

# Usage and Scope of ICT Applications for Sustainable Development of Urban Uttarakhand.



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**Abstract:** *Urban development have seen paradigm shift in the last few decades. With the shift, technological evolution with recent development in the field of wired and wireless information communication infrastructure are making cities more sustainable and smarter. Sustainable development objective is to transform our world by 2030, where the all inhabitants benefits from development efforts. The concept of sustainable development in an endeavor to eradicate and improve the issues such as poverty, greenhouse gas emission, climate change, health care service, nutritional requirement, clean energy and building peaceful and inclusive societies. In this paper, we tried to identify the technology with respect to ICT that will help the cities of Uttarakhand to reach the goals of sustainability. We used systematic review process from various research journals, articles and reports to identify potential ICT infrastructure that can support the cities of Uttarakhand to achieve the vision of sustainability. The policy makers and administrators can use this study for successful implementation of ICT technology in the cities of Uttarakhand.*

**Keywords :** Smart City, Sustainability, ICT, Software, Smart Grid, Urban.

## I. INTRODUCTION

Since prehistoric times the main objectives of an urban area was to create an ecosystem where the population living could sense they are secure and can improve their livelihood. Many years have gone by and various urban planning methodology have got there space. However, with ever increase in urbanization process has introduced our urban areas with problem and difficulties in sustaining the happiness and quality of life [1]. This sudden rise in ill planned urbanization causes housing shortages, poor service of drinking water and sanitation, no proper waste management and traffic congestion. It is also effecting our surrounding ecosystem threatening the healthy life of the population. It is predicted

that countries such as India will see a rise in urbanization in the near future with fifty percent of the population i.e approximately 80 crores population will reside in the urban areas by 2035. Population will move towards urban areas to seek economic opportunities and better quality of life [2]. Therefore, a planned urbanization is need of the hour to attain the sustainability targets as framed by United Nations. Thus, many city managers, mayors, policy makers, researchers and commissioners they have to brainstorm with new planning methodology and Information and communication technology can be used for redesigning process.

Information and communication technology (ICT) has several advantages to achieve sustainability goals of a city [3] [4]. According to Hiltry [5] ICT can help in achieving sustainability goals but the technology can always act in supporting role. It can improve product or service demand by replacement or stimulation. There are plans such as dematerialization and demobilization. Some researchers have debated that for attaining sustainability, we need to decouple physical resources into dematerialized resources into form of service [4] [6]. ICT will have software that denotes the services and the immaterial resources, that reflects the significance which could push the economy of the future [5]. Moreover, the recent development of ICT over the last decades, such as 4G, high performing low powered sensors and improved computing system. These developments is helping the researchers, policy makers and others in developing applications to achieve holistic sustainability. Cities also need to understand how investment in ICT can help them to achieve the sustainability goals.

The state of Uttarakhand is passing through the chain of transformations on all fronts to achieve the objectives of growth that must be sustain over a period. During the process of growth, the changes take place at all the fronts of development indicators such as economic, social, cultural, and urban [7]. These prompt demographic, social and environmental alterations have come along with severe challenges of population growth, environmental decay, unbalanced land and housing markets, poorly resourced public sectors units, lack of jobs in both formal/informal sectors and unhygienic living conditions. The cities in Uttarakhand is having population density per square km. is more than 8000 and more than fifty percent of road are characterized by on-road parking. Poor public transit system is adding to the level of pollution in the cities.

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Due to absence of affordable housing options large informal settlements are coming up, like in Dehradun twenty six percent of the population is presently residing in slums [8]. Travel time increase and improper use of urban transit is happening due unplanned development. This is decreasing the urban economy as a whole.

This paper focuses on a holistic view, regarding the technologies required for designing a sustainable and self-resilient city in Uttarakhand that will help us in reaching the sustainability targets. We will review to what impact ICT can have to support sustainable development and growth in cities through mapping of ICT applications and solutions.

### II. LITERATURE REVIEW

The swift urbanization is often taking toll on treasured biomes and lands for nourishing the demand of a city or a town. Also, if the urban population continue with the same consuming practices of resources without taking care the future needs, there will be serious economic, societal and environmental problems [2] [9].

International bodies and organizations have dedicated themselves on the practice of planned urbanization through sustainable manner. Due to which various definitions on sustainable urbanization have appeared in many literature. The following ones are some them:

- The President's Council of United States defined Sustainable Development through "1997 Report" terms "sustainable communities" as "communities that flourish because they build a mutually supportive, dynamic balance between social wellbeing, economic opportunity, and environmental quality" [10] [2].
- "a city where attainments in physical, social and economic development are made to last" as sustainable city [11].
- "Urban sustainability terms as a desirable state of urban settings that persists overtime" [2]. Issues and challenges such as the inclusive use of resources to give security for future generation comparison is done in the theory. Also protecting environment, reduction of fossil fuel resources usage, community self-sufficiency, and fulfillment of basic needs [12] [13].
- European Commission defined "urban sustainability" as the task to "solve both the problems experienced within cities and the problems caused by cities". The interpretation is that cities will have to resolve the challenges on their own.
- In paper by Drakakis-Smith, "well-balanced bond or correlation between the social, economic and environmental agents in society, to accomplish sustainable development" is the sustainable urbanization [14].
- UN habitat defined "sustainable urbanization" as a "never ending progression that associates social, environmental, political institutional and economic sustainability". It take along urban and rural areas synergy, covering the all sections of population from rural area to urban.

Potential of ICT is enabling an urban area to get a competitive outlook [15]. We are exploring different ICT way out for development of a sustainable city. Caragliu emphasis that the

blend of the ICT i.e use of software, IT infrastructure and intelligent sensors within important urban form and services i.e. municipality governance, healthcare, education, safety, housing, transit system and utility services creates a city sustainable [4].

ICT for administration purpose was the primary focus for the Climate group. They mentioned that urban local bodies can use data, information and telecommunication device purposefully to provide effective services to population and can help in monitoring their policies. It will also help to succeed and improve existing urban services, employ cross-sector alliance and development of new business model [16].

Pardo and Nam in their article suggested that different clusters divided into three scopes [17]: technology, people and institutions i.e. governance and plan. According to above researchers [17] six different categories of cities arises on technology aspect. That are "digital city, the intelligent city, the ubiquitous city, the wired city, the hybrid city and the information city". Also according to human dimension, the cities can be subdivided and defined in four groups. They are the "creative city, the learning city, the humane city and the knowledge city". Visions about ICT enabled sustainable cities comprises explanations for smart transit system, smart ecosystem, smart health care, smart energy, smart economy, smart utility service etc. [17] [4].

Maeng and Nedovic-Budic through their research [18] have collected descriptions of the ICT based city. They described cities in twelve ways which are "Electronic cottage; Technoburb, Wired City, Informational city, Intelligent city, Invisible city, Telecity, City of bits, E-topia, Digital places, Network cities and Ubiquitous city" [18][4].

For creating a sustainable ICT enabled cities the Intelligent Community Forum had listed down five successful factors. They had use the factors to find level of sustainability achieved of different cities each year [10][2]. Broadband connectivity, digital inclusion, knowledge workforce, innovation, marketing, and advocacy are success factors they had identified [19].

### III. RESEARCH METHODOLOGY

For the paper we conducted, a systematic scoping review of peer-reviewed literature. Primary focus was on ICT applications in urban development, sustainability and smart city applications for the state of Uttarakhand [20] [21] [22]. For review process, we took help of Arksey and O' Malley's systematic review framework for our study [20]. The central research question of the paper is "to identify the potential ICT applications which can enhance sustainable urban growth for the state of Uttarakhand". With respect to research, question journals and articles were searched from electronic databases of Science direct, Wiley online Library, EBSCO and JSTOR with systematic review procedure. Key terms like "sustainability", "sustainable development", "Urban development", "urban development of Uttarakhand", "smart city" and "ICT" were used to search for identifying key journals and articles.

Government reports of country and as well as for the state were considered for this study. Reports from NITI AAYOG planning and implementation body of India was especially helpful.

**IV. RESULTS**

During systematic review process, we identified some journals and articles referring to ICT applications and sustainable development. Then from government reports, we identified the challenges and issues for sustainable development of urban Uttarakhand. The primary challenges and issues identified are:

- a. Food Productivity
- b. Electricity Grid
- c. Transport system
- d. Healthcare system
- e. Water supply
- f. Waste management

With the identified challenges and issues, we found some ICT solutions from journals and articles that we got from systematic review and mapped. Table 1 provides us with the summary.

**Table- I: Challenges and issues mapped with ICT applications**

Challenges and Issues	ICT Applications	Authors and Year of publication
Food Productivity	Vertical farming and Aquaponics	Goddek,2015; Santos,2016; Anna, 2013;
Electricity Grid	Smart Grid	Bhattacharya, Rathi, Patro, & Tapa, 2015; Li, 2011; Yu, Wen, Yu, Wu, & Lü, 2014; Peng & Yan, 2011; Taylor, 2014;
Transport system	Usage of GIS and intelligent devices	Stimmel, 2015; Singh, Chani & Parida, 2014; Anna,2013; Van Audenhove, 2014; Heo, 2014;
Healthcare system	MEDiSN	Heo, 2014; Washburn, 2010; Kramers, 2014
Water supply	ICeWater	Fantozzi, 2014; Kramers, 2014
Waste management	Intelligent devices and communication	Babkano, Oyefolahan, Zubairu, & Etuk, 2020; Heo, 2014

**V. ICT FOR SUSTAINABLE URBAN CITIES IN UTTARAKHAND**

To find the ICT applications that can enhance the development of sustainable cities in Uttarakhand by continuous food supply, reduction of energy use in cities and providing 24 X 7 electricity supply, reduce congestion, efficient traffic system and reduce migration from Uttarakhand had been identified. We had also focused upon reduce, reuse and recycling of waste generated from urban area and improved healthcare system. This identification of ICT tools had been emerged through literature review of various journals, research papers, institutional reports and conference proceedings.

**A. Food Productivity**

To feed today and future population of cities using sustainable food supply is a need and challenge. Pressure on natural resources and climate with ever-growing urban population, global food security is vital. Cities of Uttarakhand will also face the same problem in the future. The state of Uttarakhand is having different climatic variance and present differing methodology for agriculture production in the plains and hilly terrains. While commercial agriculture is in practice only in the plains [23]. Subsistence farming is prevailing in the hilly region. The hills practice mixed cropping and while in the plains, it is single crops [24]. Irrigated land is easily seen in the plains, with over eighty-seven per cent land being irrigated as against a mere ten per cent in the hills according to government report [24]. In addition, the seed replacement rate for the plains stands at twenty per cent, while for the hills it is four per cent. Productivity differs significantly between the hills and plains. More than seventy-five percent of the inhabitants of Uttarakhand depends on agriculture for their livelihood in the state. The average size of holding in the state is around 0.98 hectare [23]. Therefore, for sustainable food supply in Uttarakhand, we will need zero waste and low energy technologies. Vertical farming and urban agriculture, if planned and employed suitably, can offer sustainable and pioneering solutions for successful food security. Sky Greens vertical farm in Singapore, is one of the example. Here vegetables grown in abandon houses, which are up to nine meters in height and covers three hectares. Commercial production for variety of vegetables started in May 2012. The aim is to increase production of vegetables while decreasing use of water, electricity, land and reducing contamination to the environment. Jack Ng designed it, for which he received “Singapore’s Ministry for National Development R&D Merit Award” in 2011. Food cannot be digitalized as dematerialization and demobilization is not possible. To get the knowledge of what we consume and how it affects the ecosystem, ICT can be implemented [4]. We can say, “ICT in combination with intelligent devices to tell us about the best possible choices from environmental and availability point of view”.



To urbanize food production aquaponics systems can also be a solution [25]. Socio-environmental benefits can be achieved through this system. Inhabited industrial buildings can be used for aquaponics farming. It benefits in re-establishing a viable action without putting pressure on use of land [26]. With this price of urban land can reduce and decrease exploitation abandoned structures that have a lower worth. It will also induce fresh food supply with no environmental issue and expensive storage related challenges. This will help in short supply chains, with sustainable growth for all. This farming system can be a way of job creation in cities. As cities are places are in proximity to ICT technologies and can help to create benefit of innovation. Aquaponics could help in development of new vertically integrated agricultural productivity system covering all the value chain. Value of aquaponics can also enhanced if artificial intelligence utilization by focusing on productivity and further decreasing the supply chain costs[25][26].

### B. Electricity Grid

For past few years, electricity markets and technologies is experiencing rapid growth and progress, with emphasis on accessibility and reliability. The need for purified air through renewable resources and for oil freedom through electric vehicles stimulating interest in development smart grids. Demand of electricity is rising over a decade in all major urban areas of Uttarakhand. Electricity consumption in Uttarakhand has grown more than five times in the last decade [27]. After separation from Uttar Pradesh, Uttarakhand's economy is on an upward growth path. This upward trend in economy have put pressure on Uttarakhand demand of electricity [27]. Urban areas of the state facing the stress for the states development vision. As per the Central Electricity Authority (CEA), the forecasted demand of the energy for Uttarakhand is 10480 GWh and the available energy is only 8363 GWh. The state's peak demand is 1600 MW and the available power is only of 1430 MW [27]. Frequent electricity cuts happening almost every day are disrupting normal life in Dehradun and other parts of the State. Even when the electricity is there, the low and unstable voltage is proving a problem.

Market-oriented reforms in electricity, growth in digital economy and concern of climate change is creating headache for policy makers. It brings in the need of quality electricity, affordable power, adequate power, clean power and environment protection. Thus, smart grid development should be encouraged and general grid to be upgraded. Smart grid operates with the latest data analytics and telecommunication tools to facilitate clean energy production, energy storage, to create smart control-measurement system infrastructure, demand-side management, energy conservation and distribution computerization to transmission grid intelligence [28][29]. The objective of smart grid is to meet the imminent power demands. The Smart Grids European Technology Platform quoted Smart Grid as "an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both, in order to efficiently deliver sustainable, economic and secure electricity supply" [30]. As defined by some researchers

Smart Grid is the modern grid machinery that is covering all the part of value chain in power sector [31][32][29].

### C. Transport System

In Dehradun capital of Uttarakhand, forty eight percent of roads are used for on street parking on both the sides. Poor public transit system has led to excessive movement of intermediate public transport named "Vikrams". They run without permits thus increasing the level of pollution in the city. There is significant amount of unplanned route planning and mismanagement for the vikrams and city buses [8][33]. Private operator through bus and IPT is operating the existing intra city public transport system in Dehradun. The private buses with fleet of 100 buses are running on 10 routes according to transport department report. Vikram is the main mode of public transit in the cities of Uttarakhand. These are being operated from the roadside, utilizing the road's right of way as a platform for departure and arrival stations. This is causing the delay of other vehicles movement on the road [34][35]. Scenario in other cities in the hills are far worst. There is no proper intra and intercity transport. These is leading to traffic congestion and tourism is being effected which is the main source of revenue for the state.

The planning of urban transit system need to move forward from our orthodox views about delivery. Wherever the transportation infrastructure is seen accommodating and encouraging the use non-motorized transport in planned manner, positive effects on public health and reduction in carbon footprint have been observed [34]. Further, research papers and reports have shown that lack of reasonably priced transportation creates inequity, decreased contact to education, and fewer leisure amenities for all inhabitants [4]. In addition, if we can integrate electric vehicles fueled by renewable energy can decrease the pollution and carbon footprint level of a city. Therefore, there is a need to create awareness within the population if we want to see a positive impact. So If we believe that smart technologies helps in resource sustainability, there may be no extra impactful in improving public health outcomes.

Challenges in urban transportation planning with ICT applications are traffic congestion mitigation with geographical information system, equipping highways and urban roads with intelligent devices like transducers, sensors, and radio frequency identification device and global positioning system technology in vehicles [4]. Data and information on immediate basis can help existing setup to improve and it can also help to build out new public transport mode [34]. At global platform, institutions and policy makers have been cooperating to improve transport infrastructure. The European Union has been the most purposeful about really creating a unified structure of improving transport planning and infrastructure. The European union opinions that transportation infrastructure development must take support of smart technology for advanced synchronization in planning and implementation process with a good service model [36].

The significant impact for transportation-related ICT technology is to aid create sustainable urban transit. Thus supporting the control of movement, speed and carbon footprint of traffic of urban roads. An extensive review of study highlights that transport speed and volume are the primary parameters that is enhancing congestion and crashes. Also increasing the carbon footprints of a city. In addition, it is seen that pedestrian related accidents is increasing due to speed and volume of traffic. Much of this influence or urban street landscape design.

The movement of traffic can be optimized through upgraded control system, and overhauling present transport network for smooth connectivity and it will offer more route choices to the population [34]. The technology with analytics applications can play important role in decreasing the above-mentioned issues and challenges. This include sensors, real time camera viewing; mobile data; internet of things, ZIGBEE, and GPS technologies. Data of vehicle individualities such as speed, length, and class will be easily collected. With this data redesigning urban transit landscape is possible [1][34][36].

#### D. Health care system

Medical centres in the Uttarakhand are dogged by a shortage of work force, inefficient equipment in the operating theatre and deficient number of labour rooms. The problem of a severe shortage of doctors in Uttarakhand is a very real one, largely because of a reluctance to serve in remote hilly areas. Uttarakhand is grappling with the convenience problem. Expert personnel are unwilling to travel and work in remote areas of the state due to poor transportation and infrastructure. The population in the state is scattered and thus the construction of more sub-centres and primary health centres is required.

Automation in the patient observing process in health centers, calamity or epidemic scenes, can balance the workload of healthcare staff. The value of care can also considerably rise. The MEDiSN system is a real-time physiological data gathering and information monitoring system can be used for such purposes [1]. It consists of an 802.15.4-based network and mobile physiological data monitors. MEDiSN has three different urban medical and healthcare settings. Pilot study shown effects in practical clinical sensing system deployments and highlighted the usefulness of wireless information systems to a healthcare staff [1] [19]. In MEDiSN, the data reliability and validity was the utmost challenge, and this was resolved by carefully analyzing the settings used by introducing a trustworthy transmission network to the initial system form [4]. As, MEDiSN use 802.15.4 radio transmission network, this can be united with other mobile instruments. So starting healthcare uses in diverse situations will not be an issue [1]. If there is, an increase in use of MEDiSN along with comprehensive pilot studies information of a larger population we may observe success on a scale that has not been seen earlier [4]. Naturally, such technology can lead to improve the health of its inhabitants, thus, increasing the worth of healthcare in densely populated urban area like that of Uttarakhand [1].

#### E. Water Supply

In-efficient operation, ageing pipelines, wastage of water and ensuring twenty hours quality water supply are some of the issues troubling the water supply in urban Uttarakhand [37]. These issues and challenges have pressed the concerned participants like the service providers, policy makers and private entities concern in improving the water supply [37]. The stakeholders rarely communicate and collaborate. Thus creating difficulty for themselves to realize the improvements required for the overall system redevelopment [4] [37]. Hence, the potential for optimization in water supply becomes a challenge. In order to address this issue ICT intervention is required.

One ICT solution conceptualized by European Union is "ICT Solutions for Efficient Water Resources Management (ICeWater)". The objective was to improve the operation and quality of drinking water supply to inhabitants in urban areas by regulating the supply of water to the actual usage (Fantozzi et al., 2014). This will also decrease energy consumption by integrating smart-grid technology. Water spilling can also be in control through smart leak detection. Wireless sensor technology is being used in the system for water flow measurement. It provides a decision support system for the water services so that demand and supply trends can be analyzed on real-time basis. Prediction of leakage is possible with help of statistical data analytics so that water supply system damages can be resolved before they arise [4][37]. With help of ICT data measurement module, decision support systems will help in optimizing the water supply operation. The demand and consumption pattern statistics can be accessed online to the relevant participants. It will allow dynamic pricing schemes to customers. This helps in conserving our natural resources [37]. Services such as predictive maintenance, leakage detection and locating will help in reduce wastage of water. New networking concepts are required for better information flow in order to reach the objective of creating sustainable water management [37] [38]. The data gathered with this type of service allows information gathering on consumer water usage. In addition, to progress in the effectiveness of the water management new metering and dynamic pricing schemes should be initiated [37].

#### F. Waste Management

The ICT-Based Waste Management is a layout that works on ICT applications in urban waste disposal on point-to-point basis. That is from point of source to final dumping point either to the landfill; waste to energy plant or to the recycling centers. The process starts from the household point. The households will be able to communicate through their mobile services requesting the waste disposal service provider to dispose their waste. Fee will be charged from the household for the waste disposal services in the mentioned scenario [39]. After receiving the request, the service provider decides the identity and location of each appeal and based on that, allocates a particular waste collector to a particular household to collect the waste. The waste collectors are recorded adhoc staffs of the waste management office.

The service provider will assign the collectors to the appropriate resident based on their location from the household through an application software [39][40].

The waste collected is dumped in the nearby ward dumpster. Organic waste and the other for inorganic/metallic waste are dumped into two separate compartments within the dumpster. Responsibility of segregating waste into plastic or otherwise and dump them correctly in to the dumpster is with the collector [39] [41]. Data on weight or volume of waste collected by service providers from the sensors attached within the dumpster.

With help of this intelligent device the service providers is able to monitor that dumpster's waste level. When level will be full, the movement of waste to disposable site will take place. Based on the location of dumpsters which can be tagged with global positioning system, the application software will assign appropriate waste carriers to empty the dumpsters into the disposal site. The waste carriers are similar to the collectors but have vehicles to empty roll-ons/dumpsters with the waste of households. With their records at the service providers, waste carriers will be assigned dumpsters that are closer to their locations or even to multiple dumpsters if there are some filled ones in the same locality [39] [42].

### VI. CHALLENGES IN ICT INTEGRATION

There are challenges in implementing the above ICT applications ICT applications in present urban scenario of Uttarakhand. Yes, it can use the present available technology and infrastructure but challenge will rise while integrating it. Some of challenges of integration that have been observed are [1] [43][44][45]:

- a. Cloud interfaces and infrastructure at urban level
- b. Standardizing network scalability
- c. Addressing the devices that will be used
- d. Network and system interoperability
- e. Network management
- f. Cyber security
- g. Sensing devices modalities

### VII. SUMMARY AND WAY FORWARD

Urban areas shift from old form to sustainable impact is a trend that we cannot ignore. The cities globally and some cities of India are using ICT for creating sustainable urban ecosystem. Through this paper, we tried to reflect the idea of an ICT supported and enabled sustainable city with all intended and planned for a single rational goal—the dream hope and happiness for the urban population of Uttarakhand. Cities of Uttarakhand can also follow some of the best practices being used in the other cities of India.

However, we will continue to debate that creating an ICT enabled urban ecosystem is tougher than just putting the above-mentioned technologies, developments and infrastructure together like a riddle. Rather, we tried to recognize the technology development and their acceptance gaps in ICT implementation. We also introduced some issues and challenges that are so far being tried but mitigation not achieved. Such issues and challenges comprise of the

operational integration of various ICT application systems with different telecommunication techniques, and assuring confidentiality of information created for different purposes. Likewise, an important challenge that researchers often do not see is the variance in opportunities and information of the state-of-the-art technologies with the policy makers. Maintaining a good network of communication between the two groups is the way to decrease the differences. This will help in reduce the gap and create more opportunities to appraise the performance of such systems in real-life environments for further improvements to sustainable urban growth. With these efforts, our vision of escaping from unsustainable city to a sustainable city may be in close reach.

### VIII. CONCLUSION

Through this paper, we presented the available ICT applications related to create sustainable urban ecosystem for the cities of Uttarakhand. The researcher's objective was identify the scope of ICT applications most suited to resolve the issues related to urban Uttarakhand which is hampering the state's sustainable growth. ICT applications suited for urban Uttarakhand were identified through systematic review of literatures available. The literature reviewed are related to smart applications, sustainable development of urban areas and ICT applications at a city level. The paper has elaborated on suited ICT applications with respect to implementation, challenges, usage, control and communication system. In conclusion, we want to say the administrators and policy makers of the state can approach the manufacturers of the ICT applications identified and create partnership to attain the sustainable growth of urban Uttarakhand.

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