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Public Health Planning and Citizen Engagement: Exploring the Need and the Sustainability of an Open Source Platform for Dengue Prevention in Sri Lanka

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Abstract

The rise of Information Communication Technology (ICT) has offered the world a new and efficient mechanism to increase active citizen engagement. Growth in open source technology has widened the space for engaging a vast number of citizens limitless of geographical and hierarchical boundaries via crowdsourcing real-time data. Even though there is a boom in using ICTs in connecting and sharing knowledge and information among different stakeholders, still, there is a considerable gap in using open source technology in combating public health issues around the world. As a country with a high internet usage rate, Sri Lanka still shows underutilization of such technologies in monitoring and preventing non-communicable diseases. Dengue is a serious health threat in Sri Lanka which shows the need for active surveillance in prevention. The main objective of the paper is to seek the potential possibility of using the Internet of Things (IoT) in preventing dengue outbreak in Sri Lanka. Also, it aims to identify the opportunities for using a mobile application and even tries to address the usability issues that could arise when introducing and retaining a mobile application. By doing that, this paper will contribute to filling the gap in research on functionality and usability issues and also introduces a user-friendly open source application to prevent dengue outbreak in Sri Lanka. The proposed development of the mobile platform for dengue prevention has considered the economic and social understanding of people as rational thinkers and collective actors and also has used the user-friendly guidelines of mobile application development.

Keywords: Dengue prevention; Information communication technology; Open source technology; Public health planning

Introduction

With the failures of the neoliberal model in managing public wellbeing efficiently and fairly, now the citizens are stepping out and becoming the producers of knowledge shaping the rational decision-making process in parallel with the traditional bureaucratic decision-making mechanism [1]. The rise of Information Communication Technology (ICT) has offered the world a new and efficient mechanism to increase active citizen engagement compared to the traditional participatory methods [2]. Much of this work is facilitated by open source programming where software engineers work collaboratively and share their software developments freely on the internet [3]. Growth in open source technology has widened the space for engaging a vast number of citizens limitless of geographical and hierarchical boundaries via crowdsourcing real-time data [4]. Open source platforms instigate and strengthen the participatory democracy by increasing interactive dialogues between planning authorities and a large number of people upon crucial issues faced by the cities [5] This transition has created a new chapter in societies where knowledge and information shared among peer groups, researchers, scientists and governments for finding solutions for their issues in a vast array of fields such as traffic management, pollution, environmental planning, and public health planning [4].

In recent years' dengue fever has been identified as a severe health concern by the World Health Organization (WHO) because of the alarming increase of the dengue-infected cases around the world and also because of the significant economic and social damage it causes on the endemic countries [6]. Dengue is a mosquito-borne infection widely spread over many tropical and subtropical regions where over half of the world population living in these countries [6]. Dengue fever is transmitted by female mosquitoes mainly from the species *Aedes aegypti* and, to a lesser extent, *Ae. albopictus* [7]. Dengue can cause the full spectrum of disease from an infection to a mild self-limiting disease and to a fatal disease [6]. The dengue fever (DF) can develop a severe illness that may be fatal and also can lead to hemorrhagic fever/dengue shock syndrome (DHF/DSS) [6]. The actual numbers of dengue cases are underreported or misreported. A recent study indicates the estimated number of dengue cases as 390 million per year around the world and the reported cases have been increased from 2.2 million in 2010 to 3.2 million in 2015 [8]. Sri Lanka is facing the dengue epidemic since 1960 and the year 2017 showed a dramatic increase of reported dengue cases including 215 deaths [9]. Heavy rain falls, and the failure to clean the potential breeding places, have caused in increasing the number of affected people especially in urban and semi-urban areas. The need for active surveillance and efficient communication is emphasized in many times as the traditional methods are inadequate and ineffective in controlling fast spreading dengue outbreak in tropical countries [10].

With the proliferation of mobile technologies and users, new opportunities have emerged in using such technology in promoting public health around the globe [11]. Also, there are various ready-to-use open source software tools to facilitate the collection, management,

and sharing of field data using mobile devices with a centralized data management system [12]. However, there seems an underutilization of technology for promoting public participation in the public health sector in the world as well as in Sri Lanka [13]. Even though few mobile applications have been introduced to increase active citizen engagement in the field of dengue prevention, mal-functionality of these applications remain as a question.

The primary objective of the paper is to seek the potential possibility of using the Internet of Things (IoT) in preventing dengue outbreak in Sri Lanka. Also, it aims to identify the opportunities for using a mobile application and even tries to address the usability issues that could arise when introducing and retaining a mobile application. By doing that, this paper will contribute to filling the gap in research that addresses the functionality and the usability issues that arise in developing a mobile application [14].

The paper is organized as follows: first, the article will provide a review on open source technology as a tool for citizen science approach with a special focus on the importance in the public health sector. Next, the paper will go into an analysis of open source interventions in Sri Lanka in the dengue prevention sector. The literature review will discuss the theoretical background as well as the sustainability and the user-friendly aspects of mobile applications as a guide for future development. The potential opportunities and the particular requirements of a dengue prevention application will be analyzed using empirical findings of a survey carried out in the Dehiwala Mt-Lavinia Municipal Council area. Based on the findings, finally, the paper presents some recommendations for the future development of a dengue prevention mobile application.

Open Source Technology as a Tool in the Field of Public Health Sector

In general, local governments have realized the need for engaging more with the public as a way moving forward fastly in combating local issues and finding sustainable solutions. In this attempt citizen science approach is useful where the general public are engaging in scientific research activities and generating knowledge with their intellectual capacity or broad experience with the tools and resources available for them [13]. Citizen science approach is strengthened with the network of individuals (citizens) and scientist and also engage with governance with the power of information technologies especially with the development of open source techniques.

Citizen science approach involves engaging with the citizens to 'crowdsource' data acquisition processes, data analysis, interpretation, and study dissemination in a simplified manner. Moreover, citizens are engaged from data collection to action. The tremendous advantage of using crowdsourcing is the ability to gather rich, intense data in a short period with a minimum cost [15]. Further, the citizen science approach brings local knowledge to the table. It empowers the citizens and legitimizes the ownership of the projects to the general public [16]. Local governments will enable to understand the local networks through the citizen science approach which provides a guide to finding local leaders and volunteers when implementing the projects.

Citizen scientists are advancing from open source technology and trying to find solutions for public issues by using open source tools in the varied fields ranging bird or insect mapping to finding solutions for environmental and health problems [5,17]. With the proliferation of ICT, now the citizen scientists are more active in the fields of traffic management, accident reporting, and waste management. Further citizen science technologies have been used and potential to employ in studies in relation to the sense of safety, fear of crime in urban settings [18-20] and walkability aspects in planning [21].

Even though there is a boom in using ICTs in connecting and sharing knowledge and information among different stakeholders still, there is a considerable gap in using the citizen science approach in combating the public health issues in countries [13,22]. Community engagement in public health area is essential when introducing more sustainable community-oriented health policy interventions [23]. Mainly, when the diseases are spread and expanded under climate change, the prevention can be hard without active surveillance. Citizen science in public health can also notify local agencies about the status of spreading diseases, residents' perceptions and views and provide access to prevent and manipulate causes and risks. Moreover, this may enable government agencies to address resident concerns, and 'empower' them to strike a balance between such concerns and issues [22].

With the proliferation of mobile technologies and users, Sri Lanka shows a high prospect in utilizing such techniques and capabilities to improve public life. Sri Lanka is in an epidemiological transition where tuberculosis, dengue, Japanese encephalitis, diarrhea, and acute respiratory infections are still in existence [24]. Sri Lanka is facing an unpredicted outbreak of dengue fever over the past years. During the year 2017, the total number of 186,101 suspected dengue cases were reported, and as of 24 May 2018, a total of 19,459 suspected dengue cases were reported to the Epidemiology Unit of the Ministry of Health (MoH) of Sri Lanka with over 320 deaths in 2017 and 20 deaths in 2018 until May. Dengue is spread all over the country, and over 40% of dengue cases were reported from the Western province [25].

Surveillance of mosquito breeding places is a critical component of how health authorities manage and reduce the risk of mosquito-borne disease. The mosquitoes that drive outbreaks of dengue can breed in very little quantity of water spots and not as easily measured and found by traditional surveillance approaches. Effective control needs a wider engagement with the public in real time. The active surveillance requires lots of human resources and time which weaken the monitoring and prevention system. Open source tool provides solutions for these issues and generates rich real-time data across the whole area [26]. Enhancement of GPS-enabled devices, Crowdsourcing and Volunteered Geographic Information has facilitated deploying Geo-ICT based Citizen Science platform with a particular emphasis on public health. Still, prudent and effective use of geospatial technologies requires fostering of a highly skilled workforce for developing, maintaining Geo-ICT solutions for public health. Citizen Science in public health can develop practical knowledge, in the pursuit of worthwhile causes related to diseases and spreads [27]. Applying the citizen science-based approach in tracing mosquito breeding places spatially provides up to date information which is vital for the authorities to take action against spreading. Much stronger engagement with the public will not only give the data to the authorities but also make a pressure to act against the breeding and spreading.

Sri Lanka, however, struggles with the outdated manual paper-based dengue management system. Community education and direct engagement on dengue prevention have been executed in this traditional system. Sri Lanka is one of the countries with the most affordable rates of mobile services in the world, with penetration rates higher than most developing countries [28]. However, there seems an underutilization of technology to combat dengue in Sri Lanka [26].

With the recent outbreak of dengue, few mobile applications were developed in the country, with the interest and involvement of different stakeholders.

Information Technological Interventions for Prevention of Dengue in Sri Lanka

Time to time, few technological interventions have been introduced to increase the effectiveness of the dengue prevention system in Sri Lanka. These systems were launched at different levels with different stakeholders and communities. Veta-Fight Dengue is a mobile application that developed to empower citizens to take part in dengue prevention actions by themselves. The social media comments on Veta-Fight, however, indicate the mal-functionality of the application. The reviews on the comments for Veta-Fight Dengue App indicate the community desire in taking actions against their complaints by a relevant authorized person rather than waiting for the community to take measures [29]. The central principle of Veta-Fight Dengue APP of asking the community to take part in cleaning their environment seems disadvantaged on the application because it restricts the community participation to act against neighbors without any authorized power. Moreover, active voluntarism is not popular as a cultural norm in Asian context also disadvantaged on the functionality. According to Dickmann, in community activities, people would instead do nothing thinking someone else does it [30].

Similarly, the Death to Dengue (D2D) mobile application has been introduced aiming to empower neighborhood communities to be surveillance on their safety including dengue prevention. This APP includes different features such as sending alerts, sending checklists for the general public and building neighborhood groups [31]. Similar to the Veta-Fight APP, this APP also doesn't have a connection with the relevant authorities. As it's a community-based APP, the users cannot communicate with the officers or neither make a complaint to take necessary actions. It controls and limits the steps that can be taken to prevent dengue as the general public cannot take actions on others' premises. Mo-Buzz is another intervention in the field of dengue prevention and is not in use at the moment.

In contrast, most of the available dengue prevention APPs provide functions and features for collecting data related to dengue and disseminate information among the general public or government agencies. Based on the discussions with the officials, it was revealed that current information dissemination on existing breeding locations or potential areas is not adequate to make decisions.

Theoretical Background

The design element and the public participation of an open source platform can be viewed and interpreted through the economic and sociological approaches. Liu and Sandfort argue the usefulness of using both approaches in predicting public participation and identifying the needs of the community. Economists view the community participants as rational thinkers of benefits. People would consider the long-term benefits based on trust, rule designs and expectations before participating in a common activity. According to the rational economic theory, people do not participate in collective action unless they receive any benefits. This can be a tangible or intangible benefit. However, some scholars viewed informal relations and the way that they create some incentives [32]. Lerner and Tirole suggest signaling on incentives motivate contributors to participate. For example, people would gain a reputation within their community by engaging in a common activity by participating in an open source for the common benefit [33]. This motivates the non-contributors to take actions in common tasks.

Sociological perspectives provide a theoretical understanding of how to attract community participation. Sociologists consider the structure of the group such as the density, community size and also the existing relationships. Gould has pointed out two push factors for peoples' collective action. First, people engage in joint efforts to match the contribution of others because of the norms of fairness. Secondly, people would take part in common activities, if they know their input is valued and not wasted [30]. Further, he says that people would invest in action if it seems that others will also join in to produce a positive result. On the other hand, non-contributors will face pressure when the collective community action is visible.

Combination of both economic and sociological perspectives provides sufficient guidelines for designing a sustainable user-friendly online platform. The future development of the mobile platform for dengue prevention will incorporate both economic and sociological aspirations of people as a framework for the sustainability of the product. Further to the broader theoretical coverage, we looked at the other potential elements for introducing a sustainable and user-friendly mobile application.

Sustainable and User-Friendly Aspects of Developing a Mobile Application

The critical part of the mobile application development is to evaluate and monitor every part of the development to ensure the sustainability and the usability of the end product. With the past experience of mobile application developments, scholars have identified some 'good concepts' and 'practices' for user-friendly and sustainable design elements of an application.

User experience is crucial for the sustainability and the retention of the application. The user experience is not just about making the experience user-friendly, but it needs to convince users that it is usable, useful and desirable. According to Mike Gualtieri location, locomotion, immediacy, intimacy, and device are the five dimensions that help to retain the user with the mobile application. When using a mobile application, the most attractive element is simplicity and convenience [34]. The application should allow the user to use it anywhere without limiting to a place. Also, the application should be compatible with the capabilities of the mobile device they have.

Over the years with his experience, Dieter Rams the chief designer of the company of Bauran identified ten good characteristics for long-lasting mobile application development. According to his analyses, a good design should be an innovative, useful, aesthetic, understandable, unobtrusive, honest long lasting thorough down to the last detail, environmental- friendly and with little design.

Gamification is a powerful tool that can be used in motivating people to use the application. Gamification is a strategy that applies game mechanisms to non-game activities to change the user's behavior of an application. It improves users' engagement by allowing the user to gain scores for their actions on the application which will direct them to obtain tangible or nontangible incentives [35]. As outlined in the research papers these intensives can promote active and long-lasting participation compared to the non-gaming mobile applications.

User-friendly mobile applications should be self-explaining in its use via the clear structure of the surface-screen [36]. As a result of the

clear structure, the user doesn't need to spend additional time learning the functionalities of the APP. Clear structure and clear symbols lead to self-explanation. Good design is innovative, makes a product useful, aesthetic and makes the product understandable.

When considering about citizen science platform, it consists of various other components than a mobile application. Accordingly, on the application development perspective, the development of citizen science platform is a crucial task. For health officials, geospatial scientists or citizens to truly address the current issues, information gaps, and technological barriers should be minimized. Deploying and utilization of such systems should be able to carry out by non-programmers, minimally trained users and organizations [37]. Therefore, the APPs and the systems should provide an opportunity for unprecedented users to interact with such systems. In order to sustain the project, the system must be developed and implemented as FOSS synergy.

When it comes to the mobile applications where the public can report their issues it should be linked with the relevant authority to sustain the application; otherwise, people will lose their trust with the application [38]. At the same time, the application should develop trust by ensuring their voices have been heard.

To utilize the user's desires and also to assess the end product sustainability in Sri Lankan context, we conducted a need and a sustainability assessment with the general public in the Dehiwala Mt. Lavinia Municipal Council area.

Study Location

Dehiwala Mount Lavinia Municipal Council (DMMC) has been identified as the research location for this project due to two reasons. 1) the reported increasing number of dengue cases. 2) extended interest and the support from the administration of the council and the health medical officer to conduct a pilot project in DMMC.

DMCC is the second largest municipal council in Sri Lanka with a land extent of 2,109 hectares [39]. It lies south to the Colombo Municipal Council separated from a small canal. Due to the proximity to the capital city Colombo, DMMC shows a rapid increase of the population with a 0.95 of growth rate. As the census data shows 245,974 number of community resides in the DMMC. The Dehiwal Mount Laniva township area was recognized as a district council in 1929 with a population of 25,341. With the rapid expansion of the population, it was converted to an urban council in 1931. And then converted to a municipality in 1959 with over 100,000 populations [40].

The land in the city of DMMC is predominantly in mix residential use. The mixed-pattern of land use between the residential, commercial and industrial makes a very congested and unpleasant environment along the main roads of the municipal area. Mainly 90% of the land is developed while the other 10% of land consists of marshy ground and water bodies (7%) and agricultural use (3%). The total undeveloped land amounts to 209 hectares where 138.7 of hectares are covered by marsh and water body. Some wards experience flooding during the rainy seasons. Poor drainage and garbage disposal systems have led to the prevalence of mosquito (vector) born diseases in the DMMC area very hard.

With the high density of population, Dehiwala-Mount Lavinia Municipal Council reported a high number of Dengue breeding places in 2018 [25]. According to a recent inspection carried out by the council with the support of the National Dengue Prevention Unit of the Ministry of Health, 113 possible Dengue mosquito breeding grounds out of the inspected 971 premises have been identified [25].

Need Assessment and the Socio-Cultural and Technical Feasibility Assessment

With the fast changing world, the emphasis on the sustainability aspects of a mobile application is vital as otherwise the usage and the lifetime will not last as expected. However, determining the parameters for optimal usability, and functionality is more complex and hard to predict from only the software developers perspective, instead should mix with the users perceptions too. To maximize sustainability, we conducted a need and a sustainability assessment with the general public before formatting the blueprint of the mobile application.

A questionnaire survey was conducted with the primary objective of 1) understanding the current system of dengue prevention method 2) assessing the technological, socio-cultural feasibility, and 3) determining the users' requirements. The survey was conducted with 300 people in Dehiwala Mount Lavinia Municipal council area. The random sampling method was used and the number of respondents from each ward was determined according to the population size of each ward.

The sample was comprised of different age groups with the percentages of 38.8% in 15-35 age group, 49.2% in 36-56 age group, 11.7 percent in 57-77 age group and 0.3% in above 77 age group. Monthly household income distribution showed a variation between the lowest to highest income groups. Only 6% of the participants were below Rs.50,000 category. Around 92% of the participants were in between Rs. 50,000-Rs. 200,000 income range. 2% of the participants were above the Rs.200,000 income range. When it comes to the educational level of the participants, 1.4% of participants mentioned that they haven't been to a school. 24% of participants have completed their primary school education. Over 40% of the participants indicated that they have completed the high school education, while 32.5% have completed their vocational training. 58% of the participants were males. 84% of the participants indicated that they are married.

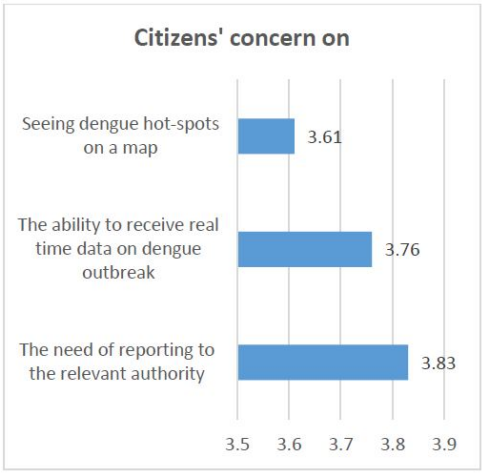

Figure 1: Participant's concern level in reporting and receiving information on dengue.

The survey gathered evidence on the concern levels of the participants on reporting and receiving real-time information on dengue outbreak (Figure 1). Participants were asked to rank their level of concern on a Likert scale starting 1 as not at all concerned to 5 extremely concerned.

Young people showed a great interest in seeing dengue hot spots on a map. As the prevention of dengue needs active citizen engagement, the survey tried to gather information on the current status of the way of communication between the relevant authority and the community. Over 90% of the participants mentioned that they communicated with the council on dengue-related matters. Around 85% of the participants have communicated with the council once a month. When it comes to community aspirations, participants thought that more people would actively engage with dengue prevention activities, if they receive incentives. Scaling on a Likert chart where 1 was mentioned as not at well, and 5 was extremely well, participants rated 3.86 for the above-mentioned question.

Using a mobile APP to prevent dengue could be a new concept for the general public of Sri Lanka. As the foundation stone, the developers should seek the confident level of users before introducing such technologies. For the sustainability of the product, we need to predict the confidence level of using the technology of the users (Figure 2).

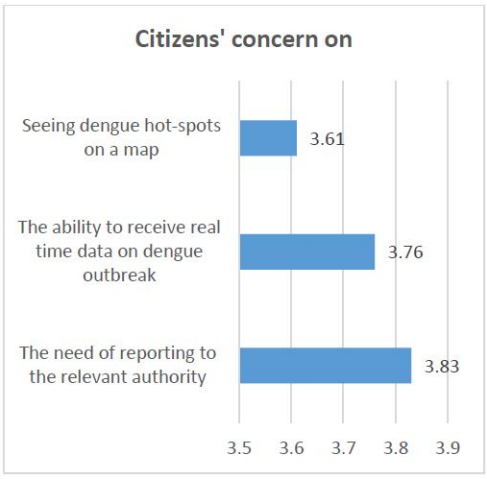

Figure 2: Participants confident level of using technology.

Findings show a high potential of introducing a mobile application as the younger age group showed a significant confidence level in using technology compared to other groups. As the younger generation grew by years, the sustainability of the product will continue (Figure 3).

Participants' educational level showed a significant correlation with the confidence level of using technology. Higher the education level showed a higher level of confidence in using a mobile application. Apart from the age and the educational level, gender and marital status also showed a correlation pattern. Males and unmarried participants indicated a higher level of confidence level in using technology related to the dengue prevention application.

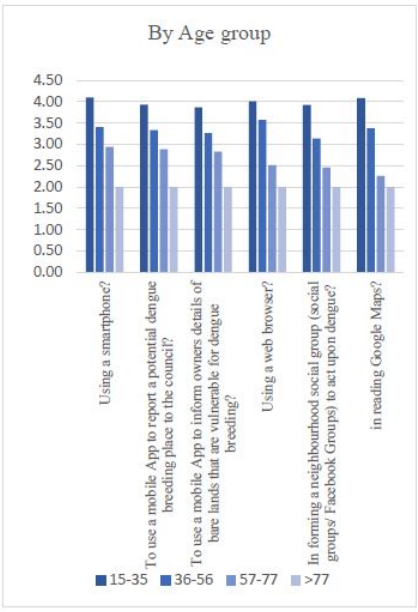

Figure 3: Level of confidence level in using technology by age.

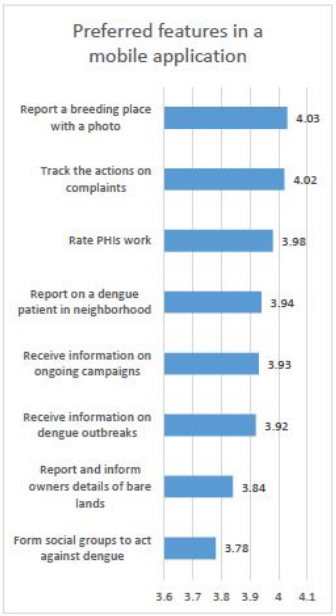

Figure 4: Preferred features in a dengue prevention mobile application.

The usability survey aimed to identify the desired features of the future product (Figure 4). Results indicated the participants desire in reporting as well as receiving the feedback on the actions taken upon their requests. The findings support the economist view on online participation which highlights people's ability of rational thinking on costs and benefits. People would not take action on common activities unless their efforts have been valued [35].

People showed less interest in forming social groups for dengue prevention. This directly points out the need for linking the general public and the relevant authorities to establish an efficient and sustainable dengue prevention system. And it clearly shows that the existing community has the capability to handle a mobile app to input data. Also, they have literacy to track the issue and understand the situation of dengue in their neighborhoods. Moreover, existing systems which have limited capabilities such as data collection and determination are not able to fulfill their requirements. In terms of promoting the use and evolution such citizen science platform, thus ensuring an optimal uptake of the results, the system could allow users to analyze data and provide capabilities to make decisions out of the data they collected as the main strategy.

Discussion and Conclusion

The survey findings provide a guideline for the future development of a dengue prevention mobile application for Sri Lanka. As a promising factor, more than half of the participants showed their highest level of concern on reporting a dengue breeding place to the relevant authority and also confirmed their current active engagement in dengue prevention activities by indicating that they have communicated with the council very often in the recent past. The ground level enthusiasm is a positive feature and also an indication of a need for a better communication system for dengue prevention activities.

The findings support the economist approach of open source participation [32]. People tend to take action on common activities if they receive tangible or intangible intensives. Gamification [36] is a tool that can be incorporated with the development of the mobile application as a way of providing intensives. As a way of moving forward, we had some initial discussions with the council on introducing a scoring system for the general public on their actions. This will include providing free parking tickets, providing priority for council's services, and providing badges or certificates for the citizens who actively engage through the APP. This creates a push factor for the non-contributors to come forward as the social norms urge them to do so [30].

The confident level of using ICT was high among the participants. Among the other age groups, the young group showed a higher level of confidence level in using every aspect of the ICT. As a developing country, this is a promising sign for introducing such technologies in the public welfare sector. As the younger generation grows with the years, this can be viewed as a great potential for the sustainability of an open source product. However, as a tool for social justice, the ICT literacy level among the elderly group should be upgraded by conducting workshops freely. A self-explaining clear and structured mobile application will facilitate any age group in society [36].

Educational level and the confidence level of using a mobile application showed a significant correlation. The findings indicated the low level of confidence level in using a mobile application among the people who have a low level of education. The recent experience with using mobile application among the taxi drivers in Sri Lanka, however, shows a contrast opinion for the findings. There is a boom in using smart technology in that industry. If the mobile application is user-friendly and simple there is a high possibility of popularizing it. Economically, if the App provides easy solutions for community problems, people will easily download it.

The findings reveal the community desire in receiving follow up messages on their requests from the relevant authority. Previous practical experience around the world, also suggests the necessity of linking the community with the relevant authority to make the application trustworthy. Sustainability of an open source technology is dependent on the value that the user receives upon their action. If they are satisfied with the action that has been taken upon their request they tend to use it again. The previous dengue prevention application which was introduced in Sri Lanka were lacking the linkage between the relevant authority and urged the community to form social groups and act upon their problems. As a remedy for this matter, we have identified the Dehiwala Mount Lavinia municipal council as the implementing partner of the dengue prevention project.

The findings of the need and the sustainability assessment of the dengue prevention mobile application indicate the high level of feasibility in introducing an App. The success and the sustainability of the product will rely on the better incorporation of the community desires and the user-friendly design elements with the development. To ensure the user-friendly and convenient structure of the application, there need several rounds of prototype testing on the ground with the participants. The development process should go several rounds with the incorporation of the feedbacks receive through the prototype testing.

Proposed system framework and recommendations

Despite a variety of mobile applications and open source platforms for dengue prevention, still, there is a need to stimulate the usage of the citizen-centric application to assist the planning of dengue control interventions. Motivate citizens to utilize such application is still a challenge. Moreover, the system should provide comprehensive information and analytical capabilities which should not require extensive experience in programming skill or great expertise in application and analysis.

Analysis of this paper proves that a confident level of using ICT, internet and smartphone literacy was high among the participants. Moreover, the enthusiasm of participants indicated a need for a better communication system for dengue prevention activities. In order to achieve the goals such as improve the utilization of technologies in public welfare and health sector, develop and implement a sustainable open source platform, a generic framework which integrates different technologies and tools was developed. An overview of integrated technological components and data flow is illustrated in Figure 5.

The framework proposes a web and mobile frontend to interact with the users, which provides data collection, visualization and analysis features and functions especially emphasized with geospatial properties. Free and Open Source Software (FOSS) is highly utilized and rapidly improving in many developed and developing countries. Also, it is highly represented in the world of GIS. In terms of usability and functionality of present FOSS architecture, this software is more sophisticated than proprietary systems. Therefore, the paper proposes, all the components and the core of the system must be developed by utilizing Free and Open Source geospatial technologies. Both mobile and web applications enable collecting and reporting the vulnerable locations for dengue and their information. Then data will be stored in a centralized server. Since the data can be contained personal information, it provides functions to Coordinator/Admin to manage the data. Furthermore, it is given privilege for authorized users and scientific researches to utilize data under the observation of Coordinator/Admin. Similarly, the system allows relevant data

discoverable and available to the general public via web and mobile frontend. Also, it enables users such as PHI, doctors, local officers, and the general public to visualize and analyze data. The recording of data and the sequent processing of data need a certain level of validation which guarantee the data are suitable to feed into higher level algorithms to do that, the paper suggests to utilize Geotagging option available in open source based Geographical Information Systems which facilitates to add geographical identification metadata such as photos, videos, notes, etc along with the latitude and longitude coordinates. Therefore, geotagging can help PHI officers to check the reliability of the location-specific information of the reported case location before uploading them into the system for further processing and analyzing.

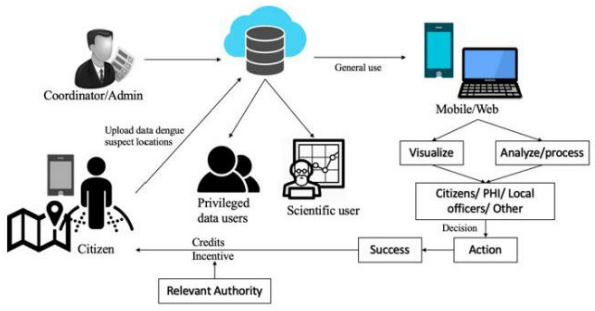

Figure 5: Overview of integrated technological components and data flow.

This intervention stimulates general public and authorities to take action against spreading dengue and improve the awareness for prevention. After every successful attempt, the citizen who engaged in the case will be provided incentive and appreciated by the local authority or the relevant organization. It focuses on provoke people in engaging with such activity, supports the creation of data for dengue prevention in Sri Lanka.

The analyzed information by the PHI officers can be presented in the form of a web or mobile applications. Due to the rapid increase of mobile phone usage of Sri Lanka, most users prefer to receive the information as an SMS notification. Therefore, Public participation in a mobile APP should be encouraged through an active campaign. As the local authority is actively engaged in the process of developing in this APP, a series of public awareness programs can be organized in different locations of the council area with the support of public health officers. As the DMMC area has a number of tertiary educational institutes the campaign program can mainly target that age group. Additional information can be announced through newsletters and brochures and can be distributed among the general public. The mobile APP can also be customized to send SMS alerts to residents of the DMMC area when the recorded number of Dengue patients in the area exceeds a particular threshold level. The big data gathered by the PHI officers can be evaluated under the ward level to determine the appropriate threshold level for each ward. Further, the data can be coupled with data collected from other secondary sources such as Meteorological Department, Census and Statistics Department, and other agencies to investigate the causative factors behind spreading of Dengue.

The study location is in the western province of Sri Lanka which shows the highest level of computer literacy rate in 2016 (38.1%). (Department of Census and Statistic, 2016) Further, the Colombo district has the highest percentage distribution of internet (31.5%) and e-mail (19.5%) using household population. Therefore, when applying these findings to another location special attention should be given for the specific demographics variations.

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