SMART ACCESSIBILITY 2020

The Fifth International Conference on Universal Accessibility in the Internet of Things and Smart Environments

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SMART ACCESSIBILITY 2020 Editors

Sandra Sendra, University of Granada, Spain
Lasse Berntzen, University College of Southeast Norway, Norway
Daniela Marghitu, Auburn University - Auburn, USA

SMART ACCESSIBILITY 2020

Forward

The Fifth International Conference on Universal Accessibility in the Internet of Things and Smart Environments (SMART ACCESIBILITY 2020) covered topics such as accessibility by design, digital inclusion, accessibility devices and applications

There are several similar definitions for universal accessibility, such as design for all, universal design, inclusive design, accessible design, and barrier free design. These and similar approaches are relevant to this conference. The focus will be on methods, tools, techniques and applications for human diversity, social inclusion and equality, enabling all people to have equal opportunities and to participate in the information society.

We believe that the SMART ACCESIBILITY 2020 contributions offered a large panel of solutions to key problems in areas of accessibility.

We take here the opportunity to warmly thank all the members of the SMART ACCESIBILITY 2020 technical program committee as well as the numerous reviewers. The creation of such a broad and high quality conference program would not have been possible without their involvement. We also kindly thank all the authors that dedicated much of their time and efforts to contribute to the SMART ACCESIBILITY 2020. We truly believe that thanks to all these efforts, the final conference program consists of top quality contributions.

This event could also not have been a reality without the support of many individuals, organizations and sponsors. In addition, we also gratefully thank the members of the SMART ACCESIBILITY 2020 organizing committee for their help in handling the logistics and for their work that is making this professional meeting a success.

We hope the SMART ACCESIBILITY 2020 was a successful international forum for the exchange of ideas and results between academia and industry and to promote further progress in the universal accessibility field.

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Table of Contents

A Universally Designed and Accessible Indoor Air Quality Monitoring and Warning System

Tamugri King Asa Musoro
OsloMet - Oslo Metropolitan University
Oslo, Norway
e-mail: tamugri.mu@outlook.com

Raju Shrestha
OsloMet - Oslo Metropolitan University
Oslo, Norway
e-mail: raju.shrestha@oslomet.no

Abstract **– A Universal Design (UD) approach to develop technology for combating health problems due to Indoor Air Pollution (IAP) from burning solid fuels leads to better accessibility and inclusivity. This concept guided the design and implementation of the prototype designated as Universally Designed and Accessible Indoor Air Quality Monitoring and Warning System (UD-IAQMWS). The system is a network of sensor-nodes that collaboratively check the Indoor Air Quality (IAQ) and notify users by means of a three-color code, auditory, visual and tactile notifications, of changes in the air quality. The notifications are designed to serve visually and hearing impaired for improved accessibility. Data from the World Health Organization (WHO), Laboratory tests, field interview data from potential users, and the use of personas in system evaluation, address user disabilities to render the system inclusive. The integration of Human-Computer Interaction (HCI), as well as a special feature (concept) specifically designed to prevent child exposure to IAP for increase accessibility, are a few innovative aspects of the system.**

Keywords - Universal Design; Accessibility; HCI; Solid fuel; Indoor Air Quality; Indoor Air Pollution; Sensor Network; UD-IAQMWS.

I. INTRODUCTION

Many systems have been invented, designed and developed to combat Household Air Pollution (HAP), a global health problem as declared in the WHO Factsheet 292, (updated May 2018). This Factsheet shows a high mortality and morbidity rate of about 3.8 million annual deaths due to HAP [1][2]. Good Indoor Air Quality (IAQ) is essential for households dependent on solid fuels for sustenance. However, some smoke detectors and fire alarms are audible but not visual, hence not very practical for hearing impaired users [5]. How then does a smoke detector address the needs of a blind or deaf person? Could there be a better way to design such a system so that it is accessible to users with disabilities or impairments?

Indoor Air Pollution (IAP) as a result of cooking with solid fuels accounts for most health-related issues, of which respiratory diseases are responsible for the high worldwide morbidity and mortality. Many WHO studies and publications confirm indoor air pollution as one of the major contributors to the causes of pneumonia, bronchitis and other chronic obstructive pulmonary diseases worldwide [1]. Also, from Figure 1, it can be observed that the pneumonia rate is rather high in children with increased exposure to carbon monoxide. That is, hypoxemic cases rise to about 25 and above for levels higher than 3 ppms, and more than 50 children are affected, for CO levels exceeding 3 ppms.

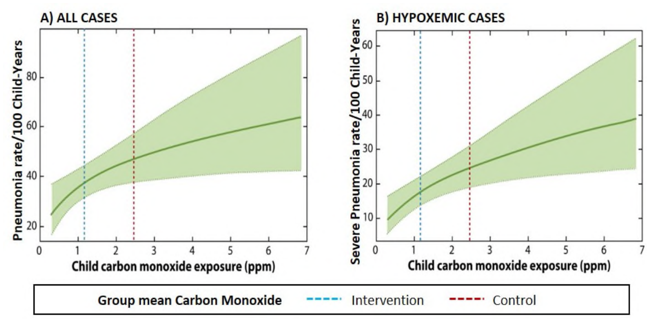

Figure 1. Physician-diagnosed pneumonia due to Carbon Monoxide (CO) exposure [2].

Any solution proposed as a means of solving or preventing some of these health problems must be without impediments. Otherwise, these would have to be studied, understood and overcome. Perhaps through research, development, and innovation, a proper technological solution can be found. This would lead to designing a system that monitors IAQ in homes using solid fuels for cooking or heating as a preventive measure to any resulting health hazards.

The Universally Designed and Accessible Indoor Air Quality Monitoring and Warning System (UD-IAQMWS) we propose is a universally designed IAQ sensor warning system integrating sensor network and Human-Computer Interaction (HCI) that offers a more accessible innovative approach to detect pollutants. A network of sensor-nodes checks IAQ and provides visual, auditory and tactile warning signals to any user or users exposed to IAP or HAP [2][4]. The system is mainly composed of the hardware unit and the mobile app that enables the system to connect to a smartphone via Bluetooth. The power and the potential of the mobile platform are harnessed for accessibility and inclusivity. The concept of UD-IAQMWS came as a research and development project partly sponsored by the Mozambique-Norway Accessibility Partnership (MAP) that was carried out in Mozambique. This paper presents a simplistic view into an otherwise complex project, with the hope of reaching the widest possible audience.

The goal of the project is to research, design and develop an IAQ sensor and warning system for homes using solid fuels as the main energy source. Its deployment where the risk for harmful emission could be hazardous to human health must provide an effective preventive solution. The system could hence be described as a Sense-Detect-Warn system, easy to use and maintain. The design and development are in accordance with the Universal Design (UD) principles. UD is defined as the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design [3]. The system also encompasses accessibility, inclusivity and the integration of a sensor network with HCI [4].

Through research, experiments, measurements, and testing, pollutant properties and the threshold for detection were determined. Built to specification, the system must be able to detect the pollutants given their characteristics. For example, an odorless and colorless gas, such as CO, is a dangerous gas to breathe in. It is about the same density as air, it is emitted from burning solid fuels and, if concentrated at 12.5% to 74.5%, it would explode. However, at concentrations of about 75%, it will burn in the air if ignited and can thus be used as fuel [5]. To detect CO, a standard sensor must be used to calibrate the sensor intended for use to keep all detection levels and thresholds on a par.

After the introduction section, Section II discusses related works. The research methodology is described in Section III. Section IV presents the design and development process. Section V describes user testing. Section VI presents the results and the results are evaluated and discussed in Section VII. Finally, Section VIII concludes the paper.

II. RELATED WORKS

IAP has been a serious problem ever since human beings started cooking inside their homes instead of out in the open, and it has health as well as economic and environmental impact.

A. *Health effects*

Research by the WHO shows severe health outcomes due to emissions from indoor cooking. WHO states on its website in Factsheet number 313, updated September 2016, the following summarized points [6]. In 2014, 92% of the world population was living in places where the WHO air quality guidelines levels were not met [6][7]. Three billion people are also at risk due to exposure to indoor pollution from using biomass and coal [7][8].

In poorer communities, the way of life requires men to be out fending for their families. Therefore, women and children who spend more time home, especially in the kitchen, cooking, are the most affected by HAP [9]. For example, the 95,000 Nigerian annual deaths related to cooking with solid fuels, include children below 5 years. The Nigeria Demographic and Health Surveys (NDHS) 2003-2013 study also indicates an about 0.8%, 42.9%, and 36.3% of neonatal, post-neonatal, and child deaths respectively [10].

B. *Economic and environmental impact*

Energy potential decreases with poverty, therefore, reliance on solid fuels often leads to the environmental quagmire of deforestation. A 2011 World Bank project reports health and environmental benefits from the promotion and use of cooking stoves. Improvements in the efficiency of the stove would greatly reduce emissions, such as carbon monoxide (CO) and carbon dioxide (CO_2) [9].

The impact of burning biomass is often stated as a global environmental problem that affects poorer countries and hence poor people [2]. In the United Kingdom, solid fuel emissions were 24.7 $\mu g/m^3$/ppm relative to CO for Manchester [11]. In 2000, household use of coal and biomass in India and China produced 86% of their combined Black Carbon (BC) emissions [12].

C. *Available solutions*

Conventional, technological and innovative solutions are the different approaches to limiting HAP, reducing health hazards and improving IAQ. Conventional solutions involve taking preventive measures without the use of any advanced technology to stop emissions from the source. Essentially, indoor pollution is tackled by rudimentary means and improvisation.

Studies show that applying WHO guidelines for source control significantly reduces risks in the health outcomes for children and adults by 20 to 50 percent [13]. According to the United States Environmental Protection (EPA), the basic techniques (conventional solutions) for an improved IAQ must involve source control, improved ventilation and air cleaners. Also, homes must be designed to include external and or well-ventilated kitchens [14]. In summary, controlling the source of indoor pollution is like closing the tap, thereby stopping the flow [14][15].

Technology and innovation centered sense-and-detect systems are arguably the most effective solutions for combating HAP. Detection of indoor pollutants is a preventive measure and detection devices include smoke detectors, such as the one developed by Loepfe et al. [16], which detects the presence of smoke from two spectrally different scattered light measurements using the principle of diffraction.

Yang's Wireless Sensor Networks (WSNs) harness a cluster of autonomous nodes that are commanded to wirelessly communicate with the controlling infrastructure whose environmental condition is being monitored [17]. Jung and Kim [18] collaboratively developed a system that incorporates a sensor network into an air conditioning and ventilation system to monitor and maintain healthy levels of IAQ. The system sounds an alarm when the measured concentrations of pollutants, such as CO and CO_2, exceed healthy levels.

Of the many commercially available systems developed to deal with HAP, most are designed for detection and warning. These systems vary in design, size, type, and technology from the simplest to the most sophisticated.

However, despite innovation and advances in technology, these detection systems have the following limitations in common:

- ***Chirping***: It is common for most smoke detectors to produce a chirping noise when the battery power is low or runs out. Many users would remove the battery when chirping noise becomes a nuisance. Due to human negligence, users may fail to replace the batteries thereby exposing the entire household to the effects of pollution and its consequences.
- ***Loud Alarms***: Many home smoke detectors have loud noisy alarms or sirens that may be a nuisance to users. Some impatient users who cannot bear the noise would then disconnect the device thereby risking their health and possibly death from pollution.
- ***Limited notification modality***: Most devices or systems offer mostly auditory notification in the form of an alarm, typically in the form of a loud alarm and a blinking light.
- ***Single sensor***: Most of the systems use a single sensor, whose sensitivity largely depends on sensor positioning. If the sensor is too far from the source, detection could occur when pollution levels are already too high. On the other hand, false alarms might also be frequent if it is placed too close to a heated or steaming source. Therefore, the sensitivity of such systems would largely depend on the position of the sensor.
- ***Lack of UD***: To our knowledge, none of the existing systems took into account the UD and accessibility aspects. One system described as a Tactile and Visual Smoke Detector System, as per patent [26], is among a few existing accessible systems. It is a multi-feedback fire alarm that includes one or more wearable (bracelet-style) signal detection and notification devices. Users are notified even when not in proximity of the detection unit. The wearable delivers different lighting and vibration patterns and alarm signals depending on the risk of pollution and informs hearing-impaired users of the threat type. However, the audible notification is not a voice notification but an alarm sound signal of sorts.

III. RESEARCH METHODOLOGY

The research method most suitable for carrying out this research project would be a mixed method. It combines both quantitative and qualitative data to achieve a design that meets the objectives of the project. Wisdom and Creswell [19] from George Washington and Nebraska-Lincoln Universities, respectively, in their paper titled, “Mixed methods: Integrating quantitative and qualitative data collection and analysis”, have defined mixed research method as an emergent methodology of research that advances the systematic integration, or “mixing,” of quantitative and qualitative data within a single investigation or sustained program of inquiry.

Information, data, and guidelines from WHO led the project’s development. As shown in Figure 2, quantitative and qualitative data from WHO is complemented by the data from laboratory experiments and measurements, as well as from test and qualitative data from user interviews to accomplish the goals of the project. This methodology assures an interlock of qualitative and quantitative data to achieve an almost flawless convergence to the objectives of the study and, hence, the project [19].

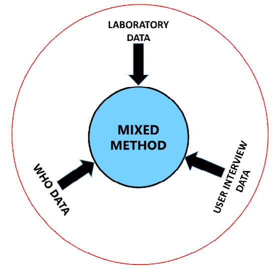

Figure 2. Applied mixed research method and data collection mechanism.

IV. SYSTEM DESIGN AND DEVELOPMENT

The system consists of two main blocks (the Hardware Unit and the Mobile Application) and their sub-systems. Figure 3 shows the two main blocks, the air quality sensor and how they connect.

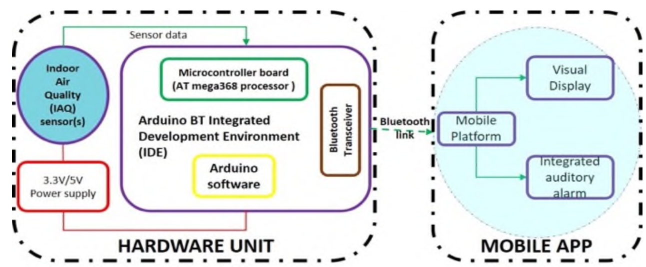

Figure 3. A block diagram of the main system units.

Simplicity, flexibility, portability, and accessibility guided the development throughout the design process. The hardware, software and mobile app are all built on open-source platforms. The design process considers the most essential features that would render the system inclusive to address the needs of users with disabilities or impairments [6].

A. Hardware

The hardware unit is essentially a sensor-node designed in the KiCad Electronic Design Automation (EDA) Suite [8]. The node integrates a Grove-air quality sensor v1.3, responsive to carbon monoxide (CO), alcohol, carbon dioxide (CO_2), and Particulate Matters (PM), such as smoke, liquified petroleum gases and other volatile substances [2]. The node also has an ATmega328 powered microcontroller, a Radio Frequency (RF) and Bluetooth transceivers. All components are fused into one Printed Circuit Board (PCB) unit compatible with the Arduino Integrated Development Environment (IDE). There, sketches (small C-language programs written in Arduino IDE) are compiled and uploaded to run the hardware or sensor-node [9]. Figure 4 shows a complete sensor-node.

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B. *Software*

The software combines an Arduino sketch and a mobile app developed in MIT App Inventor 2, which is a drag-and-drop, block-based visual programming language for creating Android devices mobile apps [7].

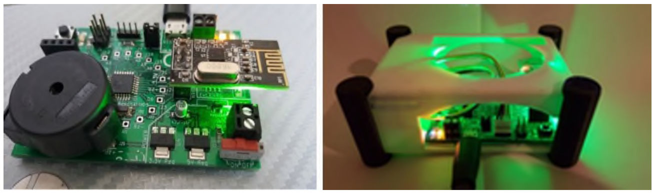

Figure 4. Complete Sensor-Node; open and encased unit.

C. *Concept and system functionality*

The concept is built around an IAQ monitoring and multiple forms of user notification of the IAQ-status. Suppose the IAQ status in a room changed, say due to cooking with wood, with the system installed, one or more sensors on the sensor-nodes might pick up emissions. When this happens, the sensor-node determines if the IAQ is good, poor or bad by processing the sensor data pollutant level. A good IAQ level sets a 3-in-1 Light-Emitting Diode (tri-LED) to Green. However, if the IAQ is poor, the tri-LED changes to Yellow and sounds the alarm. On the other hand, if the IAQ is bad, the tri-LED will be Red.

Figure 5 shows a mother and a child in the kitchen cooking with a wood stove, close to the right-hand corner of the room. The child is holding a toy in which a sensor-node has been embedded. Node 2 is designed to be wearable; Node 3 is mounted on the wall and is linked to a mobile smartphone via Bluetooth. All three nodes plus the toy are connected in an RF network with each other.

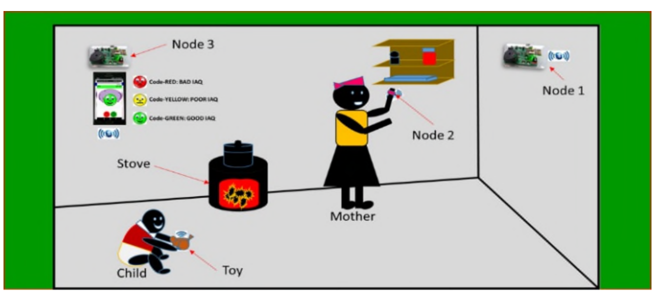

Figure 5. A pictorial diagram illustrating the UD-IAQMWS concept.

The IAQ status is displayed and audio notifications are made in the smartphone. Poor IAQ status will cause the toy to stop working. Consequently, the child will most probably complain to the mother and she would take the child out of the kitchen, open the windows or ensure proper ventilation of the room [7][10][13]. If the mother's actions improve the IAQ status back to 'Good', the child's toy would start to work again. With time, parental guidance, education or basic infant instinct, the child learns to avoid areas with poor IAQ, thereby staying healthy. Depending on the sensor readings, the phone will also display the Green or Yellow or Red emojis (as can be seen in Figure 6) on the screen, with text, and audio-voice message that would say "Code-Green, Good" if the IAQ was good or "Code-Yellow, Poor" if the IAQ was poor and "Code-Red, Bad" if the IAQ was bad. Except for the "Good IAQ", each node will sound alarms different in tone and frequency depending on whether the IAQ status was poor or bad. Note that every user action on the app is complemented by voice feedback describing the action.

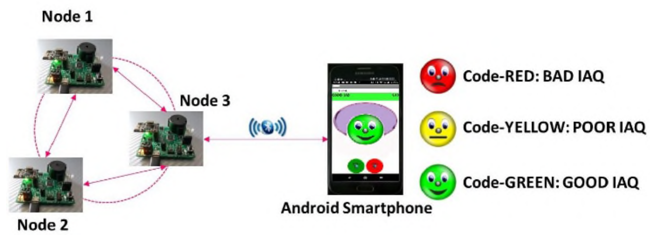

Figure 6. Network communication, system function, and notification.

V. USER TESTING

User testing was done in 2 phases. First, measurements were taken in the kitchen while the participant was cooking. They could operate the system (mobile App) by themselves or observe. Afterwards, an interview session in which participants had to answer 12 questions in about 30 minutes was scheduled according to mutual consent. There were 6 interviewees, 4 males, and 2 females. Each participant was given a unique identification number or ID. For example, #111-F corresponds to participant 1, household 1, interview position 1, and gender female [20].

Participant #111-F did not know much about technology but liked that the system could potentially keep people safe. Both #534-F and #333-M thought it would have been better if they were about to test a commercial sample. However, all participants agree they would buy the system at a reasonable price and all of them said they had an overall positive opinion about the system. Also, participant #222-F suggested that the final product should include a smartphone in the package and #535-M liked the multiple warning levels and the different notifications associated with the IAQ-status at each level.

VI. RESULTS

The results from the laboratory experiments show that the system can detect and respond to alcohol, CO, CO_2, smoke, as well as Liquified Petroleum Gas (LPG). Table I shows their detectability along with the sensor's calibration status. The system's sensor is calibrated such that the threshold for CO detection keeps the user well within the exposure levels proposed by the WHO guidelines, which provide a comprehensive, scientific and ethical standard for measures taken to curb pollution and ensure a healthy environment.

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The carboxyhemoglobin (COHb) levels resulting from the reaction of CO with the Hemoglobin (Hb) in the blood must not exceed 2% of the blood hemoglobin for a typical indoor situation. 100 mg/m^3 for 15 minutes and 35 mg/m^3 for an hour are recommended for exposures occurring no more than once a day [21]. For 24 hours of exposure, 7 mg/m^3 is recommended for a no-exercise daily routine. Exposure patterns vary with age, socio-economic status, type of home, and duration of exposure. Pollution levels that reach 50 times the WHO guidelines for clean air confirm the health outcome risk for women and children who typically spend more time inside the home than men [7][22].

TABLE I. RESULTS FROM LABORATORY EXPERIMENTS.

Test element	Detection	Status
Alcohol	Possible	Uncalibrated
CO	,,	Calibrated
CO_2	,,	Uncalibrated
Smoke	,,	,,
LPG	,,	,,

The system is by design sensitive to the risk levels; thus, detections and warnings are issued to the users, based on a series of leveled thresholds, starting from IAQ status Good through Poor, to Bad with increasing pollutant levels and risk.

VII. Evaluation And Discussion

Of all the interviewees, five said the Mobile App was simple and easy to use (one touch to connect, one-touch ‘ON’, one-touch ‘OFF’). It works as long as the Bluetooth connection is active or even when the phone’s screen is locked. Anyone with a basic mobile phone knowledge could use the app intuitively with ease. Although the evaluation of health outcomes was not the focus of the project, the interviewees were still asked if they had experienced any health problems that might have resulted from the use of solid fuels. All 6 initially answered they had not. However, participant #333-M specifically stated that he had migraines. A follow-up question was asked to ascertain how the respondent could be so sure. He then responded he experienced that only when he was using charcoal for cooking, implying the migraines could only have resulted from the use of charcoal.

The challenges encountered during the research were due to low statistical samples for testing, lack of participants qualified for the indoor (not outdoor) context of testing, language barrier and lack of participants for accessibility and inclusivity evaluation, which led to the use of personas. Persona characters, such as Karol–deaf and Xendu–blind, were correspondingly served by the tactile, auditory, and visual notifications on the smartphone [23]. Ngong–motor-impaired could still use the app since no complex gestures were required. Persona characteristics that bare a direct relation to requirements defined by the project, ensure that the context is preserved [24].

Distinguishing between systems designed to carry out similar tasks, such as detection of pollutants or monitoring of IAQ on the bases of technology and innovation is not an easy task. Systems that employ the same technology might differ in concept, design and implementation but not necessarily in principle. These coupled with the speed of development of the Information and Communications Technology (ICT) field diminish the ease of developing a novelty. However, when fully developed, the prototype UD-IAQMWS will stand apart from the other systems due to the following attributes:

- ***Accessibility/HCI***: The system is built for all persons, whether impaired or unimpaired. A special system further utilizes HCI to address child exposure.
- ***Multimodal notification***: The system offers visual, auditory and tactile (distinctive mobile vibrations that notify the visually and hearing impaired) notifications on a mobile device.
- ***Multiple sensors***: A network of many sensor-nodes offers possibilities for multiple sensor connection system. Thus, different kinds of pollutants can be detected simultaneously or contrastingly (by comparing the oxygen-to-pollutant ratio in a target area) if an oxygen sensor was also used in the network.
- ***Interconnecting systems***: Neighboring systems can communicated by configuring them properly. Such information exchange between the systems enables an assistance to an impaired neighbor (who could be a family member).
- ***Hardware flexibility***: The hardware can operate as a standalone system or in a network with other sensor-nodes. The user can also choose whether to connect a mobile phone or not. Each node has an inbuilt charging circuit and can charge its batteries via USB or solar panel.
- ***Open technology***: Both hardware and software are built for simplicity and on open-source platforms. The user can change the sensors by simply plugging in another compatible sensor. However, such changes might require slight modifications in Arduino with either serial or Universal Asynchronous Receiver-Transmitter (UART) protocol.
- ***Wireless connectivity***: The system connects and sends user notifications to a mobile device via Bluetooth. IAQ status and values are also sent and displayed on the phone screen.
- ***Compliance with UD principles***: The system complies with at least the first five UD principles [25], therefore, is accessible to a wide range of users, more than traditional smoke detectors or similar systems ever could provide.

There were some limitations in the study due to language barriers, low number of participants, limited time, and resources. However, we think that the design and implementation of the prototype presented in this study can be considered as a novel start. As it is still under development, we believe that further study can be done with more participants and hope that the system will reach its full potential in the near future.

It should be noted that the system was designed and tested only on Android systems. However, it could easily be ported in other platforms such as iOS and Windows.

VIII. CONCLUSION

In this paper, we present a universally designed and accessible Indoor Air Quality Monitoring and Warning System (UD-IAQMWS). The system can detect several pollutants, such as alcohol, carbon monoxide, carbon dioxide, smoke and liquified petroleum gas. IAQ status notifications are provided audibly, visually, and through tactile vibrations. The displayed status can be made accessible to the users with vision problems using a screen reader. Moreover, the system is customizable to fit any user's needs by simply updating the software. The mobile app's simplicity cannot be overemphasized: only 2 buttons are required to operate and there are no complex gestures needed. Any mobile user, including people with disabilities, can use the system with ease; no special training is required.

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Building Accessible, Safe and Inclusive Indian Cities

Framework for 100 Smart Cities

Nanda Kishore Alegala Nagabhushanam
National Institute of Urban Affairs
1st &2nd Floor, Core 4B, India Habitat Center
New Delhi, India
e-mail: akishore@niua.org

Kanika Bansal
National Institute of Urban Affairs
1st &2nd Floor, Core 4B, India Habitat Center
New Delhi, India
e-mail: kbansal@niua.org

***Abstract*— The action research project on Building Accessible, Safe and Inclusive Indian Cities (BASIIC) intends to showcase the implementation frameworks on how to strengthen and build institutional capacities at national, state and local levels on inclusion, accessibility and safety of vulnerable, marginalized and excluded groups with special focus on persons with disability. The paper highlights the existing status of the disabled population and the concerns addressed in the latest government schemes in India, the BASIIC project genesis, goals and objectives, as well as its detailed approach and methodology. The project envisaged its learnings to be useful in developing guidelines and policy recommendations at the national level and implementation of pilot projects through convergence with the Smart City Mission.**

Keywords- Accessiblity; Safety; Inclusive cities; Persons with Disability.

I. Introduction

Rapid urbanization has become a trend across the world, especially in the developing countries. Such a trend created its own challenges to urban life, along with the benefits. While the focus has always been on equitable distribution of resources and opportunities, the needs of marginalized population, including the differently abled, have been compromised. It is estimated that nearly one billion people (15% of the global population) experience some form of disability. Out of that number, about 30 million are residing in India, according to the 2011 Census [3].

Urban living in itself can be challenging and it is particularly true for those with disabilities. A lack of universal design can be commonly observed in public buildings like schools, banks, offices and, most of all, recreational spaces. Restricted mobility, dependence on others, lack of sensitivity among fellow citizens, create a sense of insecurity and isolation among people with disabilities, impacting their physical as well as mental health. The lack of accessibility to digital platforms, un-familiarity with the technology and unaffordability of assistive devices has impacted the intellectual growth and empowerment of the disabled population. It has become imperative to include and place emphasis on the “accessible and inclusive component” on the path for achieving sustainable development.

A. Status of the Disabled Population in India

According to the 2011 Census [3], India has around 3 crore of the disabled population, which constitutes about 2.21% of the total population. The disabled population constitutes about 2.17% [1] of the urban population, half of which is concentrated in just five states. Table I gives the details of the top five states and of the urban agglomeration with the highest percentage of disabled population. With the increase in the number of categories from 7 to 21 in the Rights of Persons with disability Act in 2016 [10], these statistics are likely to vary. There is no available data on the qualitative aspects of demographics of the people with disabilities. There is a need for enhancement and strengthening of the data available on the state of the disabled population.

TABLE I. CONCENTRATION OF DISABLED POPULATION. TOP FIVE STATES/UNION TERRITORIES AND URBAN AGGLOMERATIONS (UAs)s/CITIES (MILLION PLUS)

States/Union Territories (UT)		
States/UTs	***Numbers (Thousands)***	***Share (%) of Total***
Tamil Nadu	558.2	6.8
West Bengal	648.5	7.9
Andhra Pradesh	753.6	9.2
Uttar Pradesh	990.9	12.1
Maharashtra	1297.3	15.9
India	8178.6	100.0
UAs/Cities (Million Plus)		
Delhi UA	228.4	6.0
Bruhat Bangalore UA	251.6	6.6
Hyderabad UA	294.1	7.7
Kolkata UA	342.3	8.9
Greater Mumbai UA	484.7	12.6
UAs/Cities (Million Plus)	3832.8	2.4

Source: Census 2011 [3]

B. Existing Policies and Frameworks

The disability Act of 1995 [5] mandates the provisions for accessibility for persons with disabilities. The national policy for persons with disabilities [14] places emphasis on provisions for equal opportunities and protection of the rights of the disabled population. India is a signatory of the

"Declaration on full participation and equality of persons with disabilities in Asia Pacific Region", Biwako Millennium Framework, Biwako plus Five and the UN Convention on the Rights of Persons with disabilities [14].

The government of India has given a new direction to urban development which now has a much larger coverage and huge investments, in addition to including newer areas of the latest government schemes such as Swach Bharat Abhiyan [6], Smart City Mission [1], etc. The new missions of the government are complementing each other by enabling access to the resources available under different missions. The concerns of inclusivity and accessibility of Persons with Disability (PwD) have been highlighted in the flagship program Accessible India Campaign or Sugamya Bharat Abhiyan [15] launched by the Hon'ble Prime Minister of India (under the Ministry of Social Justice and Empowerment) in 2015 and later supported by the enactment of the Rights of Persons with Disability Act in 2016 [10]. Schemes such as Smart City Mission [1], Swachh Bharat Mission [6], AMRUT [8], Pradhan Mantri Awas Yojana – Urban [9], and HRIDAY [7] (under the Ministry of Housing and Urban Affairs), Digital India Campaign (under the Ministry of Electronics and Information Technology) [16] have the crosscutting agenda to guarantee accessibility and inclusivity components, briefly described below in Table II.

TABLE II. STATUS OF DISABILITY IN VARIOUS PROGRAMS UNDER THE GOVERNMENT OF INDIA (GOI)

Program/ Mission/ Schemes	**Year of Launch**	**Accessibility and Inclusivity Components**
Swach Bharat Abhiyan [6]	2014	Targets elimination of open defecation, conversion of unsanitary toilets to pour flush toilets, eradication of manual scavenging, municipal solid waste management and bringing about a behavioural change in people regarding healthy sanitation practices. Handbook on Accessible Household Sanitation for Persons with Disabilities was published under the mission.
Atal Mission for rejuvenation and urban transformation (AMRUT) [8]	2015	It aims at providing basic services (e.g. water supply, sewerage, urban transport) to households and build amenities in cities which will improve the quality of life for all, especially the poor and the disadvantaged, as a national priority. The components of Urban Transport include footpaths/ walkways, sidewalks, foot over-bridges and facilities for non-motorised transport (e.g. bicycles) and ensure the safety of citizens. The component of development of green spaces and parks ensures inclusion of a special provision for children, senior citizens and PwD.
Smart City Mission [1]	2015	The objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and encourage the application of 'Smart' Solutions. It focuses on inclusive development and caters to the infrastructural elements most significant to BASIIC interventions including mobility and public transport, affordable housing, Information Technology (IT) connectivity, governance, safety and security of citizens.
Digital India Mission [16]	2015	It aims at transforming India into a digitally empowered society and knowledge economy. The vision areas include: digital infrastructure as a core utility to every citizen, governance and services on demand as well as digital empowernment of citizens. The mission has been designed inclusive of the needs of PwD with the creation of apps like Accessible India App and Sugamaya Pustakalya.
Pradhan Mantri Awas Yojana-Urban (PMAY-U) [9]	2015	The scheme aims at providing affordable housing to all in the urban areas. Inclusivity components are visible in the suggestions for allotment preferences and credit linked subsidy schemes for the weaker and vulnerable sections of society, including PwD.
National Heritage city development and augmentation Yojana (HRIDAY) [7]	2015	It aims at preserving and revitalising the soul of the heritage city to reflect the city's unique character by encouraging an aesthetically appealing, accessible, informative & secured environment. The scheme's objective includes: "Increase accessibility i.e. physical access (roads as well as universal design) and intellectual access (i.e. digital heritage and GIS mapping of historical locations/ tourist maps and routes)" ensuring accessibility, safety and inclusion of PwDs.
Accessible India Campaign [15]	2016	It aims at achieving universal accessibility for Persons with Disabilities (PwDs), by enhancing the proportion of accessible government buildings (targeted to be extended to at least 50%); enhancing the transport system accessibility by adding accessibility to airports, railway stations and public transport, and strengthening the Information and communication eco-system accessibility by enhancing the proportion of accessible and usable public documents, websites, as well as the pool of sign language interpreters, accessible for public television news, programmes, etc.

II. GENESIS OF THE PROJECT

To reflect on the needs and way forward in facilitating Indian cities towards ensuring universal access and inclusive planning, the Ministry of Housing and Urban Affairs (MoHUA), in collaboration with the National Institute of Urban Affairs (NIUA), called upon the key stakeholders in the domain of accessibility and inclusivity. A consultation was organized on September 11, 2018 to seek expert insights on framing the person with disability friendly measures and policy recommendations that can be implemented through the Smart Cities Mission [1]. The key recommendations that emerged from the consultation can be broadly put into six areas of intervention, as detailed below:

1) Legislative Framework and Guidelines – Duplicity and discripencies in guidelines pertaining to universal design and accessibility need to be addressed, such that uniform standards can be established and followed across Indian cities.

2) Inclusive Design and Planning – Planning and design of projects under the Smart Cities Mission with principles of accessibility and inclusivity.

3) Institutional Arrangement and Capacity Building – Improving existing institutional mechanisms and capacity building of authorities and practitioners to carry out works pertaining to universal design.

4) Awareness Generation – Generation of awareness amongst all stakeholders and the public towards disabilities, universal design and inclusive cities.

5) Information and Communication Technology (ICT)– Incorpartion of accessiblilty components in ICT the infrastructure of Smart Cities.

6) Monitoring and Review - Regular monitoring and evaluation of universal design applications in Smart Cities projects.

To facilitate the above, there is a need for focused technical assistance at all levels of governance, for the accurate and successful adoption of PwD friendly measures in Indian cities. It is in this context that NIUA, with support from the Department for International Development (DFID) of the UK Government, is implementing a project "Building Accessible, Safe and Inclusive Indian Cities" (BASIIC). The project has formalized a Technical Assistance Support Unit (TASU), which will ensure that tenets of universal access, inclusivity, and safety, are practiced through sensitive and responsive planning. The project endeavors to promulgate the above in the ethos of urban planning and design through policy level interventions, capacity building, pilot demonstrations of contemporary solutions, and implementation of robust monitoring systems.

I. Project Goals and Objectives

The principal goal of BASIIC is to build the capacities of Indian cities to be sensitive and responsive to the needs of the PwDs. The project aims to homogenize the definitions and concepts associated with PwDs in India and to holistically build the capacity of practitioners to plan and implement with the tenets of universal access and inclusiveness. The project shall also actively work to gather the key stakeholders working on disabilities on a common platform and demonstrate innovative solutions – technologies, programs, and service delivery models in the realm of universal access.

The key objectives of the project are:

a) Consolidation of definitions, concepts, policies, provisions, and practice with respect to PwDs in India.

b) Mapping the major areas of opportunity in implementation of policies and provisions at city level and replicable solutions for making cities more accessible and inclusive for PwDs.

c) Develop a monitoring and evaluation framework for pilot cities to assess and improve their standards of universal access and inclusivity. The framework developed will be replicable for other Indian cities to implement.

II. Approach and Methodology

A. Project Initiation

The project has been initiated with understanding the target population through detailed study of the available data and stakeholder meetings to gain the sensitivity and empathy required for the project. The interaction with stakeholders, including persons with disabilities, non-profit organizations and relevant institutions working in the field, helped in understanding the needs and aspirations of PwDs along with the challenges faced by them in life every day.

B. Defining the Project Geography

Identification of pilot cities/towns is critical with any project for creating a measurable impact. Criteria were formulated for identification of partner cities in order to achieve the project objective to implement innovative pilot solutions focused on accessible/ inclusive/ safety design and planning principles in selected partner cities. The selection framework included the following influencing factors for city selection under the BASIIC project:

1) Ongoing Policies and Programs - like Accessible India Campaign [15], Smart Cities Mission [1], etc. to establish convergence between the projects/schemes.

2) Data Relevance - in terms of City Classification and Disabled Population to identify the cities in need of immediate interventions.

3) City Intent – the cities promising intent in the form of proposed or ongoing projects related to the concept of accessibility, inclusivity and safety. Association with these cities will assist in getting support in terms of leveraging partnerships, availability of funds for implementation, awareness/sensitization of the stakeholders, etc.

An intensive city selection process has been adopted comparing around 39 cities overlapping between Smart City Mission [1] and Accessible India Campaign [15]. These cities were further scrutinized to 22 cities based on the percentage of disabled population and class of city, which was further narrowed down to 14 taking into account the proposed or ongoing initiatives. The level of intent through initial accessibility audit has resulted in shortlisting of 9 cities, namely: Kanpur, Chennai, Chandigarh, Jaipur, Varanasi, Vishakhapatnam, Bhubaneshwar, Delhi and Dehradun. Out of these, two cities will be selected as partner cities for demonstration of the pilot projects. Based on experiential learning models, seven (7) cities shall shadow the partner cities throughout the pilot interventions to learn and replicate.

C. Baseline Study

1) Qualitative and Quantitative Data on the Disabled Population: BASIIC has undertaken a secondary baseline study to evaluate the current status of disability in India, both in terms of qualitative and quantitative aspects of the concerned population set. This will help in understanding the sectors of urban development which need immediate attention. It is observed, from the details in Table III, that people with hearing, visual or speech disability constitute more than half of the disabled population.

TABLE III. DISABLED POPULATION BY TYPES OF DISABILITY IN MILLION PLUS UA'S/CITIES IN INDIA, 2011

Type of Disability	Share (%)
Vision	21.4
Hearing	22.3
Speech	9.0
Movement	13.1
Mental Retardation	5.3
Mental Illness	2.6
Any Other	21.1
Multiple Disabilities	5.3
Total	100.0

Source: Census 2011 [3]

2) Status of Accessible and Inclusive Environment: An assessment of secondary data has been undertaken to understand the existing status of accessibility and inclusivity in projects in the realm of urban planning and built environment. The assessment resulted in preparation of identifying prospective sectors of intervention.

3) Status of Existing Policies and Frameworks: The status of accessibility and inclusivity of the PwD in the existing policies and guidelines was done to list the existing focus areas, existing gaps and possible areas of intervention. It was found that there is duplicity and discrepancies in existing guidelines/codes.

D. Auditing

1) Accessibility Audits: Evaluation and grading of the smart city projects will be done in terms of inclusivity, accessibility, scope and impact. This evaluation will help in identification of pilot projects.

2) Review of Existing Policies and Frameworks: A comparative analysis of the existing policies, acts, standards/guidelines and building codes helped in mapping the gaps and scope of revision in existing guidelines. Table IV gives the details of the relevant guidelines/codes.

TABLE IV. DETAILS OF RELEVANT GUIDELINES AND CODES

S.No.	Guidelines	Owner Agency	Nature
1.	National Building Code,2016 [17]	Bureau of Indian Standards, GoI	Inputs from the Disable People Organisation has been incorporated in latest version
2.	Harmonised Guidelines [18]	Ministry of Housing and Urban Affairs (MoHUA), GoI	Comprehensive document recoginsed in the RPwD act
3.	Model Building Bye-laws	Town and Country Planning Organisation, MoHUA, GoI	Guidelines for formation of all state/ city specific byelaws. Barrier free-environment is one of the forteen new features of the latest version
4.	Urban and Regional Development Plans Formulation and Implementation (URDPFI) Gui delines	Town and Country Planning Organisation, MoHUA, GoI	Comprehensive Guidelines for preparation of all development plans. Gives Infrastructural provisions for Barrier free urban development.

The review highlighted the need for a structured, comprehensive, yet harmonized, approach addressing the needs of PwDs in accordance with the existing statutory framework, to ensure appropriate implementation at all levels and to act as a reference for formulation of upcoming guidelines/ policy interventions.

3) Assessing the Existing Knowledge Base: A comprehensive repository of contextual challenges, possible solutions and expert opinions will be developed and assessed.

E. Implementation

1) City Level Demonstration and Pilot Project Implementation: Demonstration of replicable solutions/examples that augments accessible, inclusive and sensitive planning and implementation will be done with urban local bodies in the selected cities. These chosen projects will act as model projects for other cities. Table V gives the details of potential solutions for seven identified sectors for pilot project implementation.

2) Policy Level Intervention: Based on the observations of the review of the existing guidelines and statutory framework, it is suggested to do necessary enhancement and revision of guidelines/ standards leading to statutory documents i.e. the developmental plans and the building bylaws. Also, the Harmonised Guidelines [18], as prepared by the Ministry of Housing and Urban Affairs, is suggested to be revised and enhanced in a comprehensive manner to address accessibility, safety and inclusivity of PwD in built environment and be integrated in all existing and upcoming guidelines/standards. Table VI gives the details of the considerations for a structured, comprehensive and harmonised approach and relevant guidelines for intervention.

TABLE V. LIST OF POTENTIAL SOLUTIONS IN THE IDENTIFIED SECTORS

Sector	Potential Solutions
City Level Policy and Statutory Framework	Occupancy and completion certificate Developmental Plan City Bylaws Detailed Project Report for Smart city Projects
Governance	Representation in City Level Advisory Forum, Municipal Ward Committees etc.
Built Environment	Universal design of all buildings including: Housing complexes, Educational Institutions, Healthcare centers, Office complexes & Workplace Commercial establishments
Infrastructure provisions	Inclusion in Educational institutions Accessibility to art, heritage and culture Accessibility to religious sites Digitally inclusive Public engagement platforms Acessible WASH facilities
Mobility	Accessible Public Transport from buying ticket to travelling Universal Design and safe pedestrain pathways Accessible Subways and overhead bridges
Tourism	Inclusive tourism schemes Barrier Free access to religious and heirtage sites Availability of wheelchairs, audio guides within the sites Inclusive and accessible museums, art galleries, and theatres
Incorporation of ICT (Cross cutting in each sector)	Access to real time online applications and websites IT-enabled government services Access to mobile based applications Online portals for empowering PwDs IT- enabled business process

TABLE VI. CONSIDERATIONS FOR STRUCTURED, COMPREHENSIVE AND HARMONISED APPROACH OF POLICY INTERVENTION

Consideration	Application in
Understanding the statutory status and mandate of the guidelines	Developmental Plans/ Landuse Plans: Master Plan, Local Area Plans Building Bylaws and Occupancy and Completion Certification
Identification of Model Documents prepared by Central Town and Country Planning Organisation to be modified/ adopted by the State/ City Governments	Model Building Bye-Laws Urban and Regional Developmental Plan Formulation and Implementation (URDPFI) Guidelines
Comprehensiveness with respect to Disable friendly attributes in Built Environment	Harmonised Guidelines [18] National Building Code, 2016 [17]
Scope of Inter-referencing	Harmonised Guidelines [18] comprise details of general universal design elements, easy to refer in other statutory documents.

3) Knowledge Management and Training: Training programs and modules will be arranged to ease the understanding of policies and provisions for PwDs for relevant stakeholder/ practitioners at national and city level. This will help in capacity building of the civil bodies/ municipal authorities and creating a toolkit containing aspects addressing inclusive and accessible components, aiming at increased awareness among the stakeholders. Also, a knowledge network of sector experts, practitioners and stakeholder will be formulated for ease co-learning opportunities.

F. Monitoring

Monitoring and evaluation will be an integral part of this project and have been integrated into the proposed objectives for setting up a framework for sectoral monitoring of the city level efforts. In addition, to monitor the progress of the sector and partner cities, the project will also track its own progress in delivering the indicated results.

G. Intended Outcomes

The project will work towards achieving the following outcomes and assist the national, state and city level governments in achieving aligned goals:

a) Easing the understanding of policies and provisions for PwDs for relevant stakeholders/practitioners at different levels through simplification and revision of existing guidelines.

b) Developing a comprehensive repository of contextual challenges, possible solutions, toolkits and experts in matters pertaining to PwD in urban India.

c) Developing collaborative engagement and operating models with key stakeholders (such as municipalities), which can help sustain the above solutions by undertaking pilot projects in the partner cities.

d) Capacity building and dissemination of knowledge with respect to PwD among key stakeholders. This will be achieved through knowledge management and training.

III. CONCLUSION

The efforts under BASIIC will support the Government of India programs in the pilot cities and will try to propagate the results. It is envisaged that the learnings of the project will be useful in developing programs and policy recommendations at the national level. In convergence with the Smart Cities Mission program and Accessible India Campaign, the project will allow Indian cities to secure benefits through their institutional capacity building, design challenge and pilot demonstration efforts.

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