on the platform.

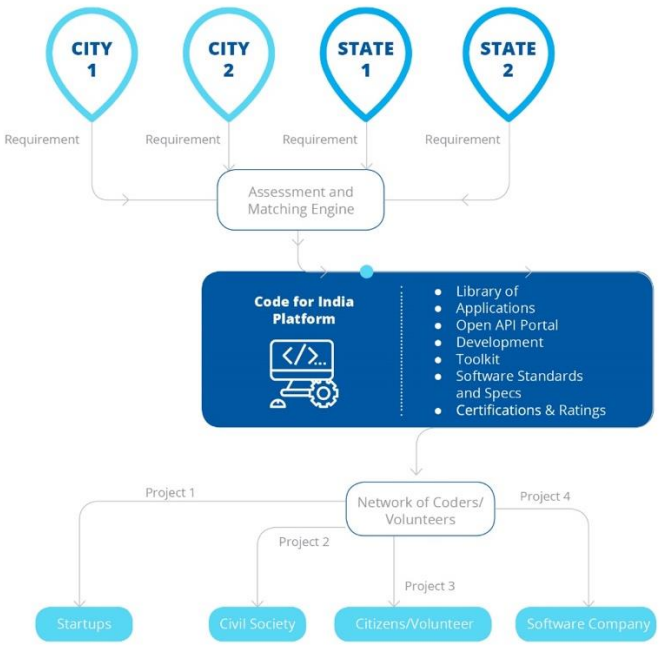

Figure 15: The SmartCode Platform

NUIH will act as a bridge between city governments and empaneled developers. It will be responsible for setting and maintaining standards for requirement formats, developer certification, development cycles, product standards and specifications etc., ensuring predictability and transparency in the system. The platform will also enable a closed loop feedback system for the benefit of all stakeholders.

Smart Cities and agencies can participate in the platform by subscribing for access through NUIH. As a part of the process, cities can indicate which elements of the NUIS they are already using and provide sample anonymized data sets for the development effort. This will ensure that cities will be able to leverage their existing digital assets and reduce the development effort and time taken to discover solutions. Upon receiving a project briefing from a city, NUIH will identify suitable development partners empanelled with SmartCode and get the project developed in an agile manner with project management being provided by the SmartCode team. Developers will have to meet the certification requirements and standards set by the NUIS. This will create a level playing field for all firms and software developers. Developers can also access the existing open source systems and build their innovations on top.

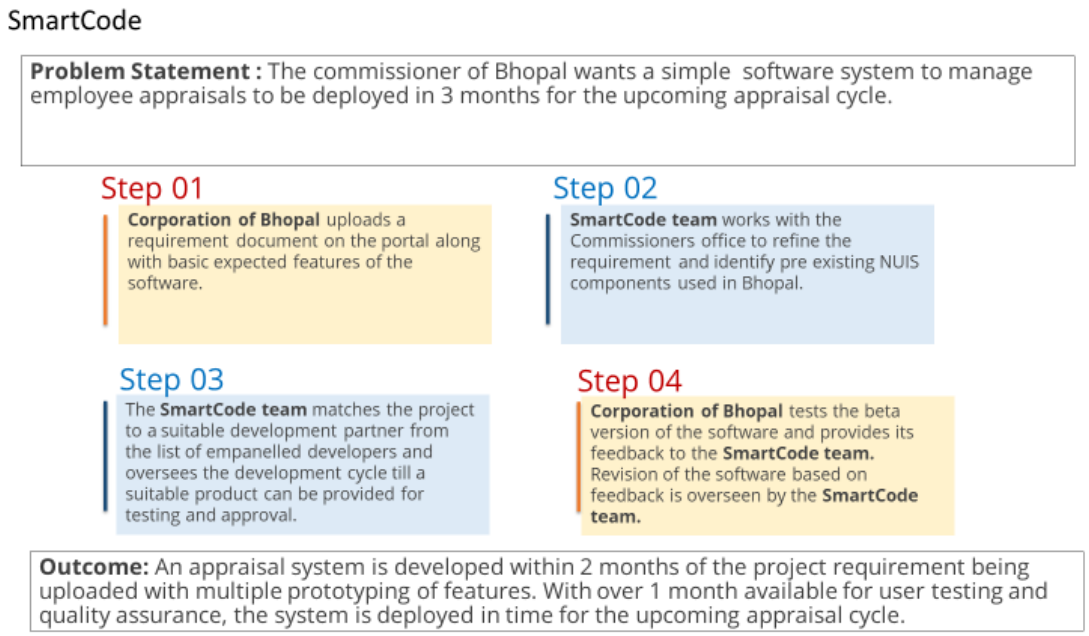

Figure 16: Developing an Employee Performance Appraisal System within 3 months

NUIS COMPONENTS USED

1. Core Data Infrastructure	
1.1 Registries	Users, Organisations, Coders, Certifications, Services etc
1.2 Data Infrastructure	**1. Data Specifications:** Certification Specs, Telemetry Specs etc **2. Open Data:** Govt Transaction Summary, Open Govt Projects etc **3. Data Fiduciaries:** Bid Submissions, Coder Profile, Individual Certificates
Enabling Processes or Documents: Requirement Templates , Coder certification process	
2. Core Services	
Authentication, Authorisation, Entity Management (Users, Organisations, Coders), Workflow Management, Search, Localisation service, Payments	
3. Urban Solution Platform	
Project Management Tool, Coding Platform	

4.7 Smart Governance

Weak urban governance is a roadblock in achieving India's aspiration of becoming a 7 trillion-dollar economy. The ULB is primarily responsible for management of cities and towns across India; however, it is currently handicapped due to capacity constraints and underperformance. The cost of failure and the cost of inaction are both rising rapidly, given the stresses caused by systemic inefficiencies, burdensome legacies, resource depletion, market instability and low levels of public participation and private investment. The ULBs also suffer from low levels of staffing and a paucity of key urban management and governance skill sets. As a result they are consistently overwhelmed by the demands of citizens, industry and state and union governments. Inappropriate spatial, physical, and financial planning and design of projects further exacerbates the problems faced at the local level. This in turn cascades into poor execution and, when combined with inadequate monitoring of systems and processes, results in cost overruns and delivery of substandard infrastructure and services.

The fragmentation of city management across multiple agencies and departments has resulted in a lack of convergence and integration. City systems lack robustness and the ability to evolve in response to changing demands from citizens and economic actors. Project planning and execution becomes inefficient without adequate information-sharing between departments, and between government and citizens – leading to a wastage of public funds. The crisis-ridden ULBs of India produce a poor quality of life for citizens and lack of ease in doing business for businesses and industries. Overall, this results in loss of productivity.

Indian cities need to improve their governance to capitalize on exponential growth, which is also an increase in potential and can be leveraged for improved outcomes. It is imperative that urban governments, city managers, citizens and municipal employees have the tools they need to manage the inherent complexity and dynamism of its cities and towns. Digital technology must play a big role in strengthening urban governance. It is already apparent in the 100 smart cities that the digitization of workflows and processes, through online and mobile-friendly applications that functionaries and citizens can use with minimal training and instruction, is resulting in efficiency gains and enhancing the performance and revenue generation for ULBs.

The Smart Governance platform will enable integrated e-governance and digital delivery of municipal services across all functional areas, such as revenue management, project management,

operations & maintenance, grievance redressal and citizen feedback. Automation of processes will increase transparency and predictability for all the stakeholders in the system. The platform will unlock the power of data in planning, finance and governance. As such, the Smart Governance platform will deliver the combined power of all the previously described platforms, such as the 'India Urban Data Exchange', the 'India Urban Connect', 'SmartProcure', 'Research & Innovation for Urban India', the 'National Urban Learning Platform' and 'SmartCode'. Through the NUIS, the Smart Governance platform will be offered as an open-source and configurable solution that ULBs of various sizes can adapt to their specific needs.

Figure 17: Accelerating Digital Governance in Urban India

The Smart Governance platform is currently available with a bouquet of applications that can enable revenue management (property tax, water and sewerage charges), ease of doing business (trade licenses, NOCs), citizen-facing services (grievance redressal, online access to services, digital

payments) and municipal management (mobile apps for employees; dashboards for decision-support, and portals for domain-specific operations & management).

Smart Governance

Problem Statement : A restaurant owner in Bangalore wants to apply for a trade license in order to open a restaurant through the city's online portal. The portal promises a trust and verify process with timebound processing of the application.

Step 01

The Restaurant Owner uses the application to apply for a trade license and uploads the required documents online. The file is automatically routed to the relevant officers. The owner is given a tracking number to monitor the file status.

Step 02

Based on initial scrutiny of documents , the business is provided with a provisional license and a 90 day deadline is set for physical inspection by **Municipal officers.**

Step 03

After completing the physical inspection the **Municipal Inspector** Issues or rejects the license. In the case of an approval the owner can download the certificate digitally and in the event of a rejection the owner can rectify the issues and reapply.

Step 04

In case there is delay in approval, the owner can file a complaint on the portal which will be tracked by the relevant authorities.

Outcome: The restaurant get approval/rejection within the stipulated time period with regular status updates on his application. The city is able to roll out a trust and verify mechanism and increase the number of businesses self registering and paying the relevant fees and taxes.

Figure 18:Streamlined trust and verify compliant trade license issuance

Following the guiding principles of the stack most of the core services including accounting, case management and content management can be replicated across solutions, therefore unlocking multiple applications that can be built across the country according to the local requirements of cities.

NUIS COMPONENTS USED

1. Core Data Infrastructure	
1.1 Registries	Users, Employees, Properties, Certifications, Services etc
1.2 Data Infrastructure	**1. Data Specifications:** Service Taxonomy, Certification Specs, Telemetry Specs etc **2. Open Data:** Govt Services Dashboard, Services etc **3. Data Fiduciaries:** Individual Tax Report, Individual Usage, Individual Certificates **4. Secure Data Enclave:** Fund Allotment Recommendation - needs access to private data of service provider to recommend fund allocation - which can't be provided hence fiduciaries need to provide ability for Secure Data Enclave
Enabling Processes or Documents: RFP templates and vendor certification process	
2. Core Services	
Authentication, authorisation, entity management (users, employees, vendors.), workflow management, search, localisation service and payments.	
3. Urban Solution Platform	
Procurement platform, vendor management solution, bidding application and contract management solutions.	

5. Benefits of the NUIS

The NUIS opens up innumerable and diverse benefits for society. Built as a public good by the NUIH, it fosters innovation and collaboration among all actors and builds value for society as a whole. All stakeholders involved in the urban sector are able to realize multiple benefits and to contribute to the singular goal of India's urban transformation. Further, as participation of actors in the ecosystem increases over time and geography, a virtuous cycle of demand and timely supply will ensure satisfaction across the ecosystem and an exponential growth in the numbers of beneficiaries. Over time, it is also expected that the NUIH will service urban needs and demands that originate overseas.

5.1 Benefits to the Public

The biggest stakeholder of the urban ecosystem is the citizen. The NUIS will create numerous direct and indirect benefits to the quality of life experienced by citizens:

Improved Services

The use of digital and 'smart' technologies will increase the efficiency and accountability of urban services and infrastructure provided. Citizen participation will improve, thereby closing the feedback loop for mutual benefit.

Collaboration with Community

Citizens can collaborate with government easily and with increased frequency; both within their community and beyond, forming stronger groups and exchanging ideas and building new collaborations. A stronger 'voice' will be created for each citizen, both virtually and physically.

Employment and Livelihood Opportunities

As the NUIS catalyzes the expansion of urban services and Innovation, it will also create access to an array of livelihood opportunities and will leverage innovation to create new employment avenues locally.

5.2 Benefits to Urban Local Bodies

ULBs will be strengthened to handle the challenges of urbanization at speed and scale. They will be better equipped to serve urban stakeholders with efficiency and at affordable cost. The administration and the employees have different contributions to the system, and therefore the benefits they reap from the stack will be varied as well.

Field-level Functionaries

Field-level employees of the ULBs will be empowered with the tools and knowledge required to perform their day-to-day activities more efficiently. By leveraging automation and artificial intelligence, low-value tasks can be eliminated from their daily schedules, allowing them to focus on delivering high-quality services.

Municipal Commissioners and Mayors

Municipal Commissioners and Mayors will be equipped with real-time dashboards and decision-support systems to manage governance processes and intervene in a timely and targeted manner with appropriate solutions and response. They will be able to devote more time for strategic planning and stakeholder engagement due to enhanced productivity.

5.3 Benefits to States

State Government officials will be able to keep a close track on the performance of cities in their state while reducing the governance and digital divides between their cities.

Reforms and Policy

State Officials can drive municipal reform and ensure compliance with State priorities and MoHUA Missions. In addition, they will capture efficiencies in urban governance and improve time-bound delivery of urban services by accelerating the access to cutting edge technology for all ULBs.

Fund-utilization and Budgeting

The state can improve urban financial management with real-time financial position tracking through NMAM-compliant double-entry book-keeping, automated budget tracking, enforcement of demand and collection and assessment of credit flows and ratings. NUIS will facilitate value capture finance, municipal credit rating and bond issuance. States can increase investment flows due to improved ease of doing business and enhance transparency and accountability through comprehensive ULB performance data.

5.4 Benefits to the Union Government

Government of India (GoI) officials will be able to drive and monitor national urban policy and practice in a focused manner by leveraging the NUIS.

Policy and Missions

GoI can drive urban policy planning and engagement at the union level by analysing real-time performance data on the state governments and ULBs across the country. Schemes and missions can be effectively managed and feedback and monitoring data can be easily shared with the states and cities, encouraging them to focus on reforms in governance and improving implementation. Disbursals of grants and programmatic funds can be speeded up through direct linkage with achievement of mutually agreed milestones.

National Collaboration & Competition

GoI can drive knowledge sharing and coordinate urban development efforts in India to catalyze nationwide innovation, collaboration and transparently managed competition amongst ULBs and other agencies. With an evidence-based and data-rich platform like NUIS, there will be enhanced possibilities for conducting special 'challenges' and for even implementing the urban programmes in 'challenge mode'. GoI can also use the platforms for launching and managing innovation challenges, hackathons and other innovation discovery activities.

5.5 Benefits to Business and Industry

Businesses will have better access to governments and will be able to determine the feasibility of investments in the urban sector by accessing improved and multi-dimensional performance data on various actors in the sector. This will greatly enhance the trust between the private sector and the public and will encourage the private sector to increase their financial and strategic commitment to the urban sector.

Ease of Doing Business

Greater digitization and automation of routine interactions between industry and government — such as licenses, NOCs, approvals — will reduce friction within the system and improve ease of doing business. Streamlined and timebound procedures for licensing, approvals, clearances and accessing information on government processes will lead to greater trust and participation.

5.6 Benefits to Researchers and Innovators

Those involved in research and innovation activities in India and across the globe will be the biggest contributors in attaining NUIH's goal of creating an ecosystem that can foster and sustain total innovation. In addition to the facilities for incubation & acceleration and capacity building that will

be available at the national campus of the NUIH, the NUIS will provide the research institutions in all states and UTs with a live ecosystem that supports their work and benefits their constituent stakeholders.

Access to Data

By digitizing services and data across the urban ecosystem, there is a sea of data which can be studied for the benefit of the ecosystem. This knowledge can in turn be reviewed and shared by many actors of the society.

Access to Clients

Innovators can find clientele and potential beneficiaries across an unprecedented geography by connecting through the NUIS ecosystem. They can also be more targeted in their approaches and can receive almost automatic feedback from the ecosystem, which becomes a 'sounding board' for their ideas and solutions.

Access to Business & Industry

The research and innovation stakeholders can connect and collaborate with the business and industry in all areas within the urban sector. They can find test-beds, collaborations, budgetary and impact funds and research grants through the dynamic and analytics-based intuitively usable databases, while also keeping abreast of all new developments in urban science and technology.

5.7 Benefits to Civil Society

There are multiple NGOs in the urban sector working with governments and citizens to improve services and living conditions of various stakeholders. The stack will provide them with greater access to information and connect with ground realities.

Participation in Policy

With higher transparency in the system, civil society can aspire to actively participate and contribute in policy-making at various levels of the government.

Philanthropic Access

With their efforts being put to more efficient use and increase in visibility, the NGOs will get better access to funding and open a wide range of philanthropic access. Donors and foundations can also access more granular information about various actors in the ecosystem, allowing them to target their investments more effectively and discover hitherto undetected potential beneficiaries.

6. Operationalizing the NUIS

To ensure that the NUIS is successfully established and adopted, ecosystem actors like the GoI, states and core ecosystem partners will need to act in a concerted manner. MoHUA will build NUIS as a national digital infrastructure that is available to ecosystem actors who can thereafter configure, customize and extend the features of the platform as per their needs.

The NUIS follows a federated architecture allowing ecosystem actors to create multiple instances that can be contextualized to the intended purpose and geography. This allows the proliferation of platforms using a common architecture by placing agency and control in the hands of ecosystem actors. This customisable and scalable architecture is described in the diagram below.

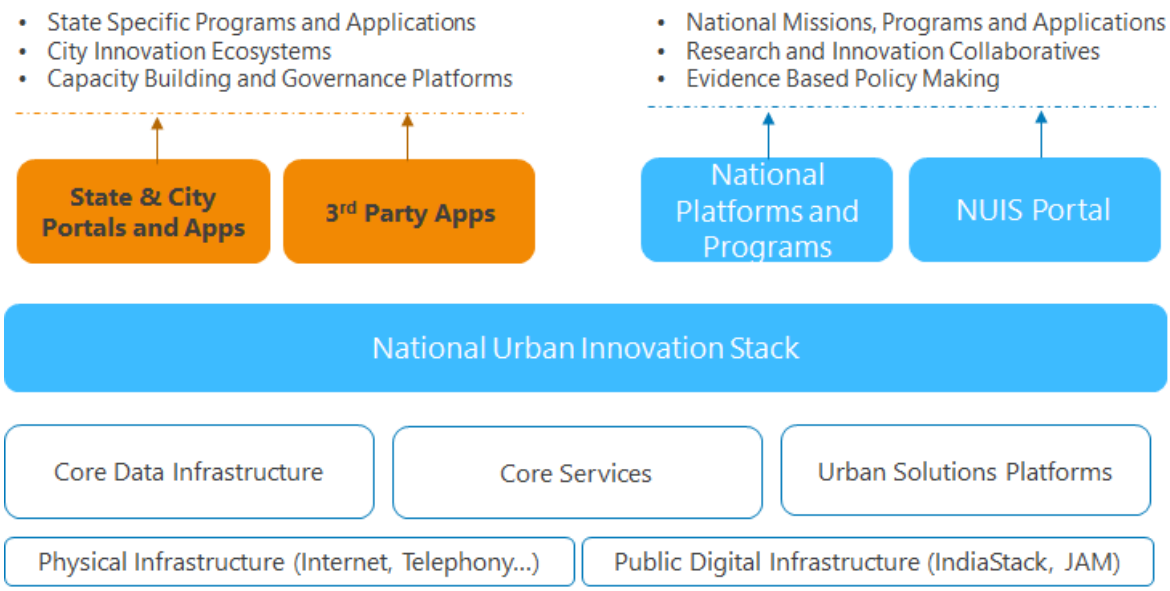

Figure 19: Federated instances on a common National Stack

NUIS does not make any assumption about implementation of a particular service and allows for all kind of actors — state, civil society and markets — to participate in the implementation of a particular instance of the stack. The actors and implementations are recommended to abide by the guiding principles and meet the stack's open standards and specifications. However, wherever needed, NUIS may also seed the ecosystem with open-source implementations of certain micro-functional services.

In order to ensure rapid operationalization of the NUIS, It will be implemented in two streams - the first, focusing on rapid development and operationalization of the NUIS itself; and the second, focusing on the institutionalization and evolution of the NUIS.

6.1 Rapid Operationalization of the NUIS

This stream will focus on developing the NUIS and making it available for ecosystem actors to adopt and deploy. This stream has two tracks:

- A ***technology track*** that focuses on developing the NUIS and making it available to ecosystem actors on the cloud for instant deployment. The Initial applications that will be available on the NUIS will enable the establishment of the key programs described in Chapter 4 and driving their implementation in a phased manner. As the ecosystem adopts these applications, more applications will be made available to ensure that emerging needs are effectively met by the stack.
- An ***ecosystem track*** that focuses on helping lead adopters prepare for deployment of the NUIS through aligning their existing systems and processes for rapid implementation of key programs, driving capacity building for ecosystem actors, and developing a digital roadmap for their programs.

6.2 Institutionalization of the NUIS

This stream will focus on institutionalizing the NUIS and evolving it to meet the emerging needs of ecosystem actors. The NUIS will be housed at the NUIH and the NUIH will engage the ecosystem to drive adoption and usage of the NUIS. The NUIH will guide the evolution of the NUIS by identifying key needs of different ecosystem actors and creating the early adoption by these actors. In driving the governance and evolution of the stack, the NUIH will work with the ecosystem to define standards, specifications and certifications as well as to inform the future roadmap for deployment, dissemination and further development of the stack. It will define the governance structures for the stack in an inclusive manner to enable the stack and the ecosystem to address urban challenges.

The NUIH is currently envisioned with three key business verticals:

- Policy and Advisory Services
  - Research
  - Capacity Building
  - Ministry Support Services
- Consulting Services
  - Project Consulting

- Program Management

- Center for Innovation Ecosystems
  - Incubator
  - Demonstrator
  - Accelerator
  - Virtual Hub (NUIS)

The 'NUIS will be the 'virtual hub' that brings immediate results to the stakeholders of the ecosystem. As such, it forms the core of the Centre for Innovation Ecosystems as the first demonstration of the Centre's contribution to the urban sector, which will thereafter progress through the incubation, acceleration and demonstration cycles to be activated in various locations across the country.

In order to drive urban transformation in India and other countries, the NUIH will engage with the ecosystem of key actors and government missions, programs, and projects through the verticals described above. The Centre for Innovation Ecosystems will be the vehicle for evolving the ecosystem in India and simultaneously promoting and replicating such an ecosystem in other countries.

7. Appendices

7.1 Appendix A – Applying Stack Thinking to Real Urban Programs

Stack Skeleton

Assembling all critical components of the stack - Guiding Principles, Standards-Specification-Certifications, Data Exchange Layer, existing open stacks gives us the base depiction on which the stack will be built.

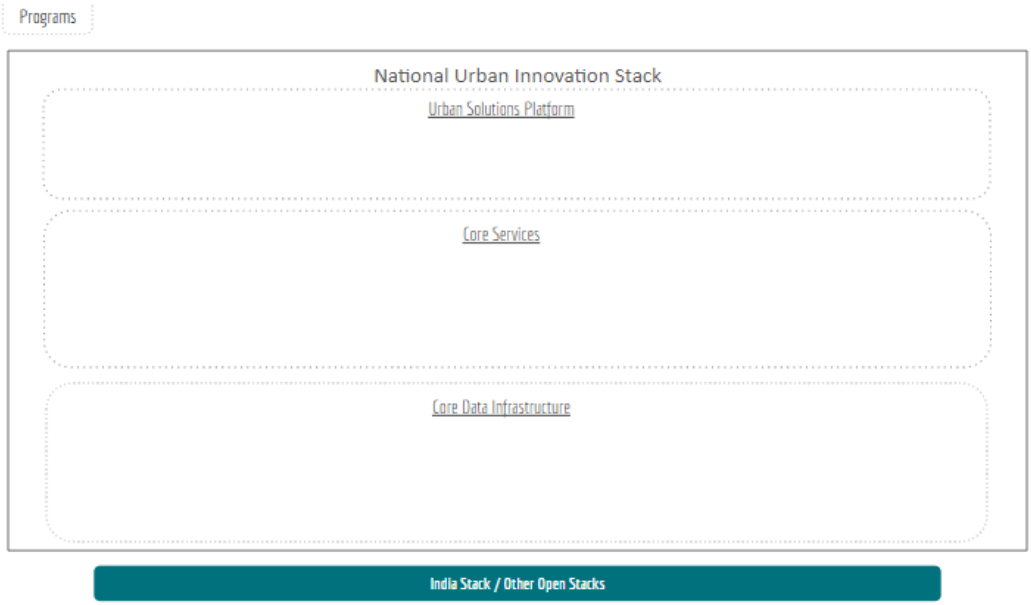

Figure 20: Stack Skeleton

Initial Program

As a program starts using the stack , a number of enabling and infrastructure services can be built into the stack . Some of the services can be called out from outside the stack to increase efficiency . For example, for an urban mobility program, multiple services can be built in the stack , and some of the services can be used from the already existing RTO application and any traffic sensors data from outside the stack.

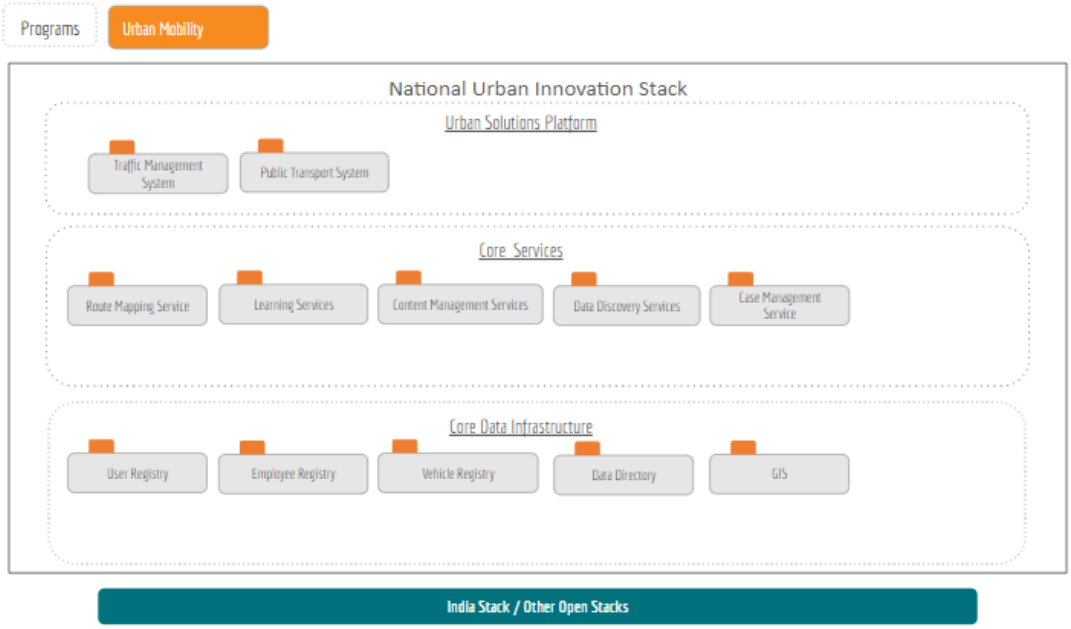

Figure 21:Initial Program Building on the Stack

Building Multiple Programs

One of the guiding principles of the stack is that it easily evolves with multiple programs being added on top of it. Every new program can use some elements from the existing services built and also easily interact with new services outside, thereby reducing the effort of implementing it. For example, in the above depiction, after Urban Mobility, Water & Sanitation as well as Solid Waste Management are added above the stack. Each of these programs started using the existing services built in the stack as shown in the figure below (Program usage on the service is color coded).

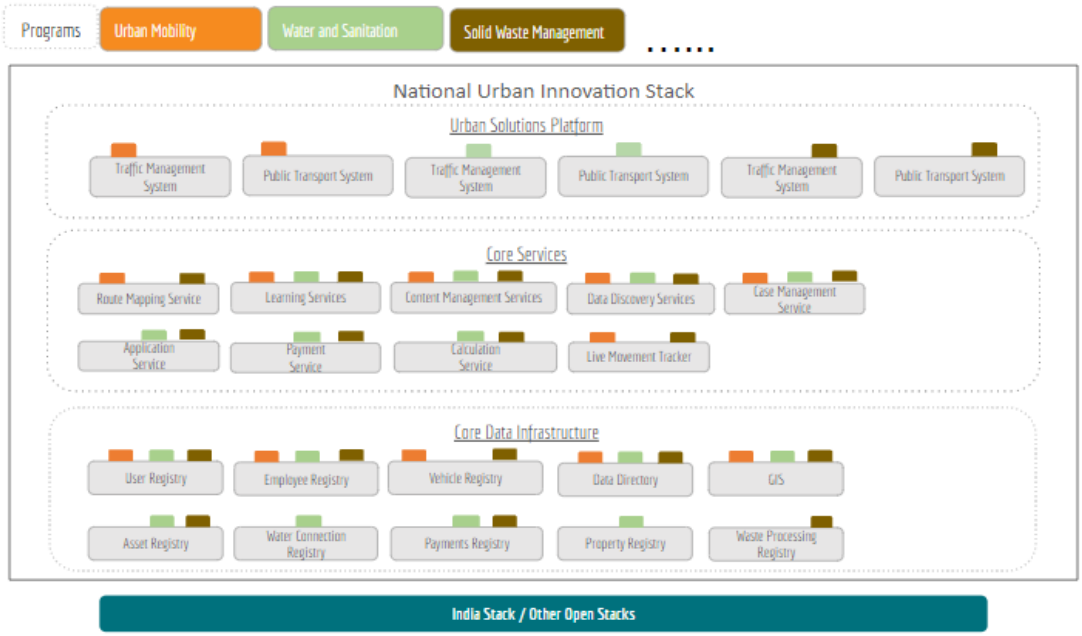

Figure 22: Evolving the Stack through multiple programs

7.2 Appendix B: Illustration of an NUIS instance in a Smart Governance Solution

A NUIS instance for a smart governance solution starts from building the core data infrastructure by defining required registries and data specifications. Building on that, abstract services are built which will then be used by multiple applications and solutions on the top layer as shown below:

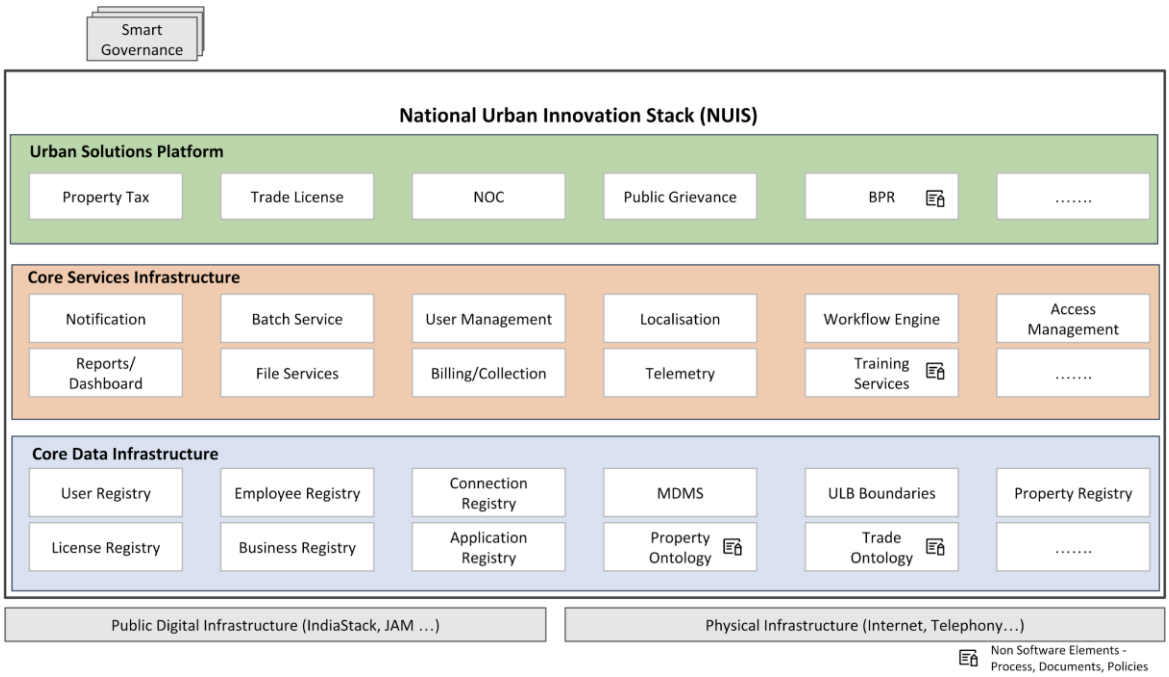

Figure 23:Building a Smart Governance solution using the NUIS

7.3 Appendix C: Building a Public Grievance Redressal System (PGRS) on the NUIS

Public Grievance Redressal System (PGRS): Citizen First – 'Improving Quality of Life'

Grievance Redressal System is mandated in government agencies and departments that are directly involved with serving citizens and organizations. PGRS covers day- to-day life problems faced by the citizens such as Service Unavailability, Hygiene issues, Lack of basic amenities. Organizations define their own process flows for grievance redressal.

Key parameters of the PGRS system are Input acceptance, Anonymity upto a certain extent, Spam Prevention, Acknowledgement & Status Tracking, Escalation, Verification, Rewards. Today, many PGRS in India approach traditional ways which is handled through letters and complaint forms. This approach has very little appeal and its usage rarely reflects the actual state of customer satisfaction or lack thereof. Thus the biggest challenges in a successful PGRS are Lack of capacity, Accountability, Delayed feedback acceptance and Transparency.

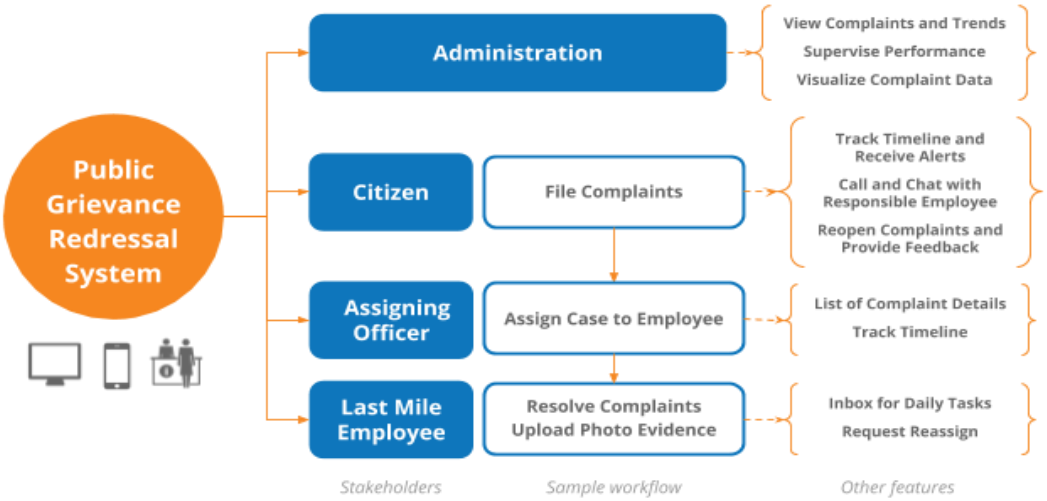

Figure 24:Building a Public Grievance Redressal System on the NUIS

Key Features (First version):

1. Grievance Filing
2. Channel - App | Web | IVR
3. Standard Ontology for grievances
4. Tracking of complaints
5. Routing mechanism
6. Notifications
7. Citizen Feedback
8. Defined SLAs for all complaints

Key Roles in the ecosystem:

1. Citizen
2. Assigning Officer
3. Last Mile Employee
4. Citizen Service Representative (CSR)
5. Administrator