Analyzing Adoption of Smart Cities through System Dynamics

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ABSTRACT

Smart city is one of the important part of construction sector that are initiated under Make in India National Program and part of Digital India Initiative. As stated in their objective India's Smart City vision is part of a larger agenda of creating Industrial Corridors between India's big metropolitan cities in India. Its other objectives also include giving a Sustainable System to cities there by giving a clean, green and quality life to its citizen. The application of Smart Solution will provide a core infrastructure which can bring sustainable and inclusive development. These developments include incorporation of new technology; technologies which are not there earlier in the life of general public. In a matter of fact as smart city will take some time to be fully available to be used by general public, the public will also take time to adopt these new technologies as part of their routine life. For this the proposed work is examining Smart City Mission through system's approach and talk about 'Virtuous' - positive and 'Vicious' - negative factors. Further a generic model is also developed and with the help of some Sub-Sector, the Loop Dynamics is also elaborated to analyze Smart City initiative. Finally a causal Loop diagram is proposed to see the functioning and adoption of Smart city. The software used to capture the systems application are Stella and Vensim.

Keywords: *Construction Sector, Government Initiative, Smart City, Systems Approach, Virtual and Vicious Loop, Sub-Sector.*

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1 INTRODUCTION

"Cities in the past were built on riverbanks," but that "they are now built along highways and that "in the future, they will be built based on availability of optical fiber networks and next-generation infrastructure."   **-Prime Minister, India - Mr. Narendra Modi**

Smart Cities Mission, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), and Housing for All in urban areas, the launch of these big urban projects in India is a sign that Indian Government is thinking and working towards the urbanization of Indian cities. It's not just the urbanization but a complete package through which people can live and maintain their life in a Smart and thus sustainable way (Smart Cities India 2016 exhibition and conference, 2015).

During voting campaign Mr. Narendra Modi, now Prime Minister of India has promised to bring the Smart City system in India and would build 100 Smart Cities across India. After taking office the Modi Government has allocated $1.2 billion to Smart City Project (cogitasia, 2015). According to Modi, Smart Cities will prove as catalyst to increase job creation and accelerating economic growth – countries like China and the UAE are betting big on Smart Cities and have already dedicated billions of dollars to Smart City Projects (cogitasia, 2015).

This paper is going to look Smart City Mission through Systems' Approach and identify various 'Virtual' and 'Vicious' factors. These factors are actually the 'Capacity Building' and 'Vulnerabilities' towards creating Smart Cities. With the help of creating Generic Model this paper will elaborate Loop Dynamics for some Sub-Sectors to analyze Smart City initiative and its adoption among people. Further a Causal Loop is created to understand the adoption of Smart City.

1.2 Need of the Study

Whenever a new project starts we sometime neglect the Vulnerabilities which are associated with the project. The Smart City Mission no doubt is bold and innovative step towards the development of urbanization in India. As a project smart city will take some time to be fully available for general public, further it is also noticeable that the public will also take time to adopt these new technologies as part of their routine life. The Systems' Approach will help us identify and understand both Capacity Building (Virtuous factors) and Vulnerabilities (Vicious factors) are reinforcing at the same time. Identification of both the Vulnerabilities and Capacity Building in a system can help us to reduce Vulnerability of one Sub-Sector with the help of Capacity Building of another Sub-Sector.

1.3 Mission Smart Cities

The Indian government machinery is working on putting together the standards for executing this mega plan, and identifying the cities to be developed in consultation with states. A few smart cities are already coming up across the country, including Kochi Smart City, Gujarat International Finance Tec-City (GIFT) in Ahmedabad, Naya Raipur in Chhattisgarh, Lavasa in Maharashtra and Wave Infratech's 4,500-acre smart city near New Delhi.(Make in India, Government of India, 2015). For Mission Smart City, 100 cities are nominated in first phase. For this Government of India has announced a Challenge for municipalities of respective cities to project the plan for urbanization of their cities. The Challenge is going on and now is in its third phase.

1.4 The core infrastructure elements in Smart Cities are

As stated in www.smartcity.gov.in there are some basic element which are called as core infrastructure for smart city mission,, as listed below.

•   Adequate water supply,

- Assured electricity supply,

- Sanitation, including solid waste management,

- Efficient urban mobility and public transport,

- Affordable housing especially for the poor,

- Robust IT connectivity and digitalization,

- Good governance especially e-Governance and citizen participation,

- Sustainable environment, Storm water drains to reduce flooding,

- Pedestrians, non-motorized and public transport facilities and parking spaces,

- Safety and security of citizens, particularly women, children and the elderly, and

- Health and education.

(Adapted from Ministry of Urban Development, Government of India., 2015)

These core infrstructure element are the basis of creating the sub sectors for generic model and stock flow model developed in section 3 and section 4 respectively.

2 SYSTEM DYNAMICS APPROACH

"Borrowed from the system theory, this paper offers a dynamic approach of complex system analysis and modeling in the form of System dynamics. System dynamics is a perspective and set of conceptual tools that enable us to understand the structure and dynamics of complex systems" stated by Sterman in his famous book on system Dynamics. (Sterman, 2000)
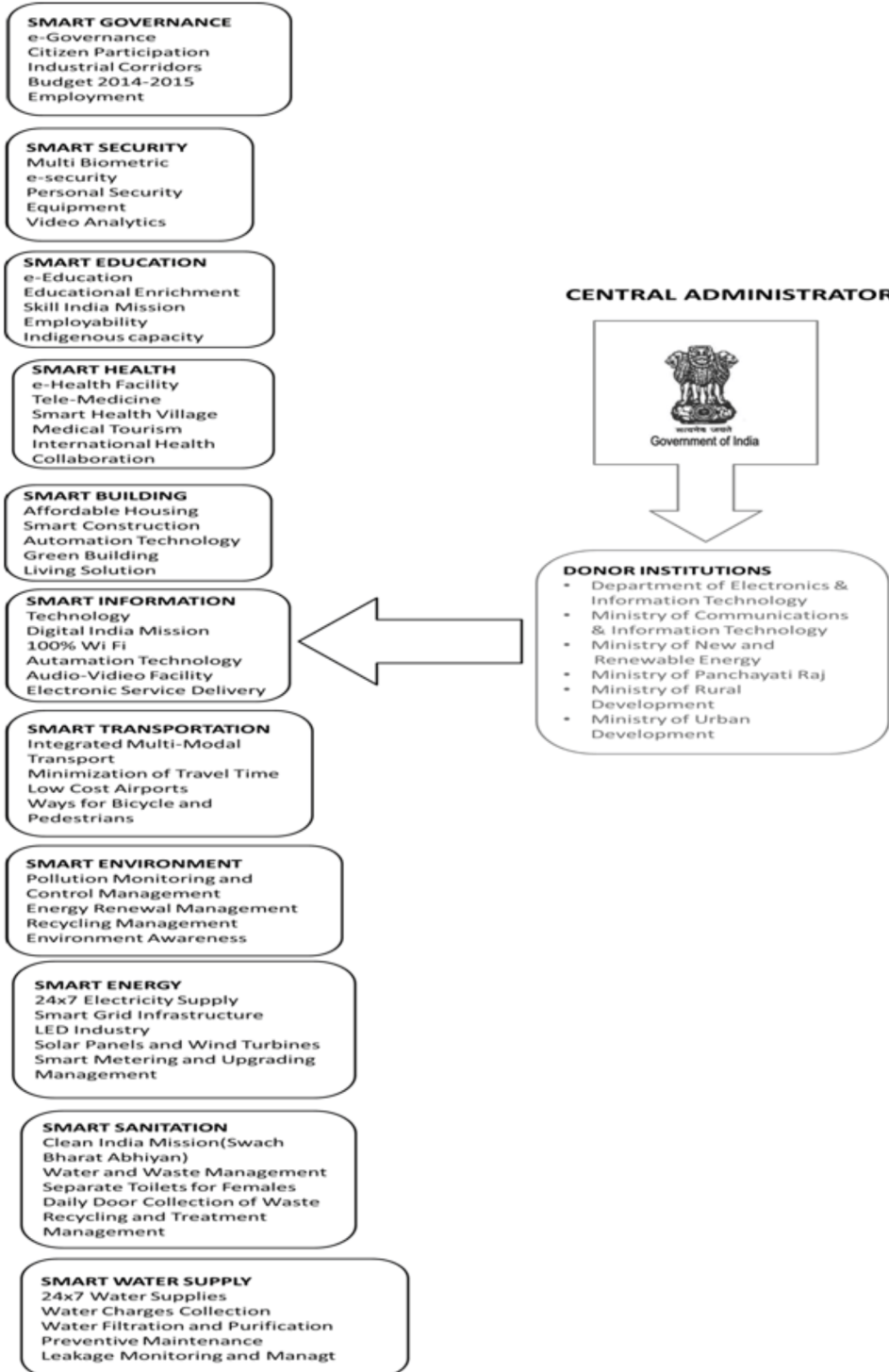
"System dynamics methodology emphasizes on internal feedback loop process and deals with the causal relations between the dynamic behavioral analysis and multi-variables that enables to represent the structure and behavior of complex systems over time, providing a method for systems description." as stated by Bhushan in its paper on supply chain management using the concept of System Dynamics.(Sanjay Bhushan, 2013)

2.1   The systems' Approach will cover following steps (Methodology)

1.   Construction of Generic model to identify Model boundary to model the needs and priorities.

 2.   Identification of relevant input variables and parameters.

3.   Identification of various Sub-Sectors.

4.   Stock Flow depiction of various Sub-Sectors.

5.   Identification of 'Virtual' and 'Vicious' factors.

6.   Causal Loop Cum stock Flow Model (Base Model) for holistic view of Smart City.

7.   Elaboration of adoption factors for Smart City through Cause Tree and Use Tree.

3 GENERIC MODEL

Applying the system dynamics modeling approach (Sterman, 2000), author has identified key system boundaries and input variables as depicted in the Generic Model (Figure 1), which are based on the basic key infrastructure identified by the Indian Government and mention on the smart city website (also mentioned in section 1.4).

SMART GOVERNANCE
e-Governance
Citizen Participation
Industrial Corridors
Budget 2014-2015
Employment

SMART SECURITY
Multi Biometric
e-security
Personal Security
Equipment
Video Analytics

SMART EDUCATION
e-Education
Educational Enrichment
Skill India Mission
Employability
Indigenous capacity

SMART HEALTH
e-Health Facility
Tele-Medicine
Smart Health Village
Medical Tourism
International Health
Collaboration

SMART BUILDING
Affordable Housing
Smart Construction
Automation Technology
Green Building
Living Solution

SMART INFORMATION
Technology
Digital India Mission
100% Wi Fi
Autamation Technology
Audio-Vidieo Facility
Electronic Service Delivery

SMART TRANSPORTATION
Integrated Multi-Modal
Transport
Minimization of Travel Time
Low Cost Airports
Ways for Bicycle and
Pedestrians

SMART ENVIRONMENT
Pollution Monitoring and
Control Management
Energy Renewal Management
Recycling Management
Environment Awareness

SMART ENERGY
24x7 Electricity Supply
Smart Grid Infrastructure
LED Industry
Solar Panels and Wind Turbines
Smart Metering and Upgrading
Management

SMART SANITATION
Clean India Mission(Swach
Bharat Abhiyan)
Water and Waste Management
Separate Toilets for Females
Daily Door Collection of Waste
Recycling and Treatment
Management

SMART WATER SUPPLY
24x7 Water Supplies
Water Charges Collection
Water Filtration and Purification
Preventive Maintenance
Leakage Monitoring and Managt

CENTRAL ADMINISTRATOR

Government of India

DONOR INSTITUTIONS
- Department of Electronics &
  Information Technology
- Ministry of Communications
  & Information Technology
- Ministry of New and
  Renewable Energy
- Ministry of Panchayati Raj
- Ministry of Rural
  Development
- Ministry of Urban
  Development

4 IDENTIFICATION OF FACTORS FOR VARIOUS SUB-SECTORS IN SMART CITY MISSION

Table list the sources from where the factors for various Sub-Sectors are identified, the table also demarcate the factors as capacity building variables and vulnerable variables.

Table1. Identification of variables for various Sub-Sectors

S.No.	Sub-Sector	Variables: Capacity Building	Variables: Vulnerability
1	**Smart Education**	Employability, e-education, indigenous capacity, educational enrichment and skill India mission	Poverty, migration, unemployment and illiteracy.
	Sources	(Indian Chamber of Commerce and Delloite, 2015) (Ravi, Tomer, Bhatia, & Kane, 2016) (Aizaj, 2016) (Jawaid & Khan, 2015) (Urban Development, Government of India, 2015) (Goel & Nadimpalli, 2015) (World Economic Forum, 2016) (Selvakanmani, 2015) (Madakam & Ramaswamy, 2015) (Ministry of Urban Development, Government of India, 2016) (VisionIAS, 2014)	
2	**Smart Health**	e-health facility, health smart villages, tele-medicine, medical tourism and international medical collaborations	population growth, health illiteracy, unscientific practices, believe in superstitions and inaccessibility to medical aids
	Sources	(National Institue of Urban Affairs, 2015) (Goel & Nadimpalli, 2015) (Bhattacharya, Rathi, Patro, & Tepa, 2015) (World Economic Forum, 2016) (Parishwad & Singh, 2014) (Indian Chamber of Commerce and Delloite, 2015) (Housing and Land Right Network, 2017) (United Nations Commission on Science and Technology for Development secretariat , 2016)	
3	**Smart Building**	Affordable housing, smart construction, automation technology, green building and living style solution	Geographical constraints, bad habits, natural calamity and effect of these smart changes on environment.
	Sources	(Patel & Padhya, 2014) (Singh & Sharma, 2016) (Shukla, 2015) (Selvakanmani, 2015) (Smart City Council, 2017) (Urban Development, Government of India, 2015) (Ravi, Tomer, Bhatia, & Kane, 2016) (Madakam & Ramaswamy, 2015) (United Nations Commission on Science and Technology for Development secretariat , 2016) (Ministry of Urban Development, Government of India, 2016) (VisionIAS, 2014)	
4	**Smart Information Technology**	Digital India mission, complete WI-FI, automation technology, audio-video facility and electronic service delivery	e-pollution, lack of basic infrastructure for digital India, too much digitization needed and habit of traditional methods of living
	Sources	(Madakam & Ramaswamy, 2015) (VisionIAS, 2014) (JLL, India, 2013) (Housing and Land Right Network, 2017) (Urban Development, Government of India, 2015) (Parishwad & Singh, 2014) (Indian Chamber of Commerce and Delloite, 2015) (Goel & Nadimpalli, 2015) (National Institue of Urban Affairs, 2015) (World Economic Forum, 2016) (Selvakanmani, 2015) (Ministry of Urban Development, Government of India, 2016)	

5	Smart Transportation	Integrated multi modal transport, low cost airport, intelligent traffic management, minimizing travel time and parallel route for bicycle and pedestrians	Uncontrolled fuel prices, extra burden on electricity, lack of civic sense, lack of following traffic rules and private vehicle ownership.
Sources	(United Nations Commission on Science and Technology for Development secretariat , 2016) (Ministry of Urban Development, Government of India, 2016) (Parishwad & Singh, 2014) (Ravi, Tomer, Bhatia, & Kane, 2016) (Patel & Padhya, 2014) (Singh & Sharma, 2016) (Madakam & Ramaswamy, 2015) (United Nations Commission on Science and Technology for Development secretariat , 2016)		
6	Smart Environment	Pollution monitoring and control management, renewal energy management, recycling management and creating environment awareness	Cutting of forest, carbon emission, changing weather condition and increase in man made changes that have adverse effect on environment.
Sources	(Urban Development, Government of India, 2015) (Aizaj, 2016) (Jawaid & Khan, 2015) (Indian Chamber of Commerce and Delloite, 2015) (Ravi, Tomer, Bhatia, & Kane, 2016) (Goel & Nadimpalli, 2015) (National Institue of Urban Affairs, 2015) (World Economic Forum, 2016) (Selvakanmani, 2015) (Housing and Land Right Network, 2017) (Ministry of Urban Development, Government of India, 2016) (VisionIAS, 2014)		
7	Smart Energy	All-time electric supply, smart grid infrastructure, establishment and development of LED industry, establishing solar energy and wind turbines management system and smart metering and up gradation management	Energy theft, wastage of energy and fuel, unawareness of full exploitation of energy and dependency on fossil fuels.
8	Smart Sanitation	Clean India Mission, waste and water management, toilets for females, daily door step collection of waste and recycling and treatment management.	Old habits, new equipments adoption is slow and lack of civic sense and cleanliness.
Sources	(Urban Development, Government of India, 2015) (Indian Chamber of Commerce and Delloite, 2015) (Goel & Nadimpalli, 2015) (National Institue of Urban Affairs, 2015) (World Economic Forum, 2016) (Selvakanmani, 2015) (Ministry of Urban Development, Government of India, 2016) (Indian Chamber of Commerce and Delloite, 2015) (VisionIAS, 2014)		
9	Smart Water Supply	Running water supply, water charges collection, filtration and purification, preventive maintenance and leakage monitoring and management.	Untreated sewage disposable in rivers, inadequate rain water harvesting and no control on individual usage of water.

Sources	(Aizaj, 2016) (Jawaid & Khan, 2015) (Urban Development, Government of India, 2015) (Parishwad & Singh, 2014) (Ravi, Tomer, Bhatia, & Kane, 2016) (Patel & Padhya, 2014) (Singh & Sharma, 2016) (Selvakanmani, 2015) (Madakam & Ramaswamy, 2015) (Housing and Land Right Network, 2017) (United Nations Commission on Science and Technology for Development secretariat , 2016)		
10	**Smart Security**	Safe city project, multi biometric system, e-security, video analytics and personal safety equipments.	Crime rate, exponential electronic data, psychological problems and unethical environment.
Sources	(Urban Development, Government of India, 2015) (Ravi, Tomer, Bhatia, & Kane, 2016) (Goel & Nadimpalli, 2015) (National Institue of Urban Affairs, 2015) (World Economic Forum, 2016) (Selvakanmani, 2015) (Housing and Land Right Network, 2017) (United Nations Commission on Science and Technology for Development secretariat , 2016) (Indian Chamber of Commerce and Delloite, 2015) (VisionIAS, 2014)		
11	**Smart Governance**	e-governance, budget allocation, industrial corridors, citizen partnership and employment.	Corruption, red-tapism and political lobbing.
Sources	(Aizaj, 2016) (Jawaid & Khan, 2015) (Urban Development, Government of India, 2015) (Parishwad & Singh, 2014) (Indian Chamber of Commerce and Delloite, 2015) (Ravi, Tomer, Bhatia, & Kane, 2016) (Goel & Nadimpalli, 2015) (National Institue of Urban Affairs, 2015) (Patel & Padhya, 2014) (Singh & Sharma, 2016) (Selvakanmani, 2015) (Madakam & Ramaswamy, 2015) (Ministry of Urban Development, Government of India, 2016) (Indian Chamber of Commerce and Delloite, 2015)		

Source: Self Constructed

5   STOCK FLOW FOR VARIOUS SUB-SECTORS

The various factors for Smart city mission are depicted in Stock-flow structure. Identification of variables for smart city and generic model are modified to constitute the stock-flow model for smart city mission in Figure2 –Figure12. The variables are identified as capacity building and vulnerable variables.
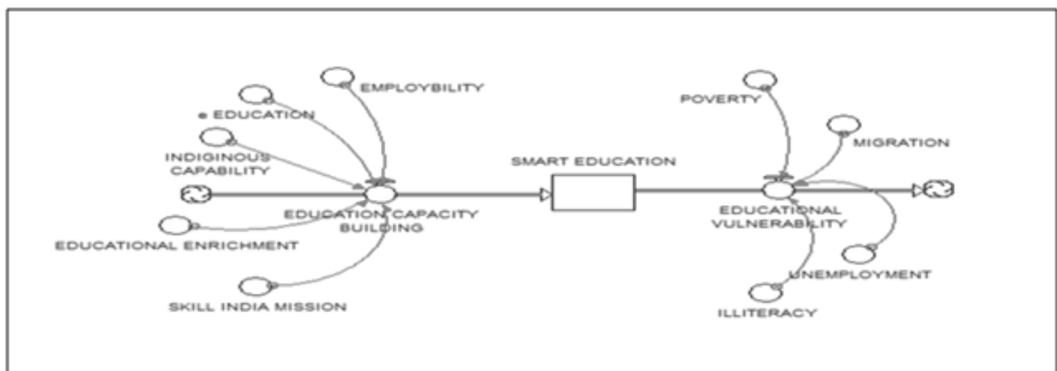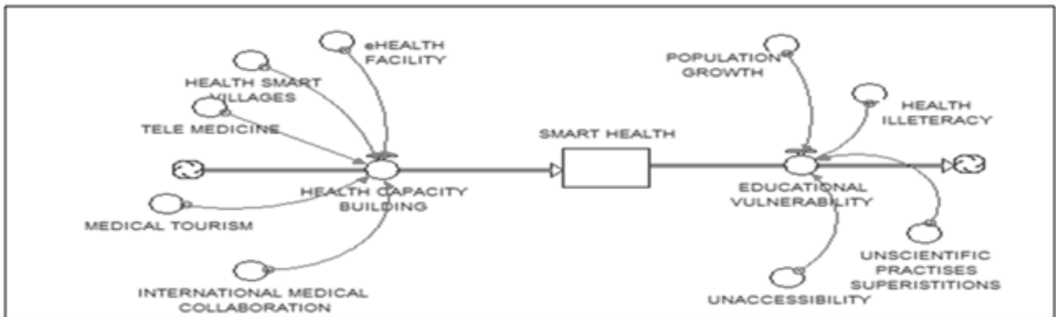

**Figure 2.** Sub-Sector: Smart Education

The Stock Flow structure for Sub-Sector: Smart Education consists of employability, e-education, indigenous capacity, educational enrichment and skill India mission as Capacity Building but the vulnerability are also co-exit simultaneously like poverty, migration, unemployment and illiteracy.


Figure 3. Sub-Sector: Smart Health

The Stock Flow structure for Sub-Sector: Smart Health consists of e health facility, health smart villages, tele-medicine, medical tourism and international medical collaborations as Capacity Building but the Vulnerability are also co-exit simultaneously like population growth, health illiteracy, unscientific practices, believe in superstitions and inaccessibility to medical aids.
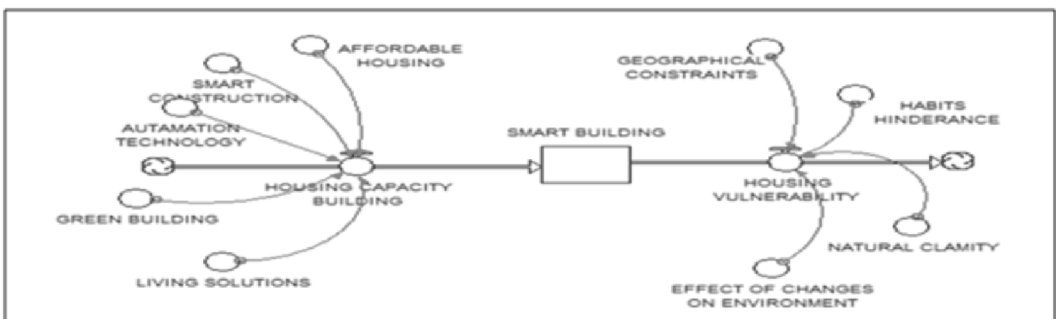
Figure 4. Sub-Sector: Smart Building

The Stock Flow structure for Sub-Sector: Smart Building consists of affordable housing, smart construction, automation technology, green building and living style solution as Capacity Building but the vulnerability are also co-exit simultaneously like geographical constraints, bad habits, natural calamity and effect of these smart changes on environment.
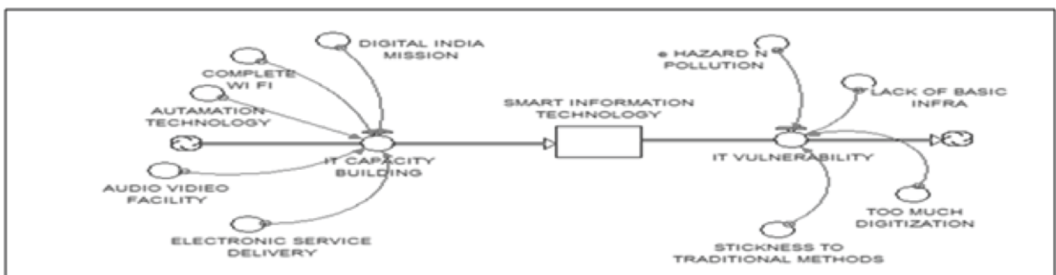

Figure 5. Sub-Sector: Smart Information Technology

The Stock Flow structure for Sub-Sector: Smart Information Technology consists of digital India mission, complete WI-FI, automation technology, audio-video facility and electronic service delivery as Capacity Building but the vulnerability are also co-exit simultaneously like-hazard and pollution, lack of basic infrastructure for digital India, too much digitization needed and habit of traditional methods of living.
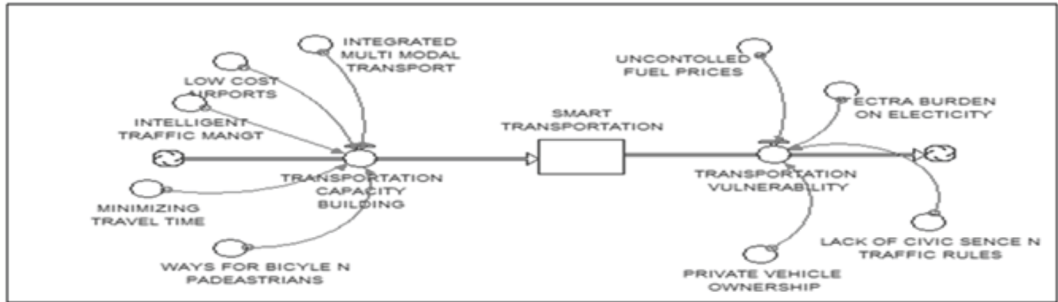

Figure 6. Sub-Sector: Smart Transportation

The Stock Flow structure for Sub-Sector: Smart Transportation consists of integrated multi modal transport, low cost airport, intelligent traffic management, minimizing travel time and parallel route for bicycle and pedestrians as Capacity Building but the vulnerability are also co-exit simultaneously like uncontrolled fuel prices, extra burden on electricity, lack of civic sense, lack of following traffic rules and private vehicle ownership.
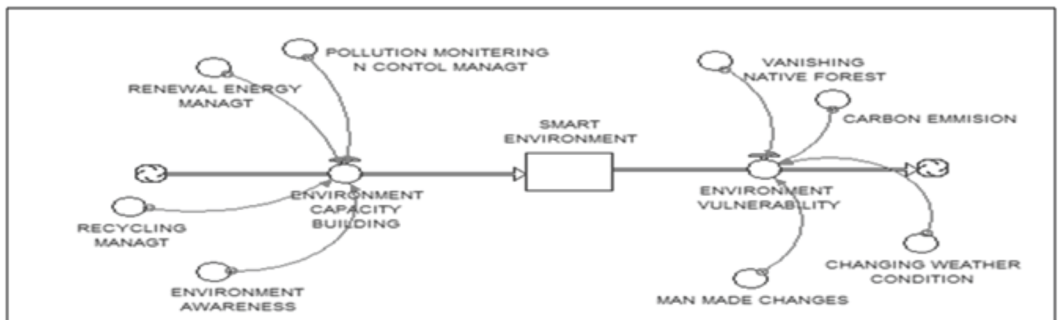

Figure 7. Sub-Sector: Smart Environment

The Stock Flow structure for Sub-Sector: Smart Environment consists of pollution monitoring and control management, renewal energy management, recycling management and creating environment awareness as Capacity Building but the vulnerability are also co-exit simultaneously like cutting of forest, carbon emission, changing weather condition and increase in man made changes that have adverse effect on environment.
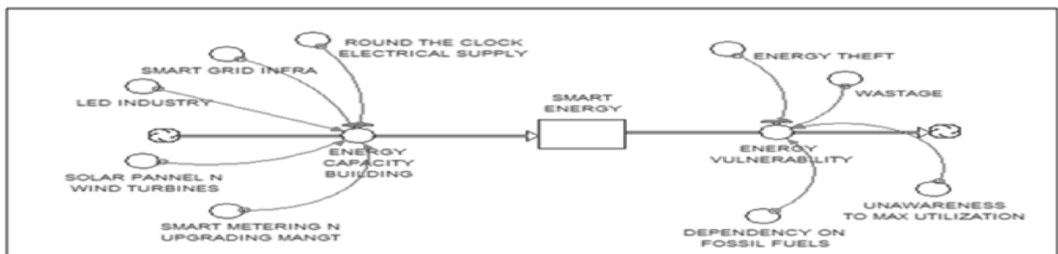

Figure 8. Sub-Sector: Smart Energy

The Stock Flow structure for Sub-Sector: Smart Energy consists of all-time electric supply, smart grid infrastructure, establishment and development of LED industry, establishing solar energy and wind turbines management system and smart metering and up gradation management as Capacity Building but the vulnerability are also co-exit simultaneously like energy theft, wastage of energy and fuel, unawareness of full exploitation of energy and dependency on fossil fuels.
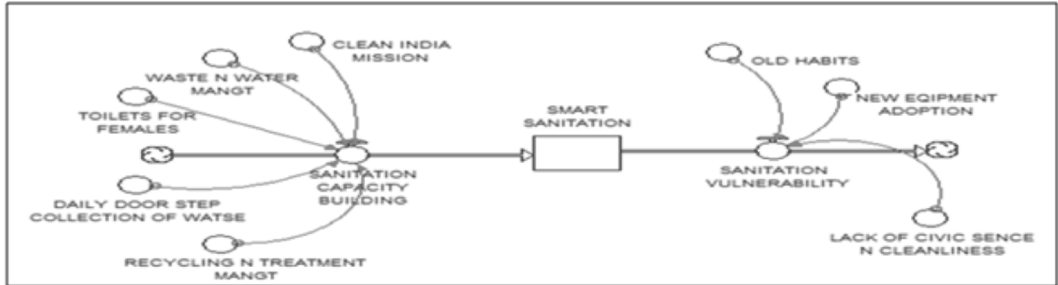
Figure 9. Sub-Sector: Smart Sanitation

The Stock Flow structure for Sub-Sector: Smart Sanitation consists of clean India Mission, waste and water management, toilets for females, daily door step collection of waste and recycling and treatment management as Capacity Building but the vulnerabilities are also co-exit simultaneously like old habits, new equipments adoption is slow and lack of civic sense and cleanliness.
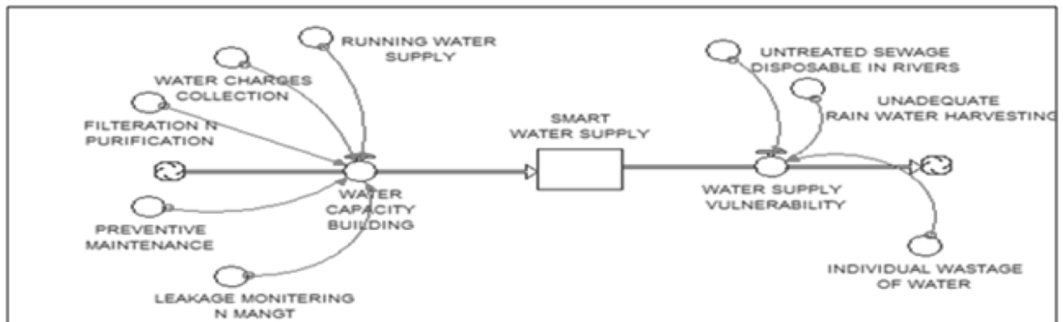
Figure 10. Sub-Sector: Smart Water Supply

The Stock Flow structure for Sub-Sector: Smart Water Supply consists of running water supply, water charges collection, filtration and purification, preventive maintenance and leakage monitoring and management as Capacity Building but the vulnerability are also co-exit simultaneously like untreated sewage disposable in rivers, inadequate rain water harvesting and no control on individual usage of water.
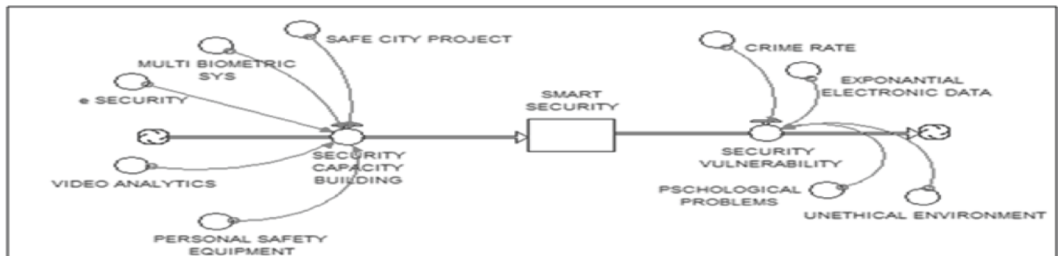
Figure 11. Sub-Sector: Smart Security

The Stock Flow structure for Sub-Sector: Smart Security consists of safe city project, multi biometric system, e-security, video analytics and personal safety equipments as Capacity Building but the vulnerabilities are also co-exit simultaneously like crime rate, exponential electronic data, psychological problems and unethical environment.
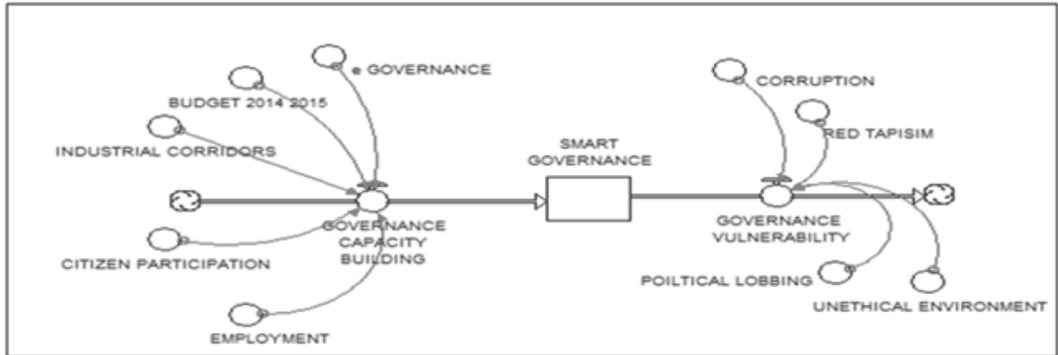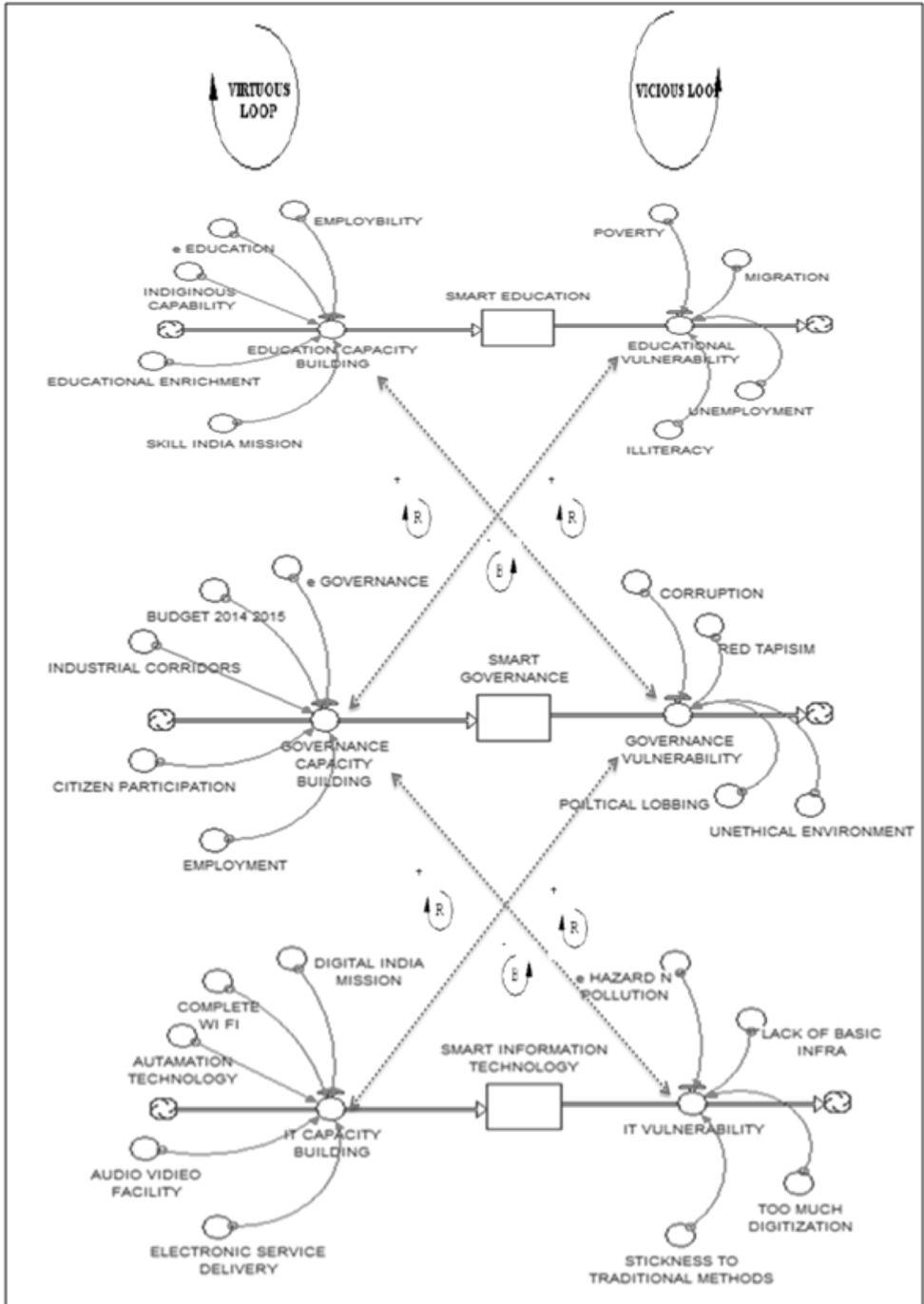

Figure 12. Sub-Sector: Smart Governance

The Stock Flow structure for Sub-Sector: Smart Governance consists of e-governance, budget allocation, industrial corridors, citizen partnership and employment as Capacity Building but the vulnerability are also co-exit simultaneously like corruption and political lobbing.

6   CAPACITY BUILDING VS. VULNERABILITIES MODEL:

These sub-sector models can again be adjoined and integrated though identified causal linkages distributing varying positive (reinforcing) and negative (balancing) influences. The stock flow model for capacity building v/s vulnerability in Figure13 is created in software: Stella Architect Trial version.

Figure 13. Integrated Stock-Flow Model for selected Sub-Sectors
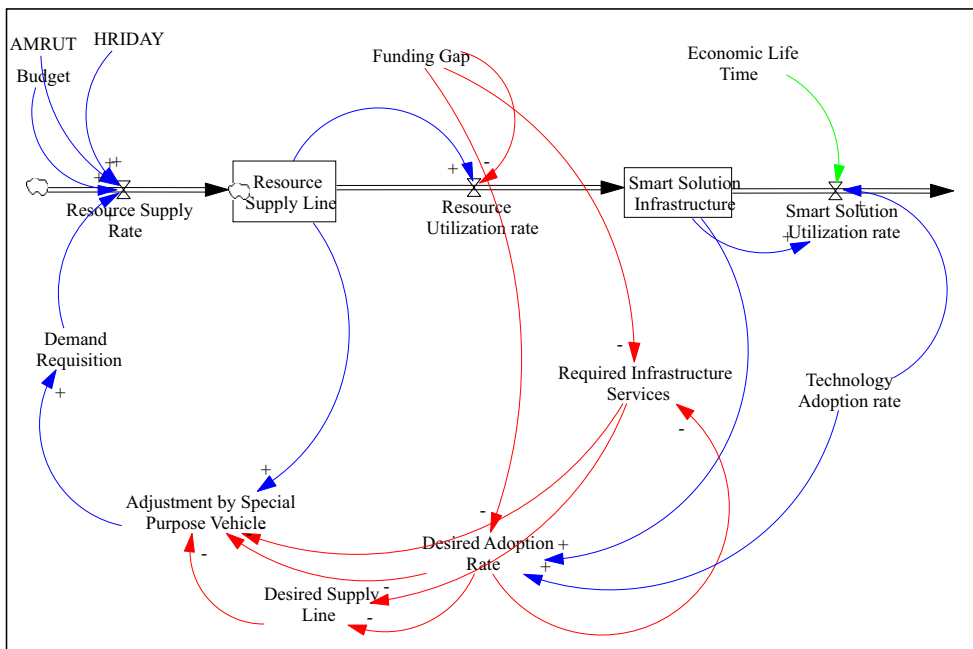Source: Self constructed in Stella Software

To understand this linkage through Dynamic Loop, the linkage is created among three Sub-sectors namely

•   Smart education

•   Smart Governance

•   Smart Information Technology

It can be seen in Figure13 that numerous cause are threats to this smart City Mission. With the help of Capacity Building factors can balance the vulnerabilities on the right side of the model. In the Loop Dynamics we can analyses virtuous causality which is set of causal effect that produces desirable effect for Smart City Mission (Capacity Building). And the other is vicious causality which is set of cause-effect that produces undesirable and Counter Balancing causality. It is also notable that Vulnerability of one Sub-Sector can be treated from the Capacity Building of other Sub-sector. This is again the interrelationship among the Sub-Sector which can easily be visualizes with the help of System Dynamics Approach.

7   THE CAUSAL LOOP CUM STOCK FLOW MODEL (BASE MODEL)

The Causal Loop cum Stock Flow Model is prepared through software: Vensim PLE for Windows version 6.3 registered for academic use only. The Causal Loop cum Stock Flow Model in Figure14 is created to understand how the adoption of smart city will happen. The model is depicting the holistic picture of the smart city construction and its adoption factors. The blue lines are showing the reinforcing effect and red color lines are showing balancing effect. The green line is having neutral effect as it is for time duration, but as the time increase it will definitely going to have reinforcing effect on this smart solution adoption system.

Figure 14. The Base Model, the Causal Loop cum Stock Flow Model.
Source: Self constructed in Vensim Software

For this two stocks are created Resource Supply Lines and Smart Solution Infrastructure. The resources enter the Smart City System from Resource Supply Rate and flows towards Smart Solution Utilization Rat. The various variables are detailed in following Table1.

Table1. Variable description for Base Model

S.No	Variable	Description	Source
1.	AMRUT: Atal Mission for Rejuvenation and Urban Transformation	Rs. 50,000 crore for five years from FY2015 -16 to FY2019-20	http://amrut.gov.in
2.	HRIDAY: National Heritage City Development and Augmentation Yojana	453.91 crore for scheme duration	http://hridayindia.in/budget -outlay
3.	Budget	INR70.6 billion (US$1.2 billion) for Smart Cities in Budget 2016	http://www.makeinindia. com
4.	Funding Gap	Slashed to Rs 9,000 crore for the next fiscal year, from Rs 9,559 crore in the current fiscal year (2016 - 2017).	http://www.financialexpres s.com/budget/economic-survey-2017/union-budget-2017-government-slashes-expenditure-on-amrut
5.	Economic Life Time	12 months; the funds are granted for every financial year	http://www.makeinindia. com
6.	Adjustment by special purpose vehicle	After every year there will be scrutiny whethe r funds are utilized properly or not also if any gap identified; it can be rectified.	http://www.makeinindia. com

Source: Adapted from various sources mentioned in the table itself

8 CAUSE TREE AND USE TREE

There is very interesting tool in Vensim called Use Tree and Cause Tree.

Table2. Defining Causes and Uses treeCauses Tree — creates a tree-type graphical representation showing the causes of the Workbench Variable.

Uses Tree — create a tree-type graphical representation showing the uses of the Workbench Variable.
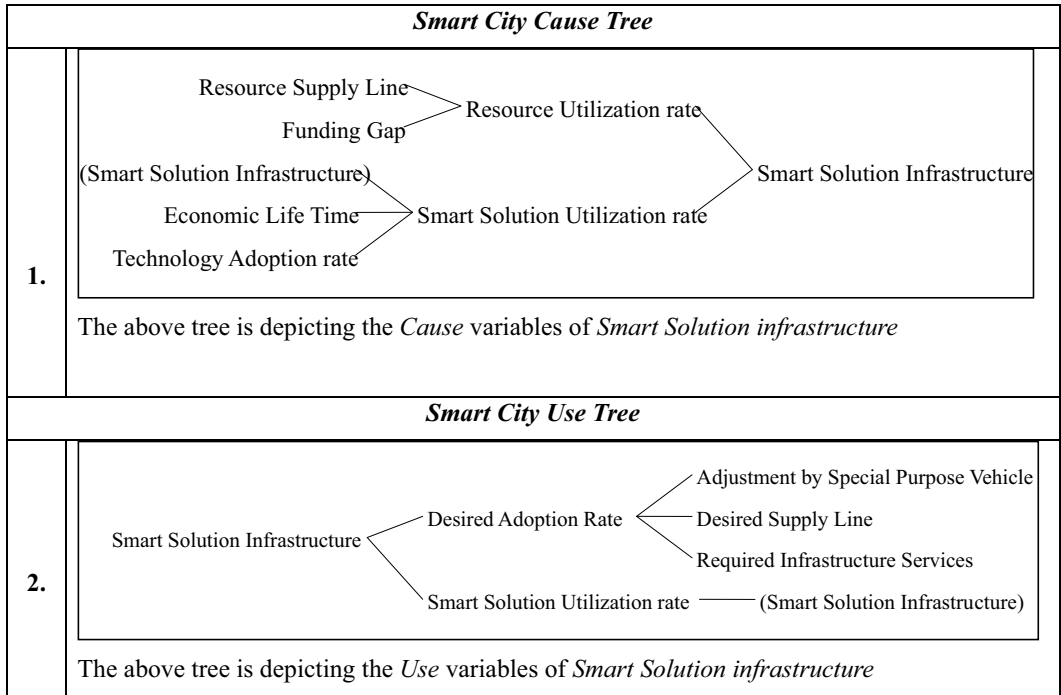
> **Causes Tree —** creates a tree-type graphical representation showing the causes of the Workbench Variable.
>
> **Uses Tree —** create a tree-type graphical representation showing the uses of the Workbench Variable.

Source: Adapted from Notes of Vensim Software
Note: Workbench is analogous to Vensim window.

Following models in Figure15 describe the cause and use tree of Smart Solution Infrastructure

	Smart City Cause Tree
1.	The above tree is depicting the *Cause* variables of *Smart Solution infrastructure*
	Smart City Use Tree
2.	The above tree is depicting the *Use* variables of *Smart Solution infrastructure*

Figure 15. Causes and Use Tree for Smart City
Source: Self constructed in Vensim Software

8   RESULT

The output of system Dynamics modeling is summarized as follows.

8.1 Generic Model

Through Smart City mission the government is going to give its citizen the adequate and assured water supply, electricity supply, will look after Sanitation & solid waste management, provide efficient urban mobility & transport for general public, proper and affordable housing, maximum digitalization& proper IT connectivity, e-Governance that include citizen participation and much more around Sustainable Environment And Systems. These infrastructure facilities are grouped in 11 heads. With the help of these 11 infrastructure heads, a Generic Model is developed which explains the whole working of Smart City Mission of Indian Government. The Generic model gives the basic understanding how the various Government body are related and collaborated to make the system of Smart city.

8.2 Sub-Sectors

Through System dynamics the infrastructural heads are captured in Stock Flow Model and named as Sub-Sectors. Various factors are identified which effects these Sub-Sectors and marked as 'Virtuous' - positive and 'Vicious' - negative factors.

8.3 Capacity Building V/s. Vulnerabilities Model

These sub-sector models can again be adjoined and integrated though identified causal linkages distributing varying positive (reinforcing) and negative (balancing) influences.

8.4 The Causal Loop cum Stock Flow Model

The Causal Loop cum Stock Flow Model is capturing the holistic picture of the smart city construction factors and its adoption factors.

8.5 The Cause Tree and use Tree

This Cause Tree is depicting the cause variables of Smart Solution infrastructure. The Use Tree is depicting the factors that use the Smart Solution Infrastructure or that are affected by Smart Solution Infrastructure.

9 IMPLICATIONS AND CONCLUSION

Through System Dynamics Approach we can easily analyze the Smart City Mission in following ways.

a) System Dynamics Approach helps in visualizing the factors affecting to Smart City Mission: Its best advantage is to have both types of factors Virtuous (Positively affecting the system) and Vicious (negatively affecting the system).

b) Providing a in-built solution system: Through Loop Dynamics it is very interesting to note that vulnerability of one Sub-sector can be treated with the help of another sub-sector's Capacity Building to counterbalance the negative effect in Smart City System.

c) Clear picture of System's working with various variables: With the help of Cause tree and Use tree any policy maker can better understand the directly affecting variables to adopt Smart City. Therefore can make better decision regarding what should be done through Special Purpose Vehicle to accelerate the adoption of Smart city.

d) For State and local Government: System Dynamics help State and local Government to fix the priorities or improve the vital services like health, safety, education etc without exceeding the budget through the simulation of model.

e) Clear vision and various priorities: Through the involvement of Sub-sectors the policy makers can easily priorities which sector needs immediate attention without harming the outcome of rest of the sector.

f) Continuous-learning Loop: System Dynamics serves a learning loop also as every event in itself is treated as case which saved for future reference as well as improving the further situations. In a advance practical approach these event or case can be used as input in creating Artificial Intelligence model for Smart City mission.

Further this model can be used to make a complete base model and simulation can be run with the help of simulation software. The current Model does not capture the behavioral aspect in adoption of Smart city and thus the further study can be extended to behavioral aspect also. Validation of the model can also be done through the data captured from any current working smart city

REFERENCES

Aizaj, R. (2016). Challenges of making Smart Cities in India. Paris, France: IFRI center for Asian Studies.

Bhattacharya, S., Rathi, S., Patro, S. A., & Tepa, N. (2015). Reconceptualising Smart Cities: A Reference Framework for India. Banglore, India: Center for Study of Science, Technology and Policy (CSTEP)..

Goel, S., & Nadimpalli, S. (2015). Modern Urbanization Challenges in setting up Smart Cities. New Delhi,India: Cushman &Wakefield .

Housing and Land Right Network. (2017). India's Smart Cities Mission: Smart for Whom? Cities for Whom? New Delhi, India: Housing and Land Right Network.

Indian Chamber of Commerce and Delloite. (2015). 100 Smart cities in India Facilitating implementation. UK: Deloitte Touche Tohmatsu Limited.

Jawaid, M. F., & Khan, S. A. (2015). Evaluating the need for Smart Cities in India. International Journal of Advance Research In Science And Engineering, IJARSE , 4 (1), 991-996.

JLL, India. (2013). Smart Cities An opportunity to transform Indian cities into global destinations. New Delhi, India: JLL.

Madakam, S., & Ramaswamy, R. (2015). 100 New Smart Cities - India's Smart Vision. NITIE, conference IEEE (pp. 1-5). Mumbai, India: IEEE.

Ministry of Urban Development, Government of India. (2016). The Smart City Challenge- stage 2. India: Ministry of Urban Development, Government of India.

National Institue of Urban Affairs. (2015). Exploratory Research on Smart Cities Theory ,Policy and Practise . New Delhi, India: National Institue of Urban Affairs.

Parishwad, O., & Singh, T. (2014). Analysing and Rating Smart City Development in India. Journal of Civil Engineering and Environmental Technology , 1 (6), 54-59.

Patel, P. R., & Padhya, H. (2014). Review Paper for Smart City. International Journal of Advance Research in Engineering ,Science and Technology , 1-6.

Ravi, S., Tomer, A., Bhatia, A., & Kane, J. (2016). Building Smart Cities in India Allahabad, Ajmer, and Visakhapatnam. Washington DC: Brookings India and Brookings Institution.

Sanjay Bhushan, D. T. (2013). System Dynamics Investigation of Capacity Building by Humanitarian Supply Chain in Disaster Prone Eco-Communities of India,working paper-416. IIMB,Research & Publications , 1-18.

Selvakanmani, S. (2015). Smart City – The Urban Intelligence of India. International Journal for Research in Applied Science & Engineering Technology (IJRASET) , 3 (6), 302-307.

Shukla, P. (2015). Smart Cities in India. New Delhi, India: The Energy and Resources Institute (TERI) .

Singh, K., & Sharma, N. (2016).

Smart Cities in India: Key areas and Challenges- Case study of Chandigarh City . International Journal in Management and Social Science , 4 (1), 386-396.

Smart City Council. (2017). In the Seam: From Smart City to Smart State. New Zealand: Smart City Council.

Sterman, J. (2000). Business Dynamics: Systems Thinking and Modelling for a Complex World. Irwin: McGraw-Hill.

United Nations Commission on Science and Technology for Development secretariat . (2016). Issues Paper On Smart Cities and Infrastructure. Budapest, Hungary : UNCTAD secretariat.

United Nations, Department of Economic and Social Affairs, Population Division. (2012). World Urbanization Prospects. New Year: United Nations.

Urban Development, Government of India. (2015). Smart City Mission Transformation. India: Ministry of Urban Development, Government of India.

Vision IAS. (2014). Smart Cities: An Answer to Problems of Urbanization in India. New Delhi, India: Vision IAS.

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

Web Reference

Cogitasia. (2015, Jan 15). modis-development-agenda-the-smart-city-concept. Retrieved Dec 2, 2015, from cogitasia.com: http://cogitasia.com/modis-development-agenda-the-smart-city-concept

Make in India,Government of India. (2015). Construction, Smart Cities. Retrieved Dec 2, 2015, from www.makeinindia.com: http://www.makeinindia.com/article/-/v/internet-of-things

Ministry of Urban Development, Government of India. (2015). /featuresofsmartcities. Retrieved Nov 30, 2015, from smartcities.gov.in: http://smartcities.gov.in/aboutsmartcities/featuresofsmartcities

Ministry of Urban Development, Government of India. (2015). Whatissmartcities. Retrieved Dec 3, 2015, from smartcities.gov.in: http://smartcities.gov.in/aboutsmartcities/Whatissmartcities

Smart Cities India 2016 exhibition and conference. (2015). Welcome to Smart Cities India 2016 exhibition and conference. Retrieved Dec 2, 2015, from www.smartcitiesindia.com: http://www.smartcitiesindia.com/Welcome to Smart Cities India 2016 exhibition and conference