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Building Foundations for Smarter Cities: A Data Ecosystem Approach

Gayatri Singh and Champaka Rajagopal

Abstract

In recent years, practitioners and researchers alike have debated whether quality of life for all can be influenced by smart cities, particularly in low- and middle-income countries. Critics have shown how siloed governance arrangements, technology bias and fragmented interventions in government led smart cities programs tend to exacerbate uneven development, increase disparities in access to basic services, and can thwart equitable (re)distribution of resources, leaving city governments politically, administratively, economically and financially weaker. To address these challenges, the World Bank's City Planning Labs (CPL) promotes an ecosystem approach to Municipal Spatial Data Infrastructure (MSDI) where technology solutions are integrated with human, legal and technical aspects. This paper shows how CPL's successful efforts in three pilot cities in Indonesia, Semarang, Balikpapan and Denpasar (2017-21), the use of the MSDI approach brought governments closer to inhabitants during the COVID-19 crisis, creating wider demand globally for embracing ecosystem approaches to data governance for smarter cities.

Key words: National Spatial Data Infrastructure, Municipal Spatial Data Infrastructure, data governance, innovation, ecosystem capacity, City Planning Labs Global

Policy maker abstract

In recent years, practitioners and researchers alike have critiqued the promise of smart cities for not enabling better quality of life for all. Particularly for low and middle income countries, researchers show how siloed governance arrangements, technology bias and fragmented decision-making processes adopted by government led smart cities programs tend to exacerbate uneven development, increase disparities in access to basic services for all, and impede (re) distribution of resources, leaving city governments weaker in terms of political, administrative, fiscal and financial management capacities than before. This paper argues that an ecosystem approach to Spatial Data Infrastructure is essential to provide foundations to the challenge of smart cities. It argues that rather than treat technology as an end, national and sub-national governments must envisage data solutions as going hand in hand with equally important human, legal and technical aspects. In this regard, international organizations and national governments are advancing the concept of National Spatial Data Infrastructure (NSDI) as an effective vehicle for facilitating seamless data development, information sharing, and collaborative decision to promote economic and social development. NSDI has, however, often been weakly implemented. We argue that the establishment of Municipal Spatial Data Infrastructure (MSDI) at the local level is imperative for effective implementation of NSDI and to bring government closer to inhabitants of cities. By drawing on the grounded practice efforts of World Bank's City Planning Labs' initiative to mainstream MSDI, we underline the importance of institutional arrangements, people, data and systems as fundamental building blocks for a robust data ecosystem at the local level. Through CPL's work in three pilot cities in Indonesia, Semarang, Balikpapan and Denpasar, we demonstrate how the MSDI approach offers long-term solutions. To conclude, we show how the success of this first phase of the initiative has created demand from seven countries across the world to adopt CPL's MSDI.

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Building Foundations for Smarter Cities: A Data Ecosystem Approach

Gayatri Singh[1] and Champaka Rajagopal[2]

I. Introduction

Technology change spurred national and sub-national governments around the world to advance smart cities as a panacea for rapid resolution of persisting challenges including inadequate access to basic services and the promise of better quality of life for all. However, nationally sponsored smart cities schemes which promise efficient transitions, particularly in low- and middle-income countries, have far from yielded access to basic services for all or enabled equitable (re) distribution of resources. Three concerns, spanning policy and operative spheres of smart cities programs are significant.

First, smart cities initiatives of national governments are mostly conceptualized through a technology bias. Governments and private corporations advance data and technological instruments in smart cities as value-neutral policy interventions, while often privileging some at the expense of others. A multitude of uncoordinated technological interfaces tends to increase the gap between governments and inhabitants of cities.

Second, at a fundamental level of policy design, sub-governments generally appoint departments in-charge of Information and Communication Technology (ICT) as custodians of smart cities programs, leaving out urban planning and service delivery departments in municipal governments from decision making processes even within their own jurisdictions. In some countries, smart cities initiatives are designed as mission led schemes, where the governance of siloed smart projects is mediated through Special Purpose Vehicles. Both governance models preclude political representation, accountability and democratic oversight in municipal regimes.

Third, in this scheme, information technology becomes a coveted end for smart cities, as they pursue the establishment of command centres designed for gated projects which are often restricted to privileged parts of cities. Smart governance of projects. as opposed to cities, tends to exacerbate uneven development, generally further weakening sub-national government's/municipal corporation's capacities to effectively deliver their obligatory functions.

This paper argues that while embracing data is inevitable and urgent for cities, a mere focus on technology solutions as a silver bullet mediated through siloed governance is not only inadequate, but also detrimental to capacities of city governments. Moreover, national government's institutional responses such as the National Spatial Data Infrastructure (NSDI), have often not translated into results at local levels. We show how the World Bank's City Planning Labs initiative offers robust and long-term ecosystem solutions to build foundations for smarter cities, bringing governments in greater proximity to people.

Spatial Data Infrastructure

The concept of Spatial Data Infrastructure first came into being in the United States through an Executive order signed by President Clinton in April 1994 (Masser, 1999). Since then, several national governments in the Global North and South have since adopted SDI as National Spatial Data

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Infrastructure (NSDI). Spatial Data Infrastructure (SDI) facilitates the production, collection, access, sharing, management, dissemination, updating and preservation of data and includes geospatial services and tools. SDIs include geospatial and non-spatial data, tools, hardware, and software. Tangibly, geospatial data may include topographic maps, land cover data, land cadastral data, transportation networks, hydrographic features, social and economic indicators for political territories, to name a few (Hu and Li, 2017). SDI is accompanied by institutional arrangements including government policies, organizational responsibilities that support coordination, core data sets from which other datasets can be created, metadata which provides information about data, data standards, software standards and support from people in the form of technical and human resource capacities (Masser, 1999; Hu and Li, 2017).

While NSDI offers a comprehensive framework at the national level of policy, some researchers and practitioners emphasize the importance of decentralized custodianship of data. The question of custodianship of data stems from the notion of data as public information. Geo-spatial data and information as a public good can be disseminated easily and shared. Contrarily, geographic information as a product can be bought and sold like any other commodity (Masser, 1999). In this vein, scholars point out that geographic information inherent to NSDIs may be viewed as a resource, a commodity, and an asset (Masser, 1991). The question of data as a public asset raises important questions about the role of the government as custodian. As the Australian Land Information Council states, “All data collected by state government agencies forms part of the State’s corporate data resource. Individual agencies involved in the collection and management of such land related data are viewed as custodians of that data. They do not own the data they collect but are custodians of it on behalf of the State” (1990a, p. 1 and 5; cited from Masser, 1999).

The concept of custodianship is important because it assumes that data is distributed among multiple public authorities which may not have been involved in its creation. Custodianship thus advocates that governments entrust the stewardship responsibility of data as close to the data originator as possible while maintaining an effective national infrastructure (US, National Research Council 1994, 14). Decentralization is therefore central to the concept of NSDI. However, effective implementation of a national geographic information strategy, research has shown, tends to predominantly depend on the willingness for collaboration between government agencies who produce, use and disseminate geo-spatial information. In middle- and low-income countries, where municipal governments are likely to face weak inter-departmental coordination, implementation of NSDI at local levels remains a challenge. Juxtaposed on this terrain of weakly coordinated agencies is the siloed governance of smart cities. It is in this context that World Bank’s Municipal Spatial Data Infrastructure offers systemic solutions.

This paper, structured in five parts, discusses the significance of NSDI-MSDI derivative to build data foundations for smart cities through an ecosystem approach. The first section below briefly lays out challenges of smart cities in relation to the three core challenges discussed above, with a particular focus on national government initiatives in middle income countries. India and Indonesia serve as cases. The second section outlines the concept of National Spatial Data Infrastructure as a systemic response of countries to consolidate the governance of geo-spatial data, with a focus on its components and challenges to its implementation in the context of siloed smart cities initiatives. The third section positions Global CPL’s Municipal Spatial Data Infrastructure initiative (MSDI) as a resilient response to inefficacies of implementing NSDI to deal with the challenge of smart cities. It advances Global CPL’s Institutions, People, Data, Systems (IPDS) framework as an integrated approach to urban data governance. The fourth section discusses international case studies to illustrate the macro and micro level benefits of embracing the IPDS as the desired urban data governance framework. The fifth section illustrates three instances from CPL’s pilot cities in Indonesia, to show the success of this first phase of the initiative during the COVID-19 pandemic. The paper concludes with an emphasis on how

MSDI's values for sustainable, participatory and equitable development has created demand from seven countries across the world to adopt CPL Global's MSDI.

II. The Challenge of Smart Cities

National and sub-national governments across the world are striving to capitalize on technology change to meet their growth and welfarist goals, to expedite job creation, deepen social benefits, reduce inequality, manage rapid urbanization and prepare cities to deal with a host of uncertainties and risks. Enterprising states in middle income countries such as India and Indonesia have boldly advanced smart cities, through new institutional arrangements such as mission-led Special Purpose Vehicles and a multitude of Information and Communication Technology innovations including technology applications, to achieve efficient service delivery and quality of urban life. While innovative states are advancing partnership with information technology companies, the extent to which smart cities can deliver benefits for all people is weakly evaluated and yet unresolved. Several models of smart cities initiatives which are anchored predominantly on efficiency and technology innovations, as opposed to building municipal capacities, serve as examples for reflection. We discuss challenges of siloed governance in smart cities initiatives India and Indonesia as cases in point, here, based on our familiarity with these contexts. However, these cases are symptomatic of wider smart cities issues which do not recognize the NSDI approach.

India Smart Cities Mission: Siloed Governance

Launched in 2015 in 100 cities, the Smart Cities Challenge in India marked a radical shift from earlier nationally sponsored schemes in its adoption of corporate governance. At the national level, the program was designed by the then Ministry of Urban Development and for the first time, Ministry of Corporate Affairs. At the local level, unlike earlier efforts, which were administered by state and municipal governments directly, this scheme financially structured the governance of the scheme through mission-led Special Purpose Vehicles (SPV). Established through the Companies Act 2013, Government of India, the company structure of the Smart Cities SPV is un-aligned with objectives of NSDI, the notion of public custodianship of data and arguably antithetical to open municipal governance which involves reciprocal relationships between the elector and the elected.

At a granular level, Smart Cities SPVs were designed as encrypted shareholding agreements between state and local governments, aiming primarily at efficiency and performance. Guidelines for Smart Cities SPVs included 50-50 percent shareholding between state governments and municipal corporations. Private sector investors were allowed as minority shareholders, with a distribution of 40-40 percent with state and local governments and 20 percent with the private party. Normatively, municipal corporations were positioned as promoters of the SPV. However, in operative spheres, the state government held veto powers. Importantly, while the SPV model purposefully held local political interference at bay, this arrangement equally deterred collective stewardship by municipal governments and accountabilities from elected representatives towards inhabitants of cities (Anand A., et al, 2018).

Smart Cities Guidelines recommended city improvement (retrofitting), city renewal (redevelopment), city extension (greenfield development) and a pan-city initiative, where data infrastructure and technology driven smart solutions were to be applied covering larger parts of the city. As Datta et al (2019) point out, since they were conceptualized as projects as opposed to city-wide strategy, the scheme only partially covered areas in the municipal jurisdiction (Anand A, et al, 2018). In this scheme, projects and data innovations envisaged under the Smart Cities program were not systemically integrated with statutory master plans for cities or urban governance for urban ecosystems. Geo-spatial data created under the Smart Cities Mission were not necessarily inter-

compatible with geo-spatial data produced by Planning Authorities. Data thus remained siloed within command centres of SPVs.

Further, while guidelines of the scheme promote public participation, on the ground, most private consultants and SPVs disseminated information through weakly coordinated media and social media platforms, to garner public consent. The exclusion of vulnerable populations with no access to smart phones raises questions on distributive consequences of a process which circumvented democratic oversight. Nagpur city offers a case in point, among several others (Raut, 2023).

Indonesia: Technology bias

'The Movement towards 100 Smart Cities' in Indonesia, launched in 2017, is a collaboration between the Communications and Information Ministry, the Home Ministry, Public Works and Housing Ministry, National Development Planning Board (Bappenas), Presidential Chief of Staff and several private organizations. The program aims to create regional technology hubs to connect people with the government with new interfaces for smart mobility, living standards, economics and environment. To achieve this, the initiative encourages city officials and citizens to increase the daily use of smart city technologies, such as the public transportation app *Trafi* and communication app *Qlue*, that provide citizens with a platform to voice their concerns and aspirations (Jakarta Globe Insight, 2019[3]). Social scientists and innovation scholars engaged with examining the Smart Cities initiative in Indonesia critique the national and local government's disproportionate focus on development of ICT infrastructure for cities coupled with inadequate comprehension of the nature of concerns that cities are facing.

Studies on capacity of governments in relation to ICT components focus on technical issues such as connectivity, data centers, data analytics, applications, and end-users. Researchers emphasize the need for governments to increase storage capacity for the data collected (Rahayu Safitri and Ratih Dyah Kusumastuti, 2020). Technical bias helps governments learn that there is an increase in the use of ICT devices such as computes and cell phones. However, these innovations do not penetrate needs of all inhabitants or custodianship of data or outcomes from municipal governments.

Others critique this technical approach, emphasizing that measuring bureaucratic readiness, including high level commitment, legal support and governance, and information and technology resources are key to the effectiveness of smart city initiatives (Pratama and Imawan, 2019). Still others confirm that the absence of guidelines for mainstreaming data governance at the national level, combined with an excessive focus on fiscal budget readiness, have left the initiative with a void in regulatory leadership (Bastian, et al., 2022) and custodianship. The result is the creation of a multitude of disconnected apps, fragmented data, weak knowledge infrastructure and inadequate social impact.

While at the national level, the scheme is a collaborative initiative between multiple ministries, the National Development Planning Agency, and the Presidential Staff Office, local level power dynamics vary from national intent. While municipal governments have political and financial strength with a directly elected city Mayor, the development of ICT data infrastructure in the smart cities' initiative are vested with municipal departments in charge of Information and Communication Technology and not with planning and service delivery line departments. Competitive bureaucratic relationships across departments at the local government level often translate into tensions. Technology-led innovations, such as Smart Apps or Command Centers promoted by local ICT departments and weak institutional

[3] https://id.ambafrance.org/Smart-Cities-in-Indonesia-s-Future-Challenge-and-Opportunities#:~:text=With%20nearly%2070%20percent%20of,resulting%20from%20past%20underinvestment%20in

coordination, tend to compromise the accomplishment of programmatic results for national governments. Also, organizational motivations for control over data assets impede bureaucratic readiness, informed municipal decisions, prioritization of investments and political accountabilities.

Four key gaps

India and Indonesia, as cases of smart cities initiatives among others, point to four fundamental gaps in data governance policy. One, government reliance on new institutions such as Special Purpose Vehicles and technological bias distances the municipal government from inhabitants of cities and their changing needs. The absence of involvement of municipal governments as a whole in administering Smart Cities Missions results in fragmented city visions, sustained sectoral silos and uneven development. Two, cities lack accurate, updated, data in formats that are inter-compatible across departments. Three, weak ecosystem capacity, in terms of institutional relationships between public, private agencies and inhabitants of cities as well as technical and human resource capacities prevents timely application of data for decision making. Four, treating technological innovations as an end shifts focus to sporadic/temporary innovations. Technology bias towards app-based decision making dissuades city government agencies from recognizing the importance of inter-compatible geo-spatial data, creating, updating, utilizing and sharing geo-spatial data, systems and tools for analyzing problems cities face. The lack of a systemic approach to data governance akin to the SDI/ NSDI framework, exacerbates the costs of basic service delivery, risk management and urban development for national and sub-national governments. At stake is nothing short of transparent and coordinated decisions, sustainable development of cities and effective management of urbanization itself.

The challenge of balancing of attractiveness of a technology-led approach versus the need for more coordinated decision making and clear custodianship of data governance for informed decision making is not unique to Indian cities or those of Indonesia's. Most cities across the world, particularly secondary cities, are facing similar challenges. Small and medium sized towns in the Mekong Delta of Vietnam are facing increased number and intensity of storms, causing disruption to local economies and livelihoods. Air pollution caused by emissions of vehicles, coal-based power plants are pressing concerns in cities in Mongolia, especially in Ulaanbaatar. Extreme heat in cities in the Sub-Saharan region and Asia and related issues are another type of concern which threatens to affect populations at scale. These risks are rooted in geographic vulnerabilities, social, economic and cultural contexts, and institutional relationships across government, private sector and inhabitants of places. These challenges do not have simple fixes that technology driven smart cities can offer. It is here that translating a comprehensive national level framework such as NSDI to local levels becomes imperative.

III. National Spatial Data Infrastructure

National Spatial Data Infrastructure (NSDI) purposefully combines technological innovations pertaining to data with the legal, human and ethical dimensions of data governance. However, given the absence of derivative protocols for implementation of NSDI, its manifestation at local levels has often remained patchy and incomplete, privileging some places in cities more than others. Missing in the regulatory derivatives are guidelines for delineating organizational roles and responsibilities, protocols for creation, storage application, dissemination and sharing of data, and sustained ecosystem capacity building to implement NSDI at municipal levels. At the operative level, NSDI derivative regulations are meant to advance data-led decision making while enabling the accomplishment of programmatic results for national government schemes at the city level through last mile delivery of government's welfarist goals. However, protocols for implementation are seldom present in most low and medium economies.

It is notable that at the national level, the SDI approach is mainstreamed across multiple countries including the United States, Canada, Singapore, Mexico, Indonesia and India, all of which have channelled the data revolution by leveraging Spatial Data Infrastructure in the form of National Spatial Data Infrastructure (NSDI) platforms to boost employment, government cost savings and economic growth. The use of geospatial information has had clear, tangible benefits to the socio-economic growth of these countries, such as through generating revenue and multiplier effects for the economy, providing jobs, or driving public sector cost savings.

In the USA, the geospatial industry generates annual revenue of approximately $75 billion[2]. For Canada, the use of geospatial information contributes more than $2 billion[3]; while for New Zealand, geospatial information contributes over $1.2 billion annually to the economy, and generates $0.5 billion through productivity benefits[4]. Additionally, a meta-analysis conducted in 2015 showed that geospatial information investments would expect to see a yield of 3.2 times their costs at the national level[5]. It examined 82 cost-benefit assessments from 1994 to 2013, to derive the returns of investment from countries investing in the collection and maintenance of geospatial information[6] (Figure 1.0).

(Source: Municipal Spatial Data Infrastructure Roadmap, 2017; produced by Singapore land Authority for the City Planning Labs, World Bank).

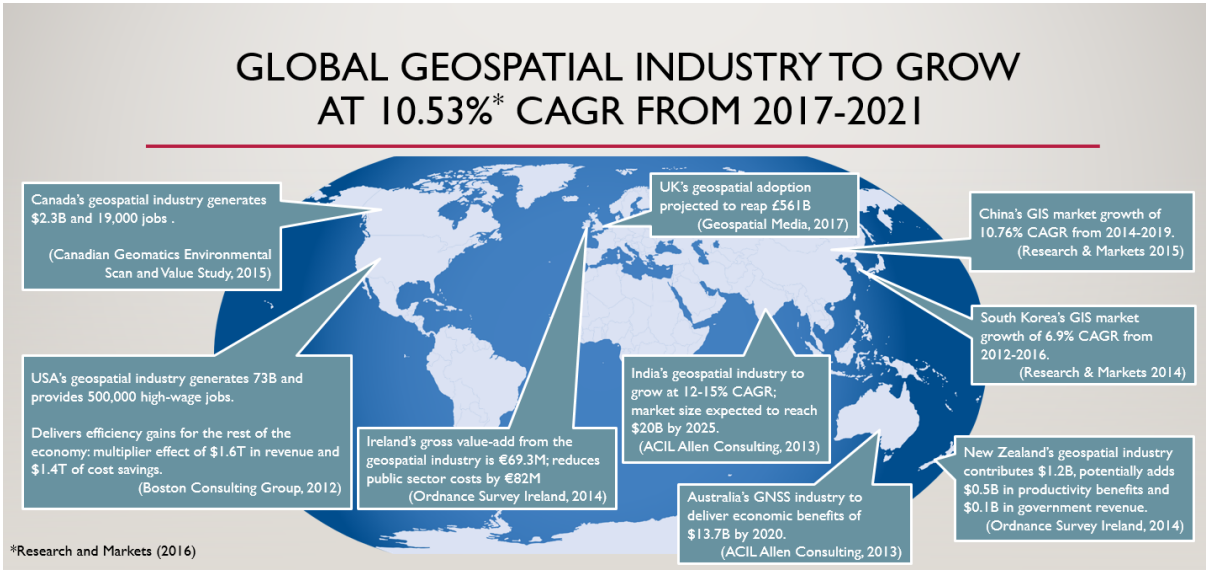

Figure 01: Global landscape of the geospatial industry and outcomes
Source: Singapore Land Authority's Report on Global Benchmarking for World Bank, City Planning Labs (2017)

Backed by policies and frameworks, bold national governments have mobilized NSDIs as effective vehicles for facilitating seamless data development, information sharing, and collaborative decision making for economic and social development. However, the extent of implementation varies across countries and in many cases, SDI has remained at the policy level. At the local level, delayed implementation combined with fragmented decisions often tend to weaken capacities of cities to manage their own challenges, while exacerbating uneven development and vulnerabilities for the poor. At the same time the lack of implementation of NSDI at local levels weaken national level initiatives, causing iterative weakening of governments (Singapore Land Authority's Report on Deep Dive Assessment, for World Bank, City Planning Labs (2017).

We argue that for effective implementation of NSDI, it must be accompanied by derivate protocols and regulations for adoption by sub-national/municipal governments. It is here that the World Bank's CPL Global's vision to institutionalize Municipal Spatial Data Infrastructure (MSDI) to implement NSDI is imperative. MSDI is a crucial data infrastructure foundation at the local level because despite the usefulness of an overarching national mandate, efforts to develop SDI at the national level are not sufficient to address bottlenecks in data informed decision-making at the city level.

With dynamic forces of urbanization and rapid adoption of geospatial data and smart technology, cities are ideally placed to become custodians of SDI, given their unique position within national government hierarchies. City governments are positioned close enough to the heterogenous range of communities that they are made of, to allow them to understand issues and priorities directly from the inhabitants, and yet high enough within the hierarchy as engines of growth and political power, enabling them to propose their own visions and solutions, be it in the form of programs, policies or regulations (MSDI Manual, 2018).

IV. City Planning Labs: Ecosystem Solutions to Siloed Decision-Making

The World Bank's City Planning Labs is a considered response for implementing NSDI while strengthening the multiple structural challenges of siloed governance and technology bias that smart cities entail. The MSDI approach promotes evidence-led decision making using geo-spatial data, to help support municipal governments with scarce resources to channel investments where most needed. Discarding siloed boundaries of mission-led development, the MSDI approach integrates national and local government policy and operational practices by entrusting political accountabilities for data led decisions at sub-national levels and custodianship of urban data governance with municipal corporations.

Countering technological bias in MSDI are four robust building blocks that focus across Institutional Arrangements, People, Data, Systems (IPDS). The IPDS framework lays out organizational roles, rules and accountabilities and addresses capacity building by strengthening relationships between multiple agencies. It does this by incorporating mutually constitutive geo-spatial competencies, setting out data standards and fundamental datasets, developing geo-portals as data warehouses for data sharing, and assisting cities to develop technology enabled tools. These tools promote access to analysis of complex data sets using visualizations of data for bridging silos as well as achieving decisions backed by evidence in a short time, while fostering consensus among stakeholders. By integrating state, business geo-spatial and contributions of inhabitants of cities, CPL Global promotes an ecosystem approach to urban data governance. Emphasizing the importance of a framework which is wider than technology innovations alone, CPL Global draws on a multitude of cases internationally, to demonstrate how evidence-driven decisions enhance economic growth and social development in mutually constitutive ways at national and local levels, while instilling ecosystem capacity across states, markets and communities.

CPL Global aims to strengthen the capacity of local governments to use geospatial intelligence to undertake data-driven planning and urban management, assisting cities by developing scalable and replicable tools that turn data into information and insights, while supporting the institutionalization and mainstreaming of data governance frameworks. CPL Global's foundational interventions create an enabling environment for geospatial innovations thereby helping cities deliver more efficiently on their core functions.

City Planning Labs is not a theoretical endeavor. It is rooted in rigorous pilots initiated in three cities in Indonesia, Semarang, Denpasar and Balikpapan. The success of these initial pilots led to the securing of multi-million-dollar support from the State Secretariat for Economic Affairs SECO, to scale up the

program globally, the first phase of which started in 2022. The program attempts not only to strengthen data led decision making in these cities but to allow scale up of the framework within each country. For instance, Indonesian national counterparts including the National Development Planning Agency, the Ministry of Agrarian and Spatial Planning/ National Land Affairs and the Geospatial Information Agency have encouraged the program to think at scale and transfer knowledge to build expertise within the country and replicate solutions without compromising innovation. Building on the experience in Indonesia, on scaling up internationally, CPL Global received requests for assistance from several countries, among whom seven form priority entry points, including Kenya, India, Nepal, Vietnam, Jordan, Uzbekistan and Ukraine, with programs a global scale out commencing in 2023.

MSDI: An Ecosystem Approach to Building Data Foundations for Cities

One of the key challenges in development is the capacity of public institutions to be responsive to the policy and regulatory environment. CPL Global's key argument is that building and managing geospatial data effectively through MSDI will allow cities to make plans and policies that will work for their inhabitants and help address persisting challenges, while effectively allocating limited resources. (MSDI Manual, 2018). To enable this data-driven approach to urban planning and service delivery, CPL Global advances an *ecosystem approach* to operationalize Municipal Spatial Data Infrastructure (MSDI) in partner cities. MSDI functions as the platform which enhances responsiveness of publiuc institutions to policy and regulatory environments. Through MSDI, geospatial information can be organized, shared, and leveraged to tackle the many challenges of sustainable urban development. Human, legal and technical aspects are an integral part of the MSDI framework, and inform the strategic investments needed by governments to support coordinated data-driven planning efforts (ibid).

Let us take a step back to understand why the ecosystem approach is imperative. Scholarly interpretations on state capacity stem from multiple disciplinary perspectives. Sociologists view state capacity as organizational competence of the bureaucracy (Centeno, et al., 2017: 05, on Max Weber). Another view of state capacity examines the ability of state agencies to accomplish their goals and missions through effective organizational design, training cohesion and reach (ibid). It is construed as the ability of states to plan and execute laws and policies with transparency (Fukuyama, 2004), including consensus building. A parallel perspective is about the types of goals a state pursues and how just and all-encompassing they are in terms of redistribution of resources (Lowi, 1964). Some political scientists view state capacity in terms of extractive capacities of states and power. Then, interpretations of state capacity are linked to the ability of states to practice democratic decision-making processes. The World Bank's perspective is one of quality of governance which focuses on the process of decision-making (ibid). Through MSDI, CPL Global's approach interprets quality of governance as quality of relationships between agencies of not just the state, but also between state and non-state agencies. We also interpret state capacity here has the ability of sub-national/ municipal governments to assume custodianship of public data.

Addressing deeper foundational gaps in the idea of institutional capacity, CPL Global's IPDS framework widens the thinking to ecosystem capacities where strong municipal governments are capable of orchestrating multiple actors, public, private and inhabitants of cities to accomplish their own welfarist goals. The initiative reconciles complex urban governance dynamics involving a diverse variety of institutions and a heterogenous range of stakeholders which simultaneously operate at multiple scales of decisions. The ecosystem approach to state capacity is significant in the current and future aspirations for smart urban governance which is increasingly characterized by fragmentation, efficiency and performance vis a vis enabling access to infrastructure for all.

It is within this ecosystem approach that CPL's MSDI implementation strategy has four building blocks: Institutional Arrangements, People, Data, and Systems (the IPDS framework). Each of the pillars is representative of the key components that are necessary to support the establishment, functioning and monitoring of MSDI implementation across short, medium, and long-term horizons. We argue that such a comprehensive framework is essential as a response to the challenge of the current imagination of smart cities and their siloed governance arrangements.

V. The IPDS Framework: International Benchmarks

A first step to understand how countries and cities have approached the setting up of data infrastructure platforms at local levels was to explore models adopted by countries with advanced economies and data governance environments. Eight benchmark cases were drawn from countries across the world to identify good examples across the four components: Institutional Arrangements, People, Data, and Systems (Figure 2.0). These were selected not as a prescriptive model for cities, but rather, as sources of aspirational ideas. The key highlights are:

Institutional Arrangements

Refers to the capacity of cities to develop and sustain formal policy, regulatory and governing structures that support geospatial related activities, and to the role of the city government in fostering the growth of the broader geospatial ecosystem.

People

Refers to creating awareness of capacity needs and identifying gaps in human resource supply regarding geospatial skills. It addresses the skills gap in the production, maintenance, and utilization of spatial data.

Data

Refers to the current situation on data availability, quality and related policies regarding formats, analysis and sharing of geospatial information. This diagnostic also considers the business case for investment in data and the extent to which the use of geospatial information can add value to existing line department Key Performance Indicators.

Systems

Refers to software, hardware and physical IT- related infrastructure required to support MSDI. A key component lies in the adequacy, functionalities and user interface of the city-level Geoportals that combine GIS and spatially referenced tabular data.

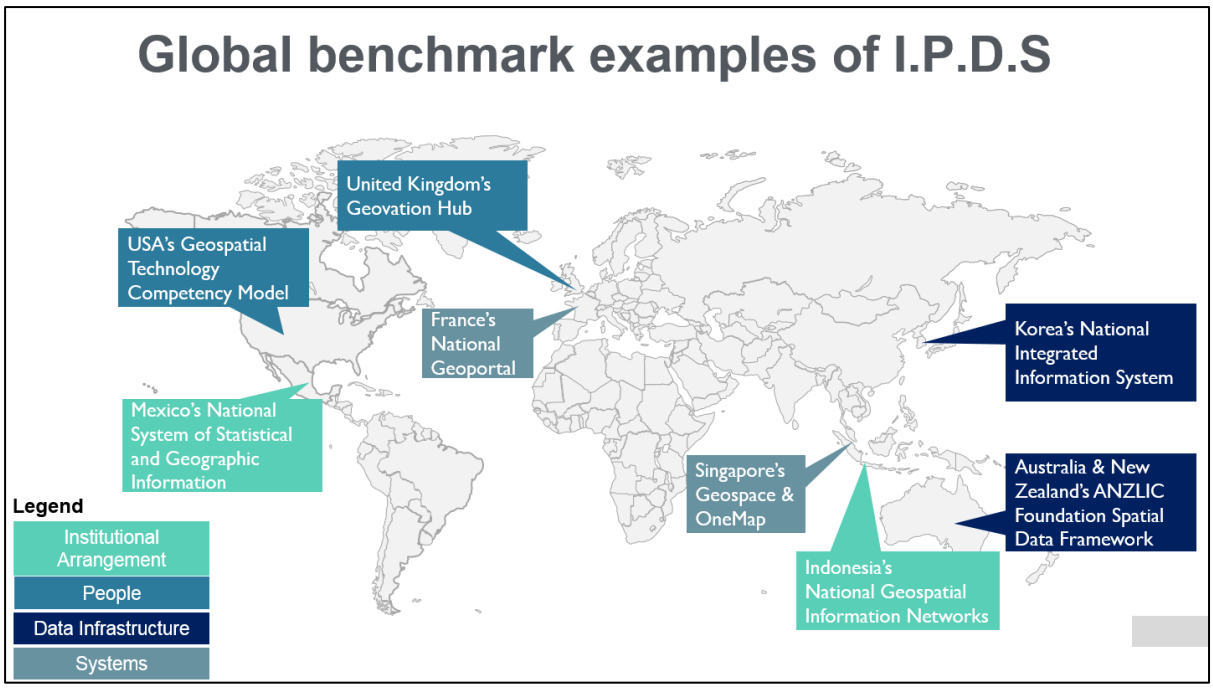

Figure 2.0: Overview of global case studies drawn for benchmarking across the I.P.D.S components.
Source: Singapore Land Authority's Report on Global Benchmarking for World Bank, City Planning Labs (2017).

Institutional Arrangements

Global practices demonstrate that data management and data sharing across government agencies, both vertically and horizontally in government hierarchies, is effective when coordination and communication protocols are established. Examples show that delineating clear roles and accountabilities of government organizations and appointment of a lead agency by law is also key to effective data governance in cities. In addition, the organization of data production and dissemination for analytical and application purposes also enable city government agencies to work towards solving real-world problems.

As an example, Mexico's National System of Statistical and Geographic Information (SNIEG) (Figure 3.0) combines both statistical and geospatial domains to produce more high-quality, integrated data for national development. Appointed as SNIEG's lead agency by law, the National Institute of Statistics and Geography (INEGI) coordinates the cross-linking and dissemination of statistical and geospatial data for various application areas. These application areas are in turn organized into National Information Subsystems, which execute geospatial and statistical activities through committees and working groups that span sectors and government levels[4].

[4] INEGI. (2017).

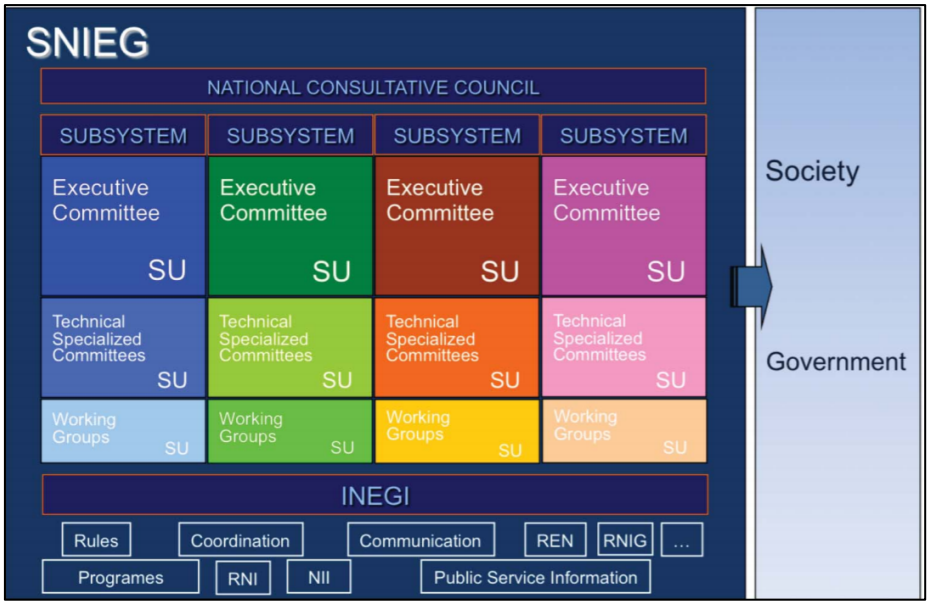

Figure 3.0: Mexico's National System of Statistical and Geographic Information (SNIEG) coordinates the production and dissemination of geospatial information effectively through both vertical and horizontal structures.
Source: *UNSTATS https://unstats.un.org/unsd/trade/mexico11/Item%2001%20-%20Mexico% 20-%20National%20System%20of%20Statistical%20and%20Geographic%20Information.pdf*

Meanwhile, Indonesia's National Geospatial Information Networks (JIGN) demonstrates a strong political commitment to overcoming coordination challenges in geospatial data sharing. Created by Presidential regulation, JIGN coordinates data sharing and processing across a network of nodes spanning 57 ministries, 34 provinces, and 514 regencies/cities. These nodes comprise the National Geospatial Information Agency, *Badan Informasi Geospasial* (BIG) at the national level; as well as production units, and management and dissemination units, at the local level. JIGN forms a key part of the One Map policy, which aims to produce a national base map, using a single geo-reference model, geodatabase, and geo-standards.

People

Current global practices demonstrate that both general and targeted approaches towards building ecosystem capacity are important. Establishing a common space for collaboration across sectors and professions is needed to spur coordination and innovation. At the same time, specialized efforts are essential to nurturing geospatial capabilities in each organizational, demographic and educational category.

For example, the United States' Department of Labour uses a comprehensive Geospatial Technology Competency Model (GTCM) to build geospatial competencies among students and the workforce. The GTCM articulates core and specialized skills and knowledge needed for successful performance across different tiers of practice, from the most general "Personal Effectiveness Competencies" to sector-specific competencies[5]. By describing recommended core abilities and work functions, the GTCM helps educators and employers align training with workforce needs and design accreditation programs nationwide. An example is The Geospatial Technology Apprenticeship Program (GTAP), developed by the University of Southern Mississippi, which uses the GTCM to help community college students

[5] United States Department of Labour. (2014).

obtain on-the-job learning[6]. The GTCM also encompasses the Geospatial Management Competency Model (GMCM), which specifies competency areas for effective managers in the geospatial industry[7].

Meanwhile, the United Kingdom's Geovation Hub (Figure 4.0) provides an experimental space for businesses and start-ups to innovate ideas using geospatial information. Established by the Ordnance Survey, the UK's national geospatial agency, the Hub offers an incubator program that mentors and funds entrepreneurs to grow and launch their ideas in the industry. It also extends resources to participants, such as expert coaching from industry leaders, workshops, and events, co-working spaces, as well as access to data and software. In addition, the Hub organises an annual Challenge for entrepreneurs and members of the public to solving societal issues geospatially. Selected ideas can qualify for prototyping at Geovation camps or the incubation program[8].

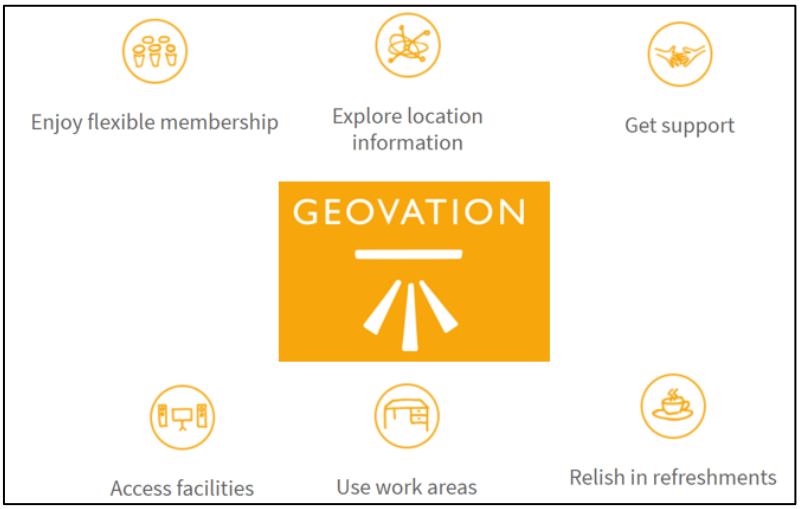

Figure 4.0: United Kingdom's Geovation Hub provides an experimental space for businesses and start-ups to innovate ideas using geospatial information. *Source: Ordnance Survey (Geovation Hub), 2017*

Data

Current global practices demonstrate the importance of identifying fundamental datasets that underpin key applications and managing them centrally for efficient access. This can be achieved through integrated frameworks that promote feedback loops between core databases and distributed hubs. Such frameworks prioritize resources for making available critical geospatial data for information activities and facilitate cost-effective re-use of the data.

For example, Korea's National Integrated Information System (NIIS) achieves efficient organization of information flows across the central and local governments, through a hub-and-spoke model. Fundamental geospatial, administrative and statistical data are managed in a central database, which feeds into a distributed network of thematic GIS applications in the government. NIIS's comprehensive model also extends opportunities to the private sector by offering open API and geoweb platform technologies (Web Map Service, Web Feature Service, etc.) for creating services. This promotes cost savings through seamless data sharing and reuse of resources[9].

[6] United States Department of Labour. (2005).
[7] URISA. (2012).
[8] UK Ordnance Survey. (2017).

[9] Kim, E. H. (2010).

The Australian New Zealand Land Information Council (ANZLIC)'s Foundation Spatial Data Framework (FSDF) (Figure 5.0) ensures the seamless exchange and widespread accessibility of national-level foundation spatial data in Australia and New Zealand. It identifies fundamental geospatial data themes, which underpin key applications, and recommends a common approach to assembling and managing them. Principles for custodianship, privacy, security, intellectual property, licensing and access are covered in the FSDF[10].

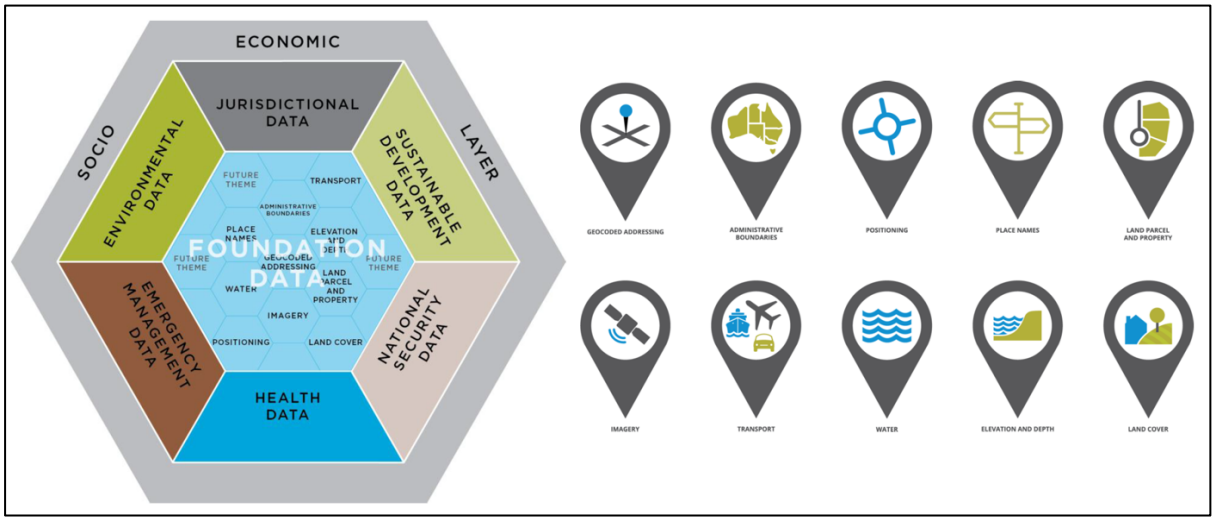

Figure 5.0: ANZLIC's Foundation Spatial Data Framework (FSDF) ensures the seamless exchange and widespread accessibility of national-level foundation spatial data in Australia and New Zealand. *Source: The Australian and New Zealand Foundation Spatial Data Framework, 2014*

Systems

Global practices demonstrate the multiplicative benefits of Geoportals toward data contributors and users. Geoportals are foundation systems that support families of applications, and connect data-sharing communities widely, throughout SDIs. They serve as and offer ready tools for building geospatial services and act as focal points for aligning goals and discussing data requirements.

For example, France's National Geoportal acts as a building block for other NSDI initiatives, which facilitates reuse and efficiency. It provides the basis for regional and thematic platforms, such as the Géoportail de l'Urbanisme for land planning, as well as geoportals by French Regions, Departments, and Communes. The Geoportal also supports broader e-government strategies, by using the National Mapping and Cartographic Agency (IGN)'s "Carto API" to integrate geospatial data and web services into agencies' e-services interfaces. For example, data can be retrieved from the Geoportal and cross-checked for filling application forms. This fits within the French Government's broader strategy to digitalize its services[11].

Singapore's data-sharing platforms (Figure 6.0), GeoSpace and OneMap, create value beyond data exchange by engaging users to deliver services and build communities. GeoSpace hosts GeoCommunities, which allow government agencies in similar domains to build analytical models and solve problems. Examples of these GeoCommunities are those for the identification of slope failures and the coordination of flight path requirements for Unmanned Aerial Vehicles systems. OneMap, on the other hand, offers localized location-based services to citizens and businesses for decision-making.

[10] ANZLIC. (2014).
[11] UN-GGIM NIA Working Group. (2017).

For example, the 'School Query' function allows parents to search for potential schools for their children within a specific radius from their homes, as part of the local school registration process[12].

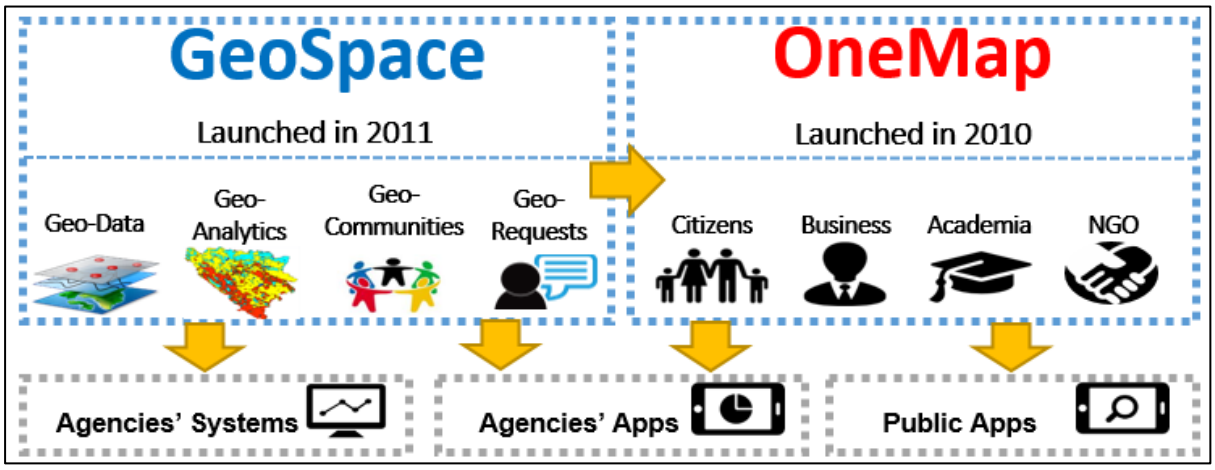

Figure 6.0: Singapore delivers services and builds communities through GeoSpace and OneMap. *Source: www.ggim.un.org/2nd%20session/country%20reportss/Country_Report_Singapore.pdf*

CPL Global's Four Building Blocks: Institutional Arrangements, People, Data Systems

Drawing on the above international benchmarks which are integral to the holistic NSDI approach, we argue that smarter cities are those which build up capacity to adopt a municipal approach, i.e., CPL Global's MSDI and the IPDS framework. Within this framework, the *Institutional Arrangements* component supports the development of regulatory frameworks and organizational custodianship to promote inter-sectoral coordination. It also encourages the establishment of protocols for data sharing across government, industry, and society; thereby increasing access to geospatial information. Such sectoral coordination is only successful if *People* across line departments and even within communities, share the same vision and develop their ability to utilize data for planning. An increase in geo-spatial skills further augments the ability of the city to collect, process, produce, manage and analyze *Data* to perform evidence-based urban planning. The last component of this framework aims at establishing ICT *Systems* that integrate spatial and tabular data within a single platform. Such a platform provides a tangible space for the operationalization of data sharing policies established under the Institutional Arrangements pillar and opens the possibility of vertical integration of municipal and national spatial data infrastructure.

MSDI and the IPDS Framework: Moving towards coordinated decisions for Smarter Cities

CPL Global offers guidance through several publications which through a step by step approach, help cities make the MSDI their own. The MSDI Manual for instance recommends that sub-national/municipal governments undertake baseline and deep-dive surveys and build a medium term Road Map with clear prioritization, delineation of activities and budgetary allocations. Through systemic process innovations, the IPDS framework helps cities build ecosystem capacity for better coordinated decisions.

Ecosystem approach and systemic inter-dependencies

The IPDS framework establishes inherent inter-dependencies between the four components for ecosystem capacity. For instance, the idea of a minimal 'Fundamental Data Set' as the building block of the *Data* component supports optimization of public expenditure for data management while contributing to overall fiscal prudence of municipal governments. Public facing geo-portals within the

[12] UN-GGIM NIA Working Group (2017).

Systems component serves as a vehicle for data sharing, in turn supporting *Institutional Arrangements*. Easy to operate web enabled *Systems* and tools allow non-technical *People* to rapidly analyze complex datasets, make *Data* access ubiquitous and inclusionary.

Complete custodianship of the government

The success of MSDI rests in the city government taking complete custodianship of the process and products. While the complexity of the process often requires governments to obtain support in the form of technical assistance, the process and its outcomes are led and owned by the government. In addition to quantifiable improvements towards data-driven planning, the long-term benefits of a well-functioning MSDI include enhanced transparency and accountability which in turn leads to improved service delivery, public trust and a better quality of life for citizens. In an ideal situation, priority activities from the MSDI roadmap must be included as Key Performance Indicators in the city's mid-term development plan as well as sectoral strategic and spatial plans (MSDI Manual).

Scalable and flexible with multiple entry points

The IPDS framework is flexible and scalable, implying cities with varying levels of capacity and at different stages of MSDI development can leverage and build on the framework (ibid). Within the IPDS framework, city governments can identify and prioritize activities that will serve as entry-points for introducing, operationalizing and socializing MSDI activities across all stakeholders. While developing their MSDI roadmap, geared with the results of baseline assessments, some cities may first decide to focus their efforts on developing legal and regulatory foundations for data management activities – these may include formulating local government decrees for data governance and management, or protocols for data sharing or framing data standards to improve coordination between city agencies. Other cities may prioritize preparation of citywide base maps and other data development activities to help assess infrastructure needs. Still others may use skills development, capacity building or establishing the geoportal as entry points to introducing citywide MSDI. Such an approach enables working with existing initiatives as entry points rather than prescribing a rigid set of linear recommendations with inflexible start and end points (ibid).

Inclusive and collaborative

MSDI roadmaps are developed collaboratively with agencies for short, medium, and long-term horizons. The approach is, at all times, consultative with an emphasis on establishing a culture of inter-agency collaboration. The importance of collective knowledge and experience of city officials is critical as they will provide their perspectives on the benefits and challenges of implementing MSDI (ibid).

VI. CPL Global's MSDI for sustainable urban development and city resilience

The challenge of urbanization and risks for cities has only exacerbated post COVID-19. Rapid urbanization, climate change impact, economic and financial crises, geopolitical tensions and new societal demands are several profound crises facing cities, especially in Asia and Africa. For instance, According to World Bank development indicators, Indonesian cities are growing more rapidly as compared to their Asian neighbors, at a rate of 4.1 percent annually[13]. By 2025, it is estimated that Indonesia will have 68 percent of its population living in cities[14]. Annual urban population growth rates in Kenya are similar at 4.0 percent. India's annual urban population growth rate is relatively slower at an annual growth rate of 2.9 percent, as is Vietnam's at 2.59 percent (Census data of respective countries).

[13] World Bank (2016a).
[14] World Bank (2016a), *ibid*

Although urbanization can accelerate economic growth, urban challenges such as unending urban sprawl, outward growth, inadequate basic services, traffic congestion, pollution and disaster risks are growth impediments[15]. While countries across the world have embraced the data revolution in the form of Smart Cities to tackle these barriers to sustainable urban development, these approaches threaten to further weaken the use of data for building city resilience. We reiterate the significance of the Spatial Data Infrastructure (SDI) approach in this context.

In this paper, we have argued that countries must establish Municipal Spatial Data Infrastructure in order to ensure effective implementation of National Spatial Data Infrastructure. However, notwithstanding the importance of local level growth dynamics and risks, the United Nations- Global Geospatial Information Management (UN-GGIM) underscores several macro level trends[16] as important, moving forward. One, it emphasizes the importance of increasing adoption of cross-domain, innovative technologies, including the Internet of Things, Smart Cities implementation across municipalities, open-source computing, Artificial Intelligence and machine-learning algorithms. Two, increasing propensity for data synergies across various sources is a focus, including data collected by local or national governments (such as official statistics, land data, and other administrative datasets), remotely sensed imagery, private sector business intelligence, crowd-sourced information from the community and unstructured, real-time data derived from the Internet of Things and from social media. Three, increasing role and importance of National Spatial Data Infrastructures (NSDI) is underlined. It explains that NSDIs function as the platform by which geospatial information can be organized, shared and leveraged upon, to establish linkages with sub-national/ local level data infrastructure.

While the UN-GGIM emphasizes the important role of National Spatial Data Infrastructure to promote growth, we argue that the success of National Spatial Data Infrastructure will continue to be limited if not supported by national government initiatives to establish Municipal Spatial Data Infrastructure. The test of efficacy of NSDIs alone versus the prominence of the NSDI-MSDI approach was evident during the last phase of the pilot program in Indonesia, through the Covid-19 pandemic. All pilot cities in Indonesia came forth to leverage their local data infrastructures, guided by CPL, while dealing with diverse range of concerns. The success of MSDI was beyond expectation of members of the City Planning Labs initiative. Three process innovations are significant.

First, all three cities prioritized the *Institutional Arrangements* pillar as fundamental to establishing a sustainable MSDI. Semarang, Balikpapan and Denpasar issued local data governance decrees, promulgated by offices of respective city Mayors. The initiative to establish the Institutions (roles, responsibilities, protocols for data sharing) pillar confirmed budgetary prioritizations for creation of relevant Data (standards), People (capacity building) and Systems (tools) to be able to leverage data for decision making in most vulnerable circumstances such as the Covid-19 pandemic. The decree also clarified inter-dependencies between the pillars. As part of this effort, all three cities also initiated coordination with national geo-spatial agencies to ensure alignments with national prerogatives and the NSDI.

Second, the COVID-19 pandemic magnified the urgency and importance of real-time, accurate, and reliable data for city governments to respond in a timely way and plan for dealing with the pandemic as well as social and economic recovery. Cities in Indonesia intended to mobilise geo-spatial data to overcome traditional constraints of paper led administration in conditions of social distancing. However, lack of technical capacities to use geo-spatial data and assess localities, families and people who needed immediate attention impeded timely action. At this critical juncture, the Ministry of

[15] World Bank (2016a), *ibid*
[16] UN-GGIM (2015).

Home Affairs requested technical assistance from the World Bank to develop and scale up one of CPL's tools, the CollabData tool, which allowed easy aggregation and integration of locally collected data. Using this tool, government officials could rapidly prioritize action within available resources, match measures to be taken with national budgeting and deliver services where most needed. National and local governments in Indonesia immediately adopted the Collab tool, named *Siap Tanggap* or SIAP which translates as 'Ready to Respond', to utilize geo-coded local data collection, manage and analyze data to support communities and local governments understand the implications of COVID-19 and take relevant remedial measures. SIAP represents CPL Global's success in bringing communities and governments closer, particularly in socially vulnerable circumstances (Singh, Mamola and Duarte, 2020[17]).

Third, cities in Indonesia pro-actively initiated efforts to integrate data and plans through institutional arrangements. The city government of Balikpapan launched its one data platform which integrated tabular and geo-spatial data under one system. By developing a system of rules for integration of the two types of datasets, the city institutionalized this consolidated data into the systems platform. In a similar vein, the city of Denpasar initiated a review of its spatial plans using CPL's flagship tools which helped them identify inefficiencies in spatial plans and correct them, thereby increasing public transport accessibility and promoting a low carbon footprint.

These concrete examples demonstrate the amplified benefits of investing time in strengthening an ecosystem approach to enabling city governments to assume custodianship, manage and use data for societal benefits, rather than pursue solely technology led solutions as an end. They show how an ecosystem approach to establishing MSDI is a comprehensive response to the structural gaps in smart cities initiatives, that we set out with in this paper. The first case involving enactment of data governance decrees exemplifies the importance of *Institutional Arrangements* and vertical integration as opposed to siloed governance arrangements. The second case of SIAP shows why it is crucial for a *People* led approach to go hand in hand with *Data* and *Systems* approaches. The third case shows how the IPDS framework can help city governments integrate multiple types of *Data* with planning and optimize on investments. Cumulatively, the three instances show how cities can adopt an ecosystem approach to strengthen institutional relationships for better coordination and Smarter Cities.

In this framework, technology driven innovation advances city resilience and transcends mere efficiency goals that smart cities initiatives aspire to. We contend that innovative states would imply bold national and local governments which mobilize geo-spatial data infrastructure to promote ecosystem capacities among stakeholders with competing demands for growth and sustainability. Given the need for rapid urbanization, climate change crises, and economic growth demands, by 2025, as the world progresses the need for technology led innovation to take deeper roots, having strong ecosystem foundational approaches at city level become an imperative.

In the scale up phase supported by State Secretariat for Economic Affairs SECO, in Kenya, India, Nepal, Vietnam, Jordan, Uzbekistan and Ukraine, we aim to track the contextualization of global approaches at local levels, while strengthening the process of decentralization through integration and adaptation of National Spatial Data Infrastructure and Municipal Spatial Data Infrastructure.

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[17] https://blogs.worldbank.org/opendata/how-digital-data-helped-indonesia-respond-covid-19

References

Aditiya, A and Ito, T. (2023). Present-day land subsidence over Semarang revealed by time series InSAR new small baseline subset technique. Observation and Geoinformation. Volume 125, December 2023, 103579

ANZLIC. (2014). The Australian and New Zealand Foundation Spatial Data Framework: Making Common Foundation Spatial Data Ubiquitous Across Australia and New Zealand. Retrieved from: http://anzlic.gov.au/sites/default/files/files/One_ANZ_Foundation_Spatial_Data_Framework_Booklet.pdf.

Bastian, I, Effendi, R, Susanto, E.A, Unggara, I, Sumiyana, S. (2022). The government of Indonesia's smart city development: Fiscal capacity, cognitive models in decision making, excessive caution about future accrual of benefits, and null regulatory leadership. Front. Built Environ., Sec. Urban Science. Volume 8 – 2022.

Bott, L-M, Schöne, T, Illigner, J, Haghighi, H.M, Gisevius, K, Braun, B. (2021). Land subsidence in Jakarta and Semarang Bay – The relationship between physical processes, risk perception, and household adaptation. Ocean and Coastal Management. Volume 211, 1 October 2021, 105775

Canadian GIS & Geomatics (2013), The Value of Geospatial Information in Economy. Retrieved: https://canadiangis.com/value-geospatial-information-economy.php

Centeno, M, Kohli, A, and Mistree, D. (2017). States in the Developing World. Cambridge University Press.

Executive Office of the President (1994). Coordinating geographic data acquisition and access: the National Spatial Data Infrastructure, Executive Order 12906, Federal Register 59, 17671-17674.

Fukuyama, F. (2004). State Building: Governance and World Order in the 21st Century. Itahaca, Cornell University Press.

Henttu, H., Izaret, J-M., David P. (2012). Geospatial Services: A $1.6 Trillion Growth Engine for the U.S. Economy, Boston Consulting Group. Retrieved: https://www.bcg.com/documents/file109372.pdf

Hu, Y and Li, W. (2017). Spatial Data Infrastructures. Computer Sciences. Computers and Society. Cornell University.

Indian Express, September, 03, 2022. Floods caused Rs. 225 Crores loss: Outer Ring Road Companies Association; https://indianexpress.com/article/cities/bangalore/floods-caused-rs-225-crore-loss-outer-ring-road-companies-associations-8126614/

INEGI. (2017). Mexico's National Geostatistical Framework, and Geospatial Tools for the 2020 Population and Housing Census. Retrieved from: http://ggim.un.org/ggim_20171012/docs/meetings/GGIM7/3%20-%20Rolando%20Ocampo%20Alcántar.pdf

Kim, E. H. (2010). National Spatial Data Infrastructure: The Case of the Republic of Korea. Retrieved from: https://www.infodev.org/infodev-files/resource/InfodevDocuments_1110.pdf

LINZ (2017). What is geospatial information? Retrieved: http://www.linz.govt.nz/about-linz/our-location-strategy/what-geospatial-information

Lowi, T. (1964). American Business, Public Policy, Case Studies and Political Theory. World Politics 16(4): 677-715.

Masser, I. (1997). Conference: American Society for Photogrammetry and Remote Sensing. Volume: GIS/LIS 97.

Municipal Spatial Data Infrastructure Manual. (2018). City Planning Labs, World Bank
Municipal Spatial Data Infrastructure Report. (2017). Singapore land Authority for City Planning Labs, World Bank.

National Research Council (1994). Promoting the National Spatial Data Infrastructure through Partnerships, National Academy Press, Washington DC.

Report on Global Benchmarking of SDI-IPDS approaches. (2017). Singapore land Authority for City Planning Labs, World Bank.

Singh, G, Mamola, J.S.N, and Duarte, E.D. (2020). How digital data helped Indonesia respond to COVID-19. World Bank Blog: https://blogs.worldbank.org/opendata/how-digital-data-helped-indonesia-respond-covid-19

Smart Cities Mission Statement and Guidelines. (2015). Ministry of Urban Development, Government of India.

Trapp, N., Schneider, U.A., McCallum, I., Fritz, S., Schill, C., Borzacchiello, M.T., Heumesser, C., Craglia, M. (2015). A meta-analysis on the return on investment of geospatial data and systems: a multi-country perspective. *Transactions in GIS*, 19(2): 169-187.

UK Ordnance Survey. (2017). Geovation Hub Website. https://geovation.uk

URISA. (2012). Geospatial Management Competency Model. Retrieved from: http://www.urisa.org/clientuploads/directory/GMI/Advocacy/GMCM%20final.pdf

UN-GGIM NIA Working Group (2017). Compendium of good practices for national institutional arrangements. Retrieved from: http://ggim.un.org/meetings/GGIM-committee/7th-Session/documents/Agenda%207%20Compendium%20of%20NIA%20Good%20Practices.pdf

United States Department of Labor. (2014). Geospatial Technology Competency Model. Retrieved from: https://www.careeronestop.org/CompetencyModel/competency-models/pyramid-download.aspx?industry=geospatial-technology

United States Department of Labor. (2005). Strengthening Our Nation's Workforce with Demand-Driven Solutions: Registered Apprenticeship Trends in Geospatial Technology. Retrieved from: https://www.doleta.gov/OA/brochure/Geospatial_new.pdf

UN-GGIM NIA Working Group. (2017). Sharing Good Practices on Systems for Information Exchange and Sharing. Retrieved from: http://ggim.un.org/meetings/GGIM-committee/7th-Session/side_events/2%20-%20Lim%20Liyang.pdf

UN-GGIM NIA Working Group (2017). Compendium of good practices for national institutional arrangements. Retrieved from: http://ggim.un.org/meetings/GGIM-committee/7th-Session/documents/Agenda%207%20Compendium%20of%20NIA%20Good%20Practices.pdf

UN-GGIM (2015), Future trends in geospatial information management: the next five to ten-year vision.

UNSTATS https://unstats.un.org/unsd/trade/mexico11/Item%2001%20-%20Mexico% 20-%20National%20System%20of%20Statistical%20and%20Geographic%20Information.pdf

World Bank (2016a). Indonesia's Urban Story.
Retrieved: http://www.worldbank.org/en/news/feature/2016/06/14/indonesia-urban-story

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