Matrix for a smart city

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India has witnessed a rather rapid, and often unplanned, urbanization. At the same time, the country is expected to have the largest concentration of mega cities in the world by 2020. Thus development of and redesign (retro-fitting) of 'smart cities' has emerged as urgent requirements. However, the design parameters for a smart city are rarely defined, let alone quantified. A smart city, as a sustainable habitat, is characterized by many, often competing, parameters that require constrained optimization, which appears lacking in the current approach. A matrix for a smart city is proposed to argue that a comprehensive, sustained, integrated and critical R&D effort is required for the design and development of a smart, livable city.

With more than 60% of the population expected to live in urban habitats, there are growing concerns about developing sustainable urban habitats. It is, however, difficult to come across a clear, let alone quantitative, definition of a 'smart' city; the descriptions available in sources like *Wikepedia* are rather nebulous. In the absence of a clear definition of the characteristics and its targeted goals, development of smart cities may become more of an exercise of selling and marketing. However, while tools like digitalization may be essential for creating a smart city, there is need for a clear and target-oriented matrix to define a smart city; such a matrix will ensure that a city is truly smart and not merely digital.

There are well-known aspects like water quality and supply, energy supply and public transport; however, there are many other parameters that are not yet explicitly considered. Besides, the challenge for a smart city is to integrate various utilities to create a sustainable system without internal inconsistencies or conflicts; many of the demands for a smart city are indeed not always mutually compatible.

Disaster resilience

A city with its large population and infrastructure is prone to many hazards and disasters, both natural and man-made; a primary measure of a smart city is its resilience to these various hazards. Three parameters that can be used to quantify disaster resilience are disaster vulnerability index, disaster response time and disaster relief infrastructure. While electronic connectivity can help, physical measures are necessary to ensure disaster resilience. However, a very large city may generate extreme rainfall events, leading to flooding. There are also emerging hazards like the electromagnetic radiation from various sources in a large urban habitat that need to be considered.

Wellness and proactive disease control

A city with its large permanent and floating population is vulnerable to quick spread of diseases. Unlike in rural habitats, the healthcare paradigm in a city needs to be more proactive. One measure of wellness is the number of disease cases reported; for a smart city, this number (as percentage of population) should be comparable to a rural habitat. Naturally, wellness index will depend on the general urban environment rather than the number of hospitals or physicians.

Breathability of air

A large city, with its vehicular traffic and industrial exhaust, creates an urban air basin that becomes essentially an anomaly in the regional air quality. An index for breathability for an urban air basin can be easily defined, and has been estimated for Delhi, based on the number of hours for which pollutant concentrations are below permissible levels. This index, naturally depends on the number of vehicles on the streets; however, smart traffic planning and designs can significantly improve air quality. The air quality, however, does not depend on the total number of vehicles, but on the spatio-temporal distribution of traffic, road design and local climate.

Waste management

Clearly, efficient waste management, especially for a large city, is one of the biggest challenges of our times. However, mere transfer of wastes out of a city is not a smart idea. In addition to degradation of the neighbourhood, such measures are likely to create rural–urban conflicts. A smart city should have in-built waste conversion.

Hours of quality rest time

A city humming with sounds of expressways throughout the day and night may appear smart, but hardly a good place for a peaceful life. It may be smart to have flights leaving and arriving in the city all through the night using a smart air-traffic control system. Such a measure may improve connectivity and allow easy tourist traffic; however, such a city may eventually be too stressful to live in. An important parameter for a smart city is the hours of restful time.

Transport efficiency

In an ideal and smart city, the road network and infrastructure would be so designed as to optimize (minimize) the travel time. The transport efficiency can be measured as the time that an average commuter has to spend normalized to the time that would be taken for travelling at, say, 60 km/h with no stop.

Road safety

Road safety can be defined as the inverse of the number of road accidents. However, to create a smart city, the number, or at least the probability, of accidents needs to be related to the control variables available to the planners and the designers.

Climate compatibility

Cities can become sources of climate forcing in more ways than one. While vehicular emission from urban traffic is well recognized, the urban heat island is also an important parameter. Similarly, the urban albedo can induce radiative forcing. These can be quantified in terms of deviations from reference (rural) values. There is a growing appreciation of the role of urbanization in the evolution and dynamics of local weather, including mesoscale convective systems.

Carbon neutrality

One of the biggest challenges, until carbon-friendly technologies become practical, is avoiding mega cities from becoming carbon sources. The reduction of vehicular emission is a many-faceted problem, and parameters like idling time have been shown to play critical roles; at the same time, natural carbon sequestration can be incorporated to the urban ecology for a smart city.

Urban–rural interface

An emerging but critical design parameter for a mega city is going to be its urban–rural interface in all aspects, from livelihood to cultural. While it is more difficult to quantify such urban–rural interface, it is an important parameter in designing a smart, livable city. In particular, a smart city should be, and designed for, an active and interactive partner for a living habitat. A city is expected to be a centre for health, education and culture for the neighbouring locales; thus socio–economic–cultural connectivity between a city and its suburbs is an obvious parameter.

Technology horizon

Today we are aware of rapidly expanding technology horizon. Thus, the smartness itself is going to evolve as new technologies, lifestyles and constraints evolve; adequate flexibility for adopting new technologies should be part of a smart city.

Comprehensive design

In addition to the physico-economic parameters, aspects like crime detection, reporting and prevention must also be integrated in the design of a smart city. Similarly, a city, however smart, is dead without its cultural and emotional elements; thus design must also consider these aspects. Thus comprehensive R&D covering all aspects from technology to various laws and regulations is required.

Quantitative optimization

Quite clearly, selective measures will not provide a comprehensive solution. The final design of a smart city needs to be arrived at through a process of optimization, with an appropriate cost function and control variables. More important, however, is to identify and formulate constraints that express mutual compatibility; the problem is thus one of constrained optimization.

Approach

The involvement of many components from diverse disciplines implies that R&D for smart cities needs to be the primary mandate of an agency with multidisciplinary expertise; it cannot be achieved through uncoordinated, compartmental and sporadic efforts. Perhaps, a practical way of designing a smart city would be to develop one ab initio, without the constraints present in a unplanned (historical) city, as a functional prototype. Once all aspects have been tested and calibrated, the prototype model can be used to transform existing cities. At the same time, non-involvement of an appropriate R&D may lead to employment of measures that will have short-lived or even irreversible harmful effects.

Strategy

Given that the emerging megacities are going to define our future, the cost in developing such a prototype is well justified. However, this can be achieved in resource-smart ways through public–private partnership, as there are direct and indirect benefits. For example, in addition to the obvious economic values, such a prototype, with control variables for redesign, will be a sophisticated and versatile soft tool with international applications. In more futuristic applications, such tools can be used for designing space colonies.

There are clearly many other aspects and parameters for a smart city. This is not to suggest that technology adaptation for improved urban habitats should be postponed until one has all the answers. However, in parallel with the immediate measures, there is need for a more comprehensive definition and design of a smart city; the urgency requires immediate action.

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