DECISION SUPPORT SYSTEM FOR EVALUATING THE ENVIRONMENTAL SUSTAINABILITY OF A SMART CITY

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By

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CHAPTER 5

CONCLUSION AND FUTURE SCOPE

In the present study, a framework for ESSC has been proposed. The entire process of framework development is done in four steps: i. Selection of Indicators for Environmentally Sustainable Smart Cities, ii. Assigning weights for the indicators iii. Benchmarking of selected indicators and iv. Calculation of Smart City Environmental Sustainability Index (SCESI). The research contribution for the present research in the framework development has been elaborated in the next section.

5.1 Research Contributions

The foremost work for framework development is to identify a set of indicators that can be used to reflect the environmental sustainability of Smart Cities. The methodology adopted for indicator selection is as follows:

- The guidelines for Smart Cities Mission (SCM) of the Government of India include 14 environmental parameters: 4 under Solid Waste Management (A), 5 under Water Supply Management (B), 3 under Sewerage and Sanitation (C), and 1 each under Storm Water Drainage (D) and Ambient Environment Condition (E).
- These indicators are scrutinized on the criteria for appropriateness of an indicator, as suggested by World Bank Environment Development (WBED 2002).

Following observations has been made after screening process:

- Out of 14, 11 of the indicators (2 under category A. 5 under B, 3 under C and 1 under E) are found suitable, while 3 are considered inadequately defined in terms of clarity or objective evaluation.

In order to propose and plan Smart Cities as ESSC, a set of 20 additional indicators are screened from available literature related to sustainable cities across the world. The observations made are given below:

- Out of 20 additional indicators, only 16 could be found satisfying the requirements of appropriateness as an indicator, as per WBED (2002) criteria.
- When these 16 indicators are further subjected to evaluation on 7 criteria used by CITYkey Indicator program, only 13 (5 under category A, 2 under category B, 3 under category C, 1 under D and 2 under category E) are found fully satisfying the requirements as environmental indicators and 3 parameters are found to be inadequately defined.
- The sources of data under the Indian administrative setup and programs have also been identified.

Accordingly, a set of 24 indicators are finalized (7 for Solid Waste Management, 7 for Water Supply Management, 7 for Sewerage Sanitation and Storm water management, and 3 under Ambient Environment Condition), which can be used in the scientific framework development of ESSC.

After, finalization of indicators, weights are allocated. While all the four domains have been given equal weight, individual indicators within a domain have varying weights determined through Delphi technique, and following observations have been made.

- The analyses of the present study indicated that Degree of Segregation (w = 0.171) possesses the highest influence on SWM followed by Degree of scientific disposal of MSW (w = 0.165) and Extent of solid waste recovered (w = 0.163).

- In WSM domain the precedence indicators are Water Quality Monitoring (w = 0.167), Exploitation of underground water (w = 0.163) and Adequacy of Water Supply (w = 0.151).
- Coverage of toilets (w = 0.160), Collection efficiency of sewage network (w = 0.156) and Quality of treated sewage (w = 0.152) are the key indicators for SSS.
- The order of indicators according to their highest influence on AEC is Ambient air quality (w = 0.376), Ambient Sound Level (w = 0.325) and Ambient Surface water quality (w = 0.299).
- Cities should be encouraged to improve the performance in areas of high weight indicators to get better results on environmental sustainability.

Each of the selected indicators is benchmarked with respect to a standard value on a 0-100 scale and converted into an Indicator Score (IS) using its weight. The application of benchmarked indicator value to give indicator score (IS) may be quite handy for the cities to compare and judge its performance in specific environmental activity and direct the investment plan accordingly for better gains.

The 24 selected indicators have been used in a framework to calculate a Smart City Environmental Sustainability Index (SCESI) on a 0-100 increasing scale. The following points can be noted for index development:

- ISs are grouped to form Domain Index (DI) and DIs is used to give SCESI.
- While ISs reflect current achievement level in given specific area of environmental management with respect to benchmarked standard, DIs reflect the performance in different environmental domains, such as solid waste management, water supply etc.
- The SCESI gives an overall measure to understand and categorize the environmental sustainability of the city.

- SCESI is categorised in five Environmental Sustainability Categories: Critically Low: DI or SCESI <20; Poor: 20-40; Fair: 40-60; Good: 60-80; and Excellent: > 80
- SCESI can be used as a scientific tool to identify critical areas of intervention, investment and improvement.

The SCESI developed has been validated using the available secondary data in the public domain for five cities of India, namely, Delhi, Patna, Allahabad, Varanasi, and Bhubaneswar, which are currently being developed as part of SCM. Additionally, 10 more Indian cities are taken up from SCM list: Vishakhapatnam, Muzaffarpur, Surat, Bangalore, Indore, Jaipur, Agartala, Agra, Kanpur and Lucknow. Out of the 15 cities analysed, the result revealed that the only city which manages to secure good category (SCESI>60) of environmental sustainability is Indore. With respect to DI value, Surat is the only city to secure fair and above category in all the four domains. The analyses have been used to identify the domains under Poor (P) and Critically Low (CL) categories of environmental sustainability along with related three priority indicators which need urgent attention.

Due to resource and time constraints, the unavailability of data is a general phenomenon. For this purpose, sensitivity analysis is carried out to explore the importance of number of indicators included in the framework.

The SCESI developed in the present study is modelled to a software tool, DSS-ESSC and has following characteristics:

- It is user friendly and accessible on url smartcitydss.pythonanywhere.com.

- The developed tool can assist the policymakers and city managers in selecting the most appropriate environmental domain and respective indicators for investing fund and introducing planning actions.
- The tool can help to plan the phased intervention for addressing the current and future needs.
- The tool can suggest probable measures for improvement of each indicator which may be taken for uniformity of action in the given socio-economic conditions of a country.

Based on the results obtained and analyses done, DSS-ESSC developed in the present study for developing Environmentally Sustainable Smart Cities (ESSC) may serve as a powerful planning and decision tool. The study also helps in prioritizing the action plan related with environmental infrastructure development programs.

5.2 Research contribution to existing literature

An in-depth analysis of an extensive literature review indicates that significant development has been taken place in the direction of Smart Cities and Sustainable Cities separately. But, the integration of sustainability and smart cities notions in urban planning is a need for providing normative prescriptions for achieving the status of sustainable smart cities. Moreover, development of Smart Cities across the world has shown weak connectivity between initiatives of smartness and environmental sustainability. Thus, there is an urgent need to develop a smart city which is environmentally sustainable.

The following point gives the available information in this area and how the present research is one step ahead on the existing framework developed:

- The country needs to develop models for 'Sustainable Smart Cities' and further move to 'Environmentally Sustainable Smart Cities (ESSC)'. In the present research, the framework for ESSC has been presented.

- A holistic framework for ESSC needs to be developed. Moreover, no study has been conducted for Smart Cities in context to the Environmental Sustainability. As the framework developed till now does not use a holistic approach, a framework has been suggested, in the present study which will add an additional depth to the available research in this area. The review shows that there is ambiguity Vis to Vis intermixing/overlap of indicators which envelop a complexity and confusion to decision makers. The indicators selected in the present research are reliable, able to measure sustainability and smartness quotient, can convey clear picture and abide the criteria given by Governmental agencies. Further, benchmarking and weight allocation is done for selected indicators which will help in the monitoring and comparing the cities performance. Thus, a holistic framework has been suggested which will help in strategic planning and policy formulation in context to Smart Cities for investing funds, and implementing the action plan for development.
- The related work shows that DSS, IoT, and Big data applications related to Smart cities are used for the betterment of economic growth and standard of life without acknowledging environmental sustainability. DSS-ESSC developed, in the present research can be used as a decision-making tool keeping in view the coherent vision of developing Environmentally Sustainable Smart Cities.

5.3 Implications for practice

Smart cities initiative represents blooming of Information and Communications Technologies (ICT), driven by urbanization and industrialization. DSS-ESSC is developed to be used by organizations and policymakers involved in environmental sustainability projects. The software needs a lot of data for analyzing the current situation and predicting the priority area which needs to be addressed. Hence, data analytics, AI and IoT companies constitute the first group of target audience for the developed software. DSS-ESSC provides probable improvement measures for each domain and subsequent indicators to improve environmental sustainability of a smart city. Thus, the outcomes of the developed application will be beneficial for second group of target audience which comprises of policy-makers, city managers, MoUD, and municipalities to define and drive the planning action towards developing Environmentally Sustainable Smart Cities (ESSC) in India. The developed software will guide the investments and monitor the progressive environmental development of cities under Smart Cities Mission (SCM) in India.

5.4 Implication of research for policy formulation

The concept of Smart Cities is criticized worldwide due to a weak connectivity with the environmental sustainability quotient. Hence, policy framed for Smart Cities must include environmental sustainability as an included objective. In this direction, the model of 'Environmentally Sustainable Smart Cities (ESSC)' developed in the present research may serve as examples for smaller towns to follow and grow in future under the given socio-economic environment.

The United Nation Sustainable Development Goals (UNSDGs) is the most ambitious development agenda ever produced. The present research outcome is beneficial to achieve SDGs. Goal 6: Clean Water and Sanitation and Goal 11: Sustainable Cities and Communities and of UNSDG are most benefitted in the present research. On the basis of the index developed, a scientific basis for prioritization of indicators and probable measures can be incorporated. Moreover, DSS-ESSC can help in guiding and monitoring of investments to achieve the target of Goal 6 and 11 of UNSDG. Further, Big data gaps are the challenging task for UNSDGs monitoring. Intensified efforts are needed to fill those gaps so that a proper channelization of progress can be made. To support a rapid and effective response to a crisis, comprehensive and integrated data must be readily available. DSS-ESSC developed in the present research has the ability to support the unavailable data by some firsthand approximation value applicable in the given area for basic planning and design purposes. DSS- ESSC takes the values from such tables in the knowledge base to support the planner for initial calculations

5.5 Limitations

The present research work focussed on a framework for Environmentally Sustainable Smart Cities (ESSC) in context to developing countries, such as India. The indicators have been selected from the existing environmental parameters taken under SCM and literature concerning sustainable cities frameworks across the world. The results of the present study including indicator selection and weight allocation are highly influenced by opinion of the experts and other existing conditions, thus making the observations and interpretations possibly limited to Indian conditions and similar developing countries.

5.6 Scope of future studies

After rigorous analysis of the framework developed for Environmentally Sustainable Smart Cities (ESSC), following recommendations may be made for universal applicability:

- The approach may be extended and used for other countries as well by suitably modifying the indicators and their weights.
- Different methodology of assigning weight to indicators may be explored to refine the results.
- In the present study, all environmental domains [Solid Waste Management (SWM), Water Supply Management (WSM), Sewerage, Sewerage, Sanitation and

Storm water (SSS) management and Ambient Environment Condition (AEC)] have been given equal weights. The effect of varying weights to different domains can be explored.

- In the light of indicators selected for ESSC, other dimensions of sustainability, such as social and economic may also be suitably examined for cities under Smart City Mission and holistic DSS may be developed.

The software developed provides a method of scientific and transparent decision-making for investment and prioritizing the environmental domains for action than the conventional DSS.