
Addressing Landslide issue in Sri Lanka using a web-based mobile application

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List of Acronyms

AGPS	Assisted Global Positioning System
ADRC	Asian Disaster Research Centre
AI	Artificial Intelligence
ANN	Artificial Neural Network
API	Application Programming Interface
ASP	Active Server Pages
AUTEC	Auckland University of Technology Ethics Committee
CDN	Content Delivery Network
CPU	Central Processing Unit
CS	Computer Science
CSS	Cascading Style Sheets
CSV	Comma-separated Values
DFD	Data Flow Diagram
DMC	Disaster Management Centre
DSR	Design Science Research
DPADM	Department of Public Administration and Disaster Management
ER	Entity Relationship
GIS	Geographic Information System
GLC	Global Landslide Catalogue
GPS	Global Positioning System
H/W	Hardware
HCI	Human Computer Interaction
HSPA	High Speed Package Access
HTML	Hypertext Mark-up Language
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IDE	Integrated Development Environment
IIS	Internet Information Services
IS	Information Systems
ISP	Internet Service Provider
IT	Information Technology
IoT	Internet of Things
JSON	JavaScript Object Notation
L/W	Live Ware
LCD	Liquid Crystal Display
MCC	Mobile Cloud Computing

MPADM	Ministry of Public Administration and Disaster Management
ML	Machine Learning
MS	Microsoft
MVC	Model-View-Controller
NASA	National Aeronautics and Space Administration
NEOP	National Emergency Operational Plan
OOP	Object Oriented Programming
OS	Operation System
PIS	Participant Information Sheet
QA	Quality Assurance
RAM	Random Access Memory
REST	Representational State Transfer
RSS	Really Simple Syndication
S/W	Software
SDK	Software Development Kit
SDLC	Software Development Life Cycle
SQL Server	Structured Query Language Server
SSD	Solid State Drives
SysML	Systems Modelling Language
TFT	Thin-Film-Transistor
UI	User Interface
UML	Unified Modelling Language
URL	Uniform Resource Locator
URS	User Requirement Specification
UX	User Experience
VS	Visual Studio
W3C	World Wide Web Consortium
WCAG	Web Content Accessibility Guidelines
WF	Web Framework
WWW	World Wide Web
XML	Extensible Mark-up Language

Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person; nor does it contain material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Chathura Roshan Silva

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Ethical Approval

Ethical approval for this research was obtained from the Auckland University of Technology Ethics Committee (AUTEC) on 25th June 2019, AUTEC application number 19/193. The approval can be found in Appendix A.

Abstract

This research is focused on creating a web-based mobile application to address the Landslide issue in Sri Lanka. Sri Lanka is a tropical country which suffers from Landslides continuously due to primarily the monsoon rain season and geographical terrain factors. Rain-induced Landslides affect the lives of the people, their public and private properties, the infrastructure of the country as well as the national economy. The south-western and central provinces are the most highly affected areas in the country. Due to the dynamic weather changes and unpredictable causal factors of the Landslides, it is difficult to predict this hazard. Sri Lanka is a third world country and the government struggles with limited resources to help the victims who suffer from this catastrophe.

The Web and mobile technology are two technological mechanisms which can be used for convenient data gathering and interactive information sharing. This research has developed a web-based mobile solution which can represent information which is related to Landslides in Sri Lanka in a convenient and interactive manner. Due to the fact that the outcome of this research is a technical prototype, Design Science Research (DSR) methodology is the desired methodology for this study. This study will structure its research process to reflect on the vital phases of DSR. A literature review process, a development process and an evaluation process will be carried out to determine the desired outcome.

The data are fetched through web sources and the processed data will be visualized on the geospatial map interface of the application which uses the Google Map Application Platform Interface (API). The heavy rainfall is the primitive factor for the rain-induced Landslides in Sri Lanka. The weather history and weather forecasts are fetched through AccuWeather Web API. The locations of the previous Landslide events are fetched from the Global Landslide Index API by NASA. The National Building Research Organization is the governmental body which sketches the hazard prone locations which could trigger

a potential landslide. Those maps are purely paper based and through a web tool, those sketches are converted into map coordinates and will be displayed on the map interface.

Apart from that, users are given an interface to input data by creating markers on the map application which are the factors of Landslides. Those markers are validated through a social proofing process. Also, users can create campaigns through the application to share resources among the victims. These are the main functionalities of the intended application which are linked to the research objectives. Those functionalities are precisely illustrated in the development phase of the methodology which uses iterative prototyping as its Software Development Life Cycle (SDLC).

Furthermore, this technical solution will be evaluated through a questionnaire. The focus group consists of ten people from the south-western provinces in the country. The discussion is carried out using the feedback given by the participants as it relates to the effectiveness, benefits, weaknesses, further required development and limitations of the solution.

1. Introduction

The Web and mobile technologies can be used as a helpful tool to tackle various real-world problems. The Web and mobile technology can be utilized to access information in a convenient and interactive way. Creativity and innovation can be applied to these technological tools as a way of increasing the productivity and efficiency as it relates to tackling real world issues. This research is focused on creating a web- based mobile application which can be used to address the Landslide issue in Sri Lanka.

Landslides are an ongoing natural catastrophe in Sri Lanka which results in human losses. Although stopping or predicting this natural phenomenon may not be possible, gathering data related to these events may help to more closely and conveniently study this issue and provide relief effectively. This research process is conducted using Design Science Research (DSR) methodology and proper phases are carried out to investigate the key elements, findings and factors which are required to develop a technological artefact. Furthermore, the basic phases of artefact creation are carried out and the outcome will be evaluated.

Proper research objectives are placed as a guideline to manage the research process. This study is not entirely about creating just a web-based mobile solution it is also about understanding the factors of this natural phenomenon and finding ways to collect reliable data related to these events through web sources. Combining the data into a feasible mobile solution along with finding an innovative way to help the victims through this technological solution are the goals. Lastly, an evaluation process will be carried out and will discuss the potential benefits, weaknesses, further development requirements and limitations of this technological solution.

1.1 Background

Background demonstrates the key issue which impacts the society. Factors of the issue and its impact are discussed in this section. Country of the issue is a primary concern as research objectives and the research question are created focusing on that. Overall, the background explains the depth of the issue and its significance.

1.1.1 Landslides

A land slide is a slope failure which results in a gravity driven downhill ground movement. A landslide could create various effects ranging from a rock falling to a whole mountainside collapsing. The slope movement occurs as the gravity which forces the down slope, becomes stronger than the physical strength of the earth materials that constitute the slope. The landslide is a global catastrophe which destroys human lives, properties and the infrastructure of the country (Davies, 2015). According to the research by the Department of Geography at Sheffield University, approximately 4862 distinct landslide events have occurred from 2004 to 2016 resulting in 55,997 human casualties (J & Petley, 2018). Figure 1.1 below displays an image of “Aranayaka” Landslide in Sri Lanka which created 92 human casualties and 502 building destructions (FloodList Web, 2016).



Figure 1.1: Aranayaka Landslide (FloodList Web, 2016)

1.1.2 Factors of a Landslide

Numerous factors could cause a landslide. Due to the diverse nature of the factors which could influence, trigger or cause a landslide, it is difficult to create an in-depth factor index. According to the gathered information, a general index of factors related to Landslides can be created. The general factors of a landslide can be categorized as geological, physical, endogenic (Davies, 2015), exogenic, meteorological (Peruccacci & Brunetti, 2018), (T.McColl, 2015) and human factors (Haigh & Rawat, 2012).

The terrain features of earth (Weedaga, Rathnayake, & Wanasundara, 2019), such as, hillside slopes are one of the primary reasons that cause a landslide. The angle of the slopes, the position of the slopes, for example, the escarpment slopes (Saroja, C.S, & Gunatilake, Morawakkanda Landslide - Geology and Soil Properties, 2019) are the geological features which are linked to a Landslide. These factors can be defined as geological factors while the strength of the slope can be considered as a physical factor (Davies, 2015).

The steeping or heightening of the slope, the removal of lateral or underlying support, the loading or surcharge of the upper edge of the slope and, the changes in either relative relief as a result of faulting can be considered as exogenic factors (Alexander, 1992). The disintegration that weakens the soil created by the weathering conditions, the death of the plants which holds the soil together, and the increased infiltration of water which can lead to soil saturation and lateral pressure created by the swelling, shrinking, freezing and thawing can be considered as the endogenic causes. The hydrologic factors, such as, the ground water level is also a sub factor of the endogenic factors (Weedaga, Rathnayake, & Wanasundara, 2019).

The earth soil layer can be broken into three layers. The top level is the surface layer which holds the terrain factors. The features of the top layer belong to the exogenic factors while the features of the middle and bottom layer belong to the endogenic factors.

The middle layer is known as the slip slope and it is comprised of several clay and mineral particles. The slip surface is composed of these soil particles and nature and the physical factors of these particles could also activate a landslide as well (Ahamed, Jayasinghe, & Christoher, 2019). Figure 1.2 below illustrates a diagram which summarizes the general factors related to a Landslide.

Heavy rainfall and rapid snow melt (Davies, 2015) can be defined as meteorological factors while deforestation, construction and mining can be considered as human factors (Ratnayake & Herath, 2015).

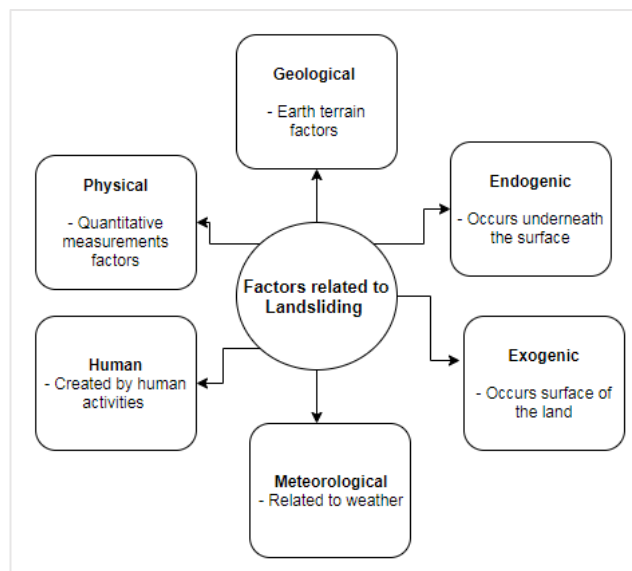


Figure 1.2: Factors which could trigger a Landslide (Source: Author)

Any human activity which could influence the exogenic and endogenic factors can be considered as human causes. Road cuts and stream cuts for agriculture could result in the removal of the underlying support of soil while construction and landfill dumping could create a surcharge of the upper edge of slope. Deforestation could destroy the plants which hold the soil strong (Hewawasam, 2010) and mineral and gem mining activities could result in weakening the slip surface (Gunathikala, 2007).

Heavy rainfall is one of the meteorological factors that triggers a land slide. Countries in Asia which face monsoon cyclones (Ratnayake & Herath, 2015) suffer from several natural disasters due to rain. Landslides are one of those natural disasters.

Figure 1.3 below depicts a map which was developed as a part of Global Landslide Catalogue (GLC) by National Aeronautics and Space Administration (NASA). The objective of GLC is to recognize any landslide influenced by rainfall (NASA, 2018).

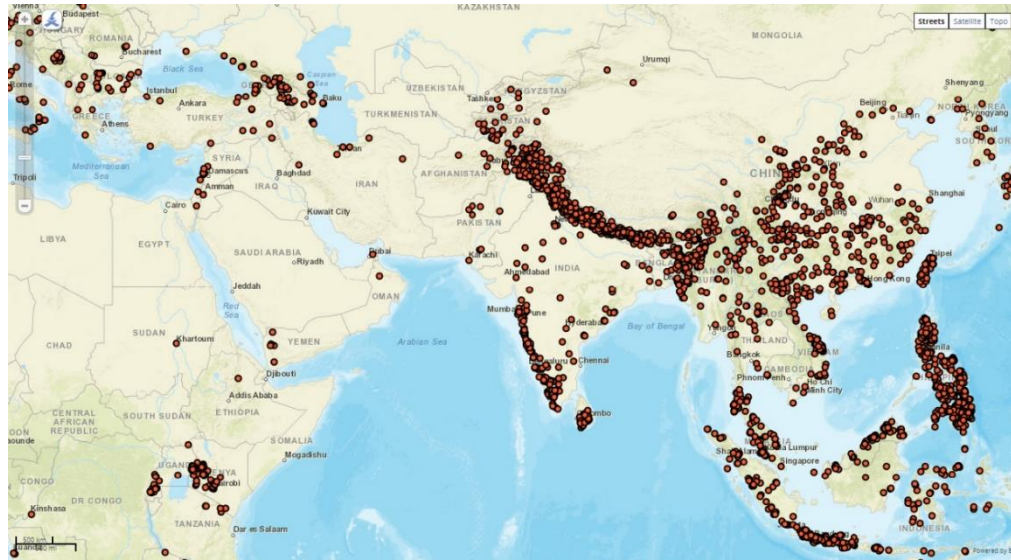


Figure 1.3: Global Landslide Catalogue (GLC) Map (NASA, 2018)

Asia is one of prominent regions which suffers from Landslides due to its geographical terrain features and monsoon cyclones. As shown in the GLC map, there are certain regions around the Himalayan arc that suffer severely from landslides due to its fragile geology, steep slopes and monsoon climates (Paudel, 2003). As the GLC demonstrates Asian countries suffer massively from rain-induced landslides.

1.1.3 Sri Lanka and Landslides

Sri Lanka, a tropical country located middle of Indian ocean. In the middle of the year, Sri Lanka faces the possibility of a monsoon cyclone and it is difficult to predict the exact time or duration ahead of time due to its nature.

Due to the geological patterns and terrain factors, such as, the steep slopes, southwestern and central provinces suffer from Landslides as depicted below in Figure 1.4.

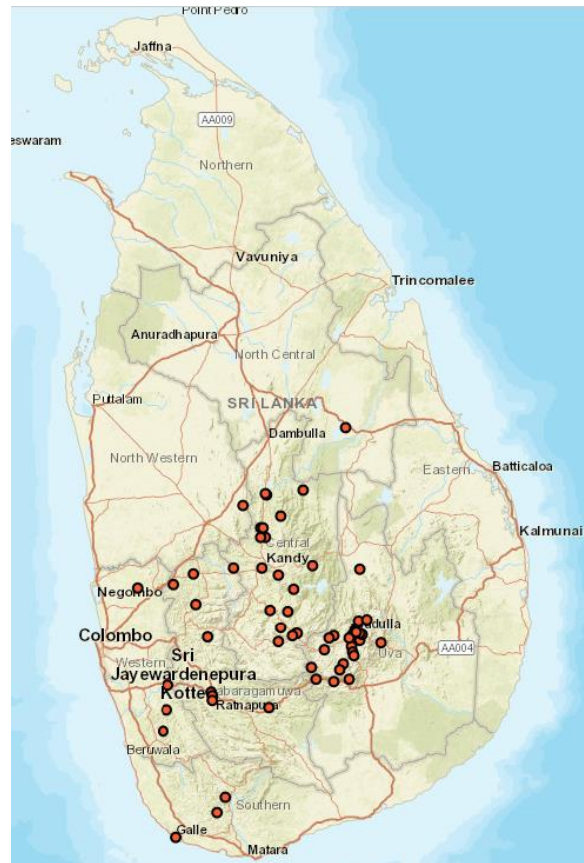


Figure 1.4: Rain-induced Landslides in Sri Lanka (NASA, 2018)

Every year Sri Lanka faces landslides which cost human lives. Table 1.1 below shows a table which demonstrates figures related to the impact of natural disasters from 1974 to 2016. This table is extracted from a report which was created by the Disaster Management Centre (DMC) of Sri Lanka. According to the statistics, Tsunami holds the first position for creating the highest number of human losses. Even though Tsunami was a rare natural disaster that Sri Lanka only faced in 2004 (Ahmed, Mulligan, Donovan, & Barton, 2017), Landslides occur frequently, and hold the second position in terms of human losses. Unfortunately, Landslides have become an ongoing natural disaster and have resulted in the highest number of human losses. Table 1.1 demonstrates the Sri Lankan statistics related to natural disaster impact from 1974 to 2016. This table is extracted from Asian Disaster Reduction Centre (ADRC) research program report.

Table 1.1: Natural disaster impact from 1974 to 2016 (Jayathne, 2016)

DISASTER/INCIDENT	DEATHS	INJURED	MISSING	HOUSES DESTROYED	HOUSES DAMAGED	AFFECTED
TSUNAMI	30959	19611	1908	57085	48208	1076240
LANDSLIDE	980	311	187	2589	10563	158959
ANIMAL ATTACK	967	605	2	195	7698	80062
CYCLONE	846	588	21	18147	111070	1371943
FLOOD	559	333	21	52763	160127	13821096
LIGHTNING	494	437	3	28	255	2072
EPIDEMIC	368	0	0	0	0	572635
STRONG WIND	148	375	44	5669	41803	420553
FIRE	101	356	0	1902	934	15058
DROWNING	75	8	13	0	0	50
RAINS	26	185	1	418	4400	745645
GALE	24	121	1	958	12675	115767
CUTTING FAILURE	23	34	0	82	769	16155
LAND SUBSIDENCE	17	8	0	69	1742	10403
EARTH SLIP	10	10	7	56	168	3043
CYCLONE & FLOOD	9	12	0	13178	37371	319128
CHEMICAL	5	2	0	1	0	424
ROCK FALL	3	4	0	10	41	576
FOREST FIRE	1	0	0	16	19	198
RETAINING WF	1	0	0	0	4	24
DROUGHT	0	0	0	0	0	16675914
LEAK OR SPILL	0	0	2	1	0	30690
STORM	0	0	0	2	33	7
TORNADO	0	0	0	25	166	430
URBAN FLOOD	0	0	0	0	0	155
TOTAL	35616	23000	2210	153194	438046	35437227

From ARDC Research program country report, 2016 by J.M.A.R. Jayarathne, created for DMC

1.2 Research Objectives

The Research objectives serve as the foundation for this study. This research has five objectives. Each objective is analysed in a systematic manner in order to achieve a successful outcome which is the aim and the reason this study has been conducted.

The first objective is examining the methods to apprehend the web-based data that is related to the Landslides in Sri Lanka. Web APIs or any other web sources can be used to obtain the relevant data. If some of the vital data is not attainable through web sources, then technical methods need to be implemented in order to convert the reliable non-digital data objects into web-based data objects.

The second objective is designing a web-based mobile prototype using front-end and back-end web languages to decipher, demonstrate and interpret the obtained data. The

primary prototype is an interface which demonstrates the data through geospatial visualization. The solution needs to have the capability to process the data into interactive information for the users. Research is focused on creating the solution using pure front-end languages without using any geospatial application tools for development. Due to being an open-source solution with a transparent coding structure, it is restricted to use any geospatial application tools for this prototype.

The third objective is designing a mobile interface to fetch the data related to the Landslides using the help of the community. Procuring the data supplied by the users and validating it and visualising it on the map are the focus of the objective. The data that has been fetched and validated is then stored in the application web server.

The fourth objective is designing a mobile interface for the users to collaborate and contribute resources for the purpose of helping the victims in an event of a natural disaster. The focus of this objective is finding the methods that will allow the application to be used for the purpose of resource sharing.

The fifth and final objective is evaluating the prototype through a questionnaire. The questionnaire tests the effectiveness, benefits, weaknesses, further development requirements and the limitations of the overall solution.

This study aims to accomplish these objectives in order to ensure that this research study is a valuable and worthwhile project.

1.3 Thesis Structure

Chapter one introduces the study. It describes the background of the study, the research objectives, thesis structure and the research questions.

Chapter two, which is divided into two parts, depicts the “Literature Review”. The first part examines the web and mobile technological concepts and advancements. The second part describes several web-based mobile solutions that have been created by the Sri Lankan authorities to tackle this Landslide phenomenon.

Chapter three delineates the “Design and Development” phase. This is a crucial part of this research since it focuses on the methodology. First, the desired methodology is analysed and the reasons for its selection are explained. Second, the desired technological solution is conceptualized by explaining the technological terminology, the data retrieval methods and it identifies underlying the factors that are related to the Landslides in Sri Lanka.

Chapter four, the ‘Building the solution’ phase, is woven around the desired Software Development Lifecycle (SDLC) and the User Requirement Specification (URS) to exhibit the functionalities of the proposed solution. A precise description of the proposed solution is conveyed through the URS.

Chapter five, the “Implementation” phase, demonstrates the steps of the actual implementation of the prototype. The technical design and the coding structure are described in this chapter.

Chapter six, the “Evaluation” phase, evaluates the compiled solution through a questionnaire. Ten participants from the south-western province in Sri Lanka, who were selected at random, were given ten questions to evaluate the effectiveness, benefits, weaknesses, further development requirements and the limitations of the solution. Finally, a discussion is created upon the evaluation to explain the research outcomes.

Chapter seven, the “Conclusion”, summarises the research that has been conducted. The research objectives, research question, methodology, development and research outcomes are briefly outlined.

1.4 Research Question

As discussed in *1.2 Research Objectives*, this research has five objectives. These include examining the methods to apprehend the web-based data related to the Landslides in Sri Lanka, designing a web-based mobile prototype using front-end and back-end web languages to demonstrate the obtained data, designing a mobile interface to fetch the data related to the Landslides through the prototype with the help of the

community, and designing a mobile interface for users to contribute resources in an event of a natural disaster to help the victims. The fifth and final objective is evaluating the prototype through a questionnaire.

Even though the Governmental authorities and non-governmental institutes have implemented solutions and processes to tackle the Landslide issue, due to the obscure nature of the Landslides and the lack of resources and funds, these solutions are not sufficient. Hence, it is necessary to create innovative technological solutions to tackle the various aspects of this natural disaster so they can be implemented for the social welfare of the people, their families and their communities.

Whilst the solutions may not be perfect or comprehensive, examining the technological tools to process the data related to the Landslides using the web and mobile technologies should be experimented with, as a helpful tool, to tackle this natural disaster. Therefore, the research question that this thesis aims to answer can be formulated as follows:

Are we able to Address the Landslide issue that occurs in Sri Lanka using a web-based mobile application which is developed using front-end and back-end languages?

This question aims to include all of the aspects of the research objectives, so this question is comprehensive as possible. “*Tackling*” can be any technological approach which will help to address this issue. “*web-based mobile*” states that this solution utilises technological aspects and the advancements of web and mobile technologies. “*Front-end and back-end languages*” specifies the web programming languages that this application is built on.

2. Literature Review

The Literature review is an integral part of the research where the existing concepts and knowledge need to be inspected in order to conduct the operations of the research. The Research objectives need to have theoretical roots in order to execute the research to achieve the outcome. The Literature review acts as a tool to assist with the formulation of the research question. The Literature review is divided into two sections. The first section investigates the technological concepts and advancements which are related to this study. Several web-based mobile application solutions are discussed in the first section in order to demonstrate how web and mobile technologies can be utilized to tackle Landslide issues. The second section investigates several technological approaches taken by governmental bodies to tackle this issue.

2.1 Technological Advancements of Web and Technology

Computer technology uses computer science as a practical tool to solve various problems. Computer science has created different innovative technological solutions to increase efficiency in solving issues and stimulate the outcome process. These solutions can be used as a tool to overcome the general issues faced by the society. Physical entities, such as, Central Processing Unit (CPU), Laptop or Smartphone can be considered as physical technological products while the Internet and Email can be considered as intangible technological products (Hare, 2017). Some solutions can be combined together in order to enhance the effectiveness of the problem-solving capability (Blokdyk, 2019). This combination can be considered as technological integration. The Web and mobile can be considered as a technological integration in the modern world which has become an essential part of technological advancements (Aziz & Madani, 2015).

Applying scientific knowledge for human welfare is one of main purposes of technology (Aziz & Madani, 2015). Technology can take any shape and it can be integrated into various platforms to enhance the effectiveness of the desired outcome. Web and mobile

technology have become integrated to increase the productivity of services and to find new solutions for human problems (Bonk, 2009). Several technological advancements related to the web and mobile have been discussed below.

2.1.1 Geographical Information Systems (GIS)

Geographical Information Systems (GIS) use spatial or geographic data to process and manipulate the data into useful information through a digital visualization. GIS uses pins, indicators, polygons and other tools to create the solution. GIS is closely related with GPS (Global Positioning System). GPS is a navigation system based on satellite technology. Fundamentally, GPS measures the range of a particular object and simultaneously observes the location by the satellite and broadcasts the signal to the user (Xu & Yan, 2016). GIS can be further used along with Location Intelligence (LI) to derive many solutions which use GIS as the primal information source (Kudamatsu, 2018). LI is a method of investigating a particular issue using geospatial data. GIS can be used by mobile applications to identify casual events in a specific location and conduct an analysis of its impact (Kudamatsu, 2018).

Spatial analysis is involved with using any formal techniques which manipulate topographical, geometric or geographic properties. Spatial analysis that is created using GIS can be used to make smart decisions using Spatial clusters, Spatial interactions models and spatial patterns which are relevant to any field-or any focus group. Figure 2.1 below exhibits a spatial cluster which depicts child poverty in South America.

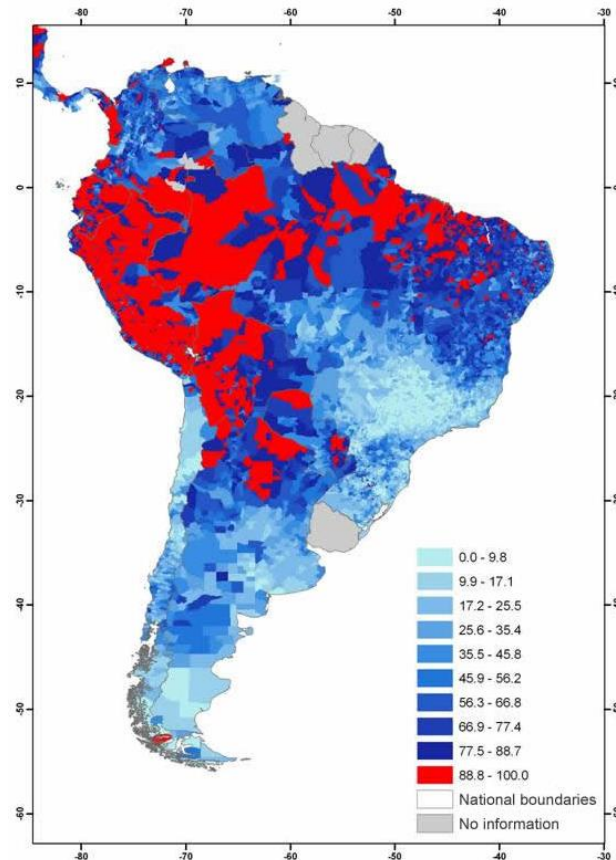


Figure 2.1: Child poverty distribution in South America continent (United Nations, 2014)

Geospatial Analysis can create useful interactive information using complicated or unstructured data patterns. Geo-mapping, variable selection and area definitions are used to generate geospatial maps (Kudamatsu, 2018). GIS technological tools can help by demonstrating the findings related to the subject in an effective and interactive manner to the audience/readers.

2.1.2 Web applications and front-end and back-end development

Software development is one of the most important aspects of information technology (IT) and computer science. Software is a collection of logical functions accompanied with data which can navigate a computer or network system. A software application is a form of software which is developed to perform specific tasks for the interest of an end-user. If an application requires a web connection to one or several servers, it can be defined as a web application (Krause, 2016).

Developing mobile and web applications requires knowledge of programming languages, developer tools, such as, software libraries, code editors and Integrated Development Environment (IDE)s. A web application operates in two environments simultaneously. Those environments are front-end and back-end. The front-end is the client-environment or the web-browser. The back-end is the server-environment or the web server. Figure 2.2 below demonstrates the front-end and back-end architecture of the web application development (Krause, 2016).

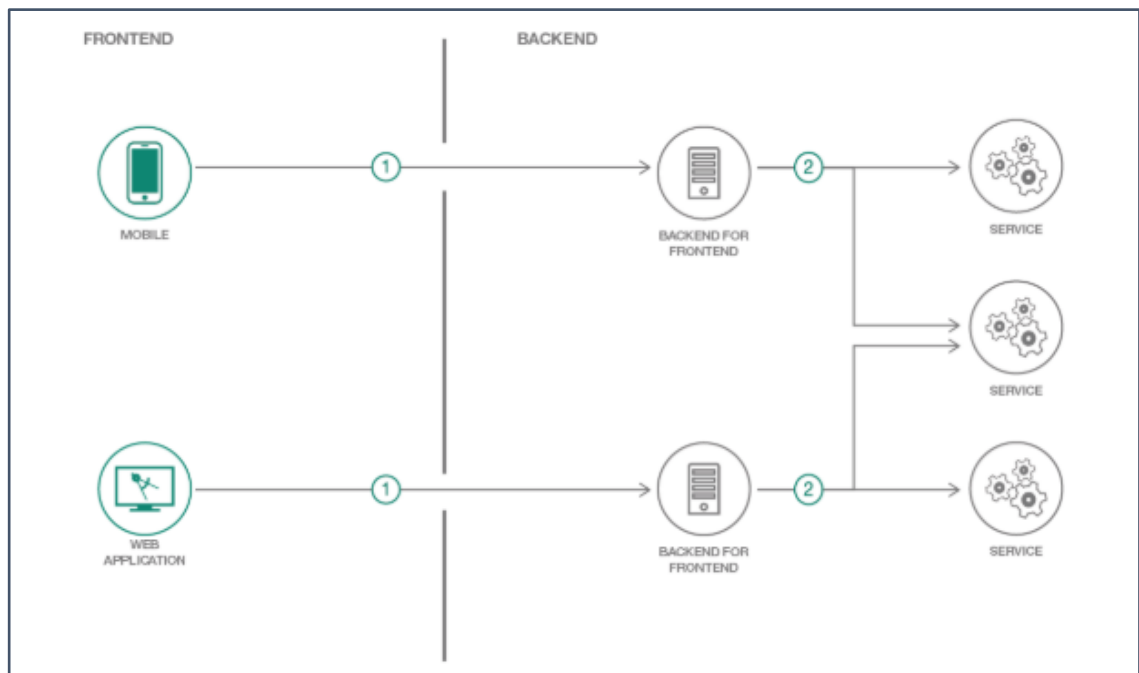


Figure 2.2: Front-end and back-end architecture of web applications (Martinelli, Samani, Tucker, Oliver, & Chang, 2018)

Programming languages which are interpreted in the web browser are known as the front-end languages while the programming languages which are compiled in the web server are known as the back-end languages. JavaScript is one of the highly used front-end language whereas Active Server Pages (ASP) is one of the highly used back-end language. User inputs and user views are primarily handled by front-end languages and the data and transactions are primarily managed by server-side languages (Vemula, 2017).

2.1.3 Mobile Application Development

If an application interface can be accessed by a mobile phone it can be described as a mobile application. If the mobile application has a back-end environment which has a connection to a web server or requires service from a web server, it can be defined as a web-based mobile application (Blokdyk, 2019).

Mobile phones were devices that had minimal requirements in the past. Along with the evolution of microelectronic engineering, the integrity of the mobile phone has changed. The modern mobile phone can execute a great number of functionalities which a personal computer can execute. The modern mobile phone is known as a Smartphone. The Smartphone has the ability to execute a great number of functionalities and the mobile phone has become a portable computer (Kavanagh, 2018). Mobile application development can use traditional industrial software processes and methodologies. Due to the portability aspect, mobilized data retrieval, inbuilt sensors, and the inbuilt features of mobile applications, they can execute extra functionalities which traditional computer applications cannot perform (Kumar & Krishna, 2016).

Android, iOS and Windows mobile are the dominant mobile operating systems that are used in smartphones. Java, CSharp, Swift and Objective-C are the primary programming languages that are used to develop the end-user mobile applications. Even though the market dominance of mobile applications has accelerated gradually, mobile application development faces various challenges. Since the smartphone is a portable device, its privacy and security are of primary concern. The marketplace has different devices with different operating platforms. Creating one application which is a cross-platform is not an easy task. Cross-platform application is an application which can run on multiple platforms. The mobile features of a smartphone change vigorously. For example, digital authentication has evolved so that face recognition through the camera or bio-metric finger recognition and it can be given as new mobile security features. Due to these new features, mobile application development methods need to be changed vigorously as well (Kumar & Krishna, 2016).

2.1.4 Web API

Before understanding “Web API”, it is vital to understand “API”. API or Application Programming Interface is an interface between two application platforms which facilitates the communication between those platforms. Due to the diverse features those platforms inherit, both platforms have to follow common documentation in order to achieve the goals of their transaction (Medjaoui, Wilde, Mitra, & Amundsen, 2019).

Web API is an interface which uses a Web Framework (WF) to create a connection between two platforms. The Client and the Server are the two platforms used in a WF. The interface between the ‘client’ and the ‘server’ to communicate and share resources through a network is the Web API. The client requests a resource and the server responds to that request. The Web API uses common identification methods to verify the request identifications. For example, an identification may come as a “Key” from a “Get” method. The Web API uses a URL (Unique Resource Locator) to send the request and the ID is transmitted through the URL. Resources can be data, such as, statistics, postal addresses or numerical figures or predefined methods to manipulate the programming segments or multimedia items, such as, images or videos. WF uses the HTTP (Hypertext Transfer Protocol) protocol to create the connection between the client and the server. HTTP is the foundation protocol for the World Wide Web (WWW) (Kanjilal, 2013).

A Web application is a program which creates a connection from a client to a server in order to achieve the tasks of the application. An example would be an Email-client application in a mobile platform. An Email-client application will automatically synchronise with an email server and download emails every hour automatically. A Web application can use a Web API to simplify the communication related to fetching the data. Some applications may use multiple Web APIs and those applications are known as Mashups. An example would be a social media application/program which keeps track of a group of friends and their fun activities (Kanjilal, 2013). An Application can use Google Map API to find the location of the group activity and Cloudinary API (Cloudflare,

Inc., 2019) to store and retrieve the images of the group. Figure 2.3 below demonstrates the APIs that are related to google services (Google Geocoding API, 2019).

Name	
Maps JavaScript API	
BigQuery API	Maps Embed API
Cloud Datastore API	Maps Static API
Cloud SQL	People API
Cloud Storage	Service Management API
Geocoding API	Service Usage API
Google Cloud APIs	Stackdriver Debugger API
Google Cloud Storage JSON API	Stackdriver Logging API
Google+ API	Stackdriver Monitoring API
Google+ Domains API	Stackdriver Trace API

Figure 2.3: APIs related to google services (Google Geocoding API, 2019)

Web APIs are used to provide numerous web services. Weather information including precipitation (AccuWeather API, 2019), financial information like foreign exchange rates (Fixer Foreign Exchange API, 2018), daily news like alert news (Statistics Netherlands, 2019), spatial and geographic details like physical locations (Google Geocoding API, 2019) and communication information like postal codes (NZ Post, 2019) can be considered as widely used Web APIs.

2.1.5 Internet of Things (IoT) via Internet

The IoT (Internet of Things) is a connection of devices through a series of layers to produce the information that is gathered through the layers. One of the layers includes the electronics-software and mobile devices that are part of it. One of the important layers is the connectivity and the network or the network of networks and ultimately the internet is the largest and most widespread network. The transmission of information through protocols and interpreting it to the User Interface (UI) is possible through web. Data needs to be properly processed and with the development of web and data modelling,

computer engineers have had issues with processed data regarding clarity and accuracy. Through the individual development of each of the layers of IoT, such as, the electronics, sensors and mobility, the amount of processed data of each layer has increased over the years, and this has led to complications naturally. Ideology behind this echo-system of IoT is to provide IoT-generated quality data to different sectors. These sectors can be energy, healthcare, environmental, transportation and safety and security (Alaya, Drira, & Gharbi, 2017). Figure 2.4 below demonstrates an illustration of the components of IoT.

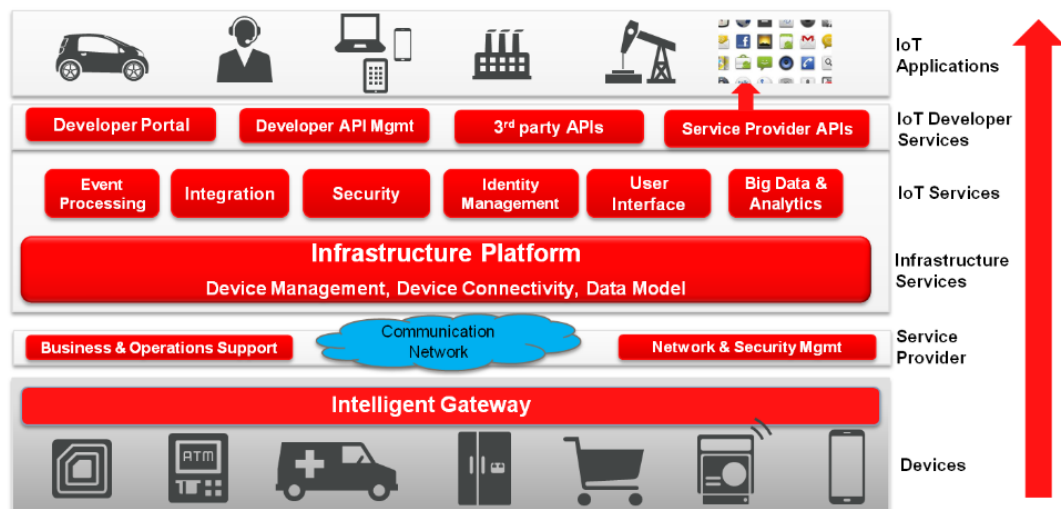


Figure 2.4: IoT components (Acharya, 2015)

2.2 Web-based mobile application solutions

Web-based mobile solutions can be used to tackle real world problems and contribute towards social welfare. Mobile applications help tackle problems in an efficient and innovative manner through better data manipulation. The following examples depict several web-based mobile solutions which have been developed to tackle various real-world issues.

2.2.1 Example 1: Healthcare mobile application

The use of deep neural networks on a mobile application focusing on healthcare is research that was conducted by Jose I. Benedetto, Pablo Sanabria, Andres Neyem, Jaime Navon, Christian Poellabauer and Bryan Xia.

Deep Learning is a derived Machine Learning (ML) method. ML is a broad scientific concept. ML is a subfield of Artificial Intelligence (AI) and Computer Science (CS). ML is woven around mathematical and logical constructions which learn from data rather than following procedures. ML processes data through real-time data learning patterns and transmits data live (Alaya, Drira, & Gharbi, 2017). Doctors and professionals in the medical healthcare world use mobile applications which help them to predict or detect data regarding anomalies relating to the medical reports of patients. Data analysis is processed through gathered data from various sources, such as, sensors, detectors and other input methods. The IoT has contributed to this advancement (Benedetto, et al., 2018). Deep neural networks rely on complex data processing thus require powerful workstations and servers. Deep neural networks are Artificial Neural Networks (ANN) which constitute human brains. ANN is not an algorithm, it is a framework of ML algorithms which process complex data (Benedetto, et al., 2018).

The requirement to have an advanced CPU server has been diminishing in recent years due to the advancement of cloud computing. Cloud computing is a technology where data processing can be done through WWW by connecting to a high standard server/CPU. The connection of cloud computing extends to mobile users where it allows the transfer of rich computational resources to users who are connected through mobile devices (Liu, et al., 2017). Retrieved medical data can be processed through the mobile healthcare application which uses cloud computing service. The capability of efficient mobilized data input and other processes is pragmatic due to these advancements that are related to the development of mobile applications.

The use of a web-based mobile application is very useful because medical anomalies are spread all over the world and rural and remote areas that do not have a strong network can get benefit from it (Benedetto, et al., 2018). A summary of the process related to the above mobile application is demonstrated in Figure 2.5 below.

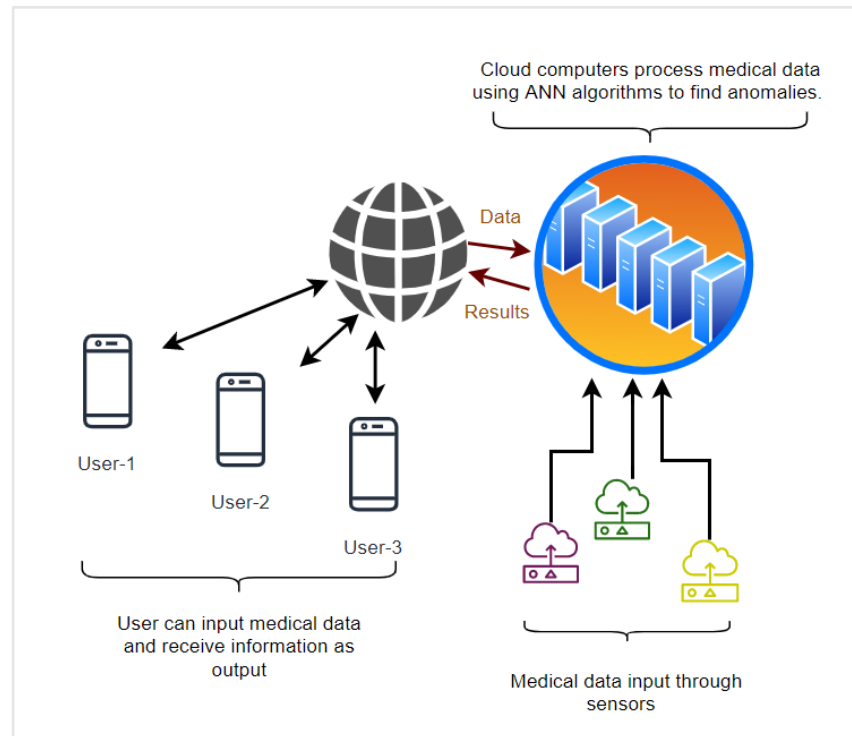


Figure 2.5: Data process of web-based mobile application which finds health anomalies using medical data (Benedetto, et al., 2018)

2.2.2 Example 2: Environmental mobile application

Smart Home 2.0 is an independent project that has been created using the infrastructure of cloud computing, IoT and mobile technologies. Using an open-source development software created by Hadoop, this application executes the functionalities of the system on the client-side. Mobile based cloud computing service supports the data processing functions (Liu, et al., 2017).

This application monitors plants, its productions and greeneries in a greenhouse. Sensors established in the greenhouse monitor the air conditioning, humidity and temperature. The User-End experience is accessed through an Android web terminal from a mobile device. Using the environment-monitoring intelligence equipment which has setup in different crops, data can be pooled into one cloud platform and simulate a large data analysis to provide suggestions for better farming.

Real-time data are monitored by the mobile devices. Figure 2.6 below exhibits the process of the Smart home 2.0 application. This mobile based solution is comprised of IoT and Mobile Cloud Computing (MCC) (Liu, et al., 2017).

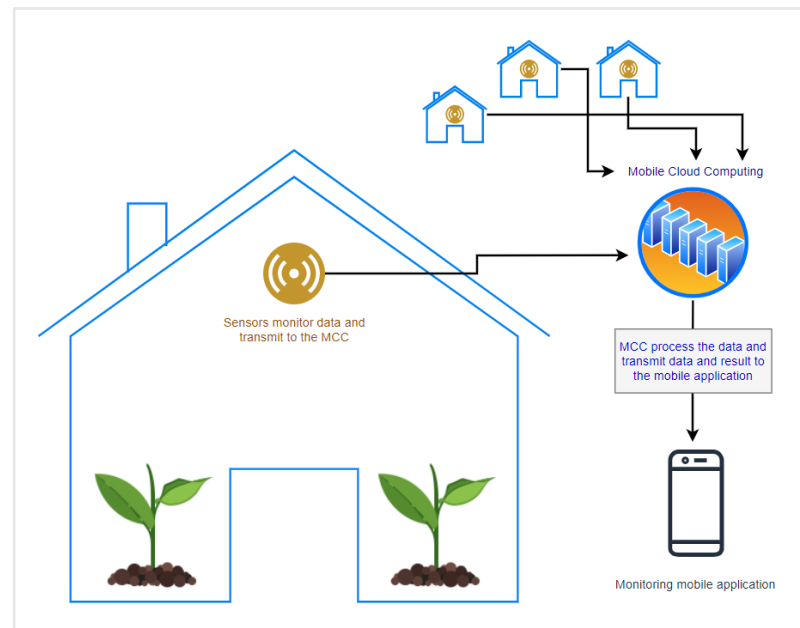


Figure 2.6: Process of Smart home 2.0 application (Liu, et al., 2017)

2.2.3 Example 3: Geographical and spatial mobile application

The GPS-Based mobile exercise application is an application which has been created by Jinwon Kim, Brijesh Thapa and Seongsoo Jang as an independent project to grasp the spatial-temporal activity patterns of people who visit Seraksan national park, South Korea.

Spatial-temporal activities are the events which occur that are related to both time and location. This application explores the activity patterns of the visitors who are using a GPS-based exercise dataset. These data patterns can be used for the actions of mitigating negative impacts to the natural resources of the national park as well to provide security to the visitors. In terms of acquiring the data, 1206 anonymous mobile application users along with 2541 activity start points were used to acquire the data. The result breaks down the activity hotspots related to the time durations, for example, morning, afternoon or evening. The result also marks risky points, such as, areas of

falling rocks or structure collapse. Figure 2.7 below demonstrates the findings in the form of geospatial data on the application generated map (Kim, Thapa, & Jang, 2019).

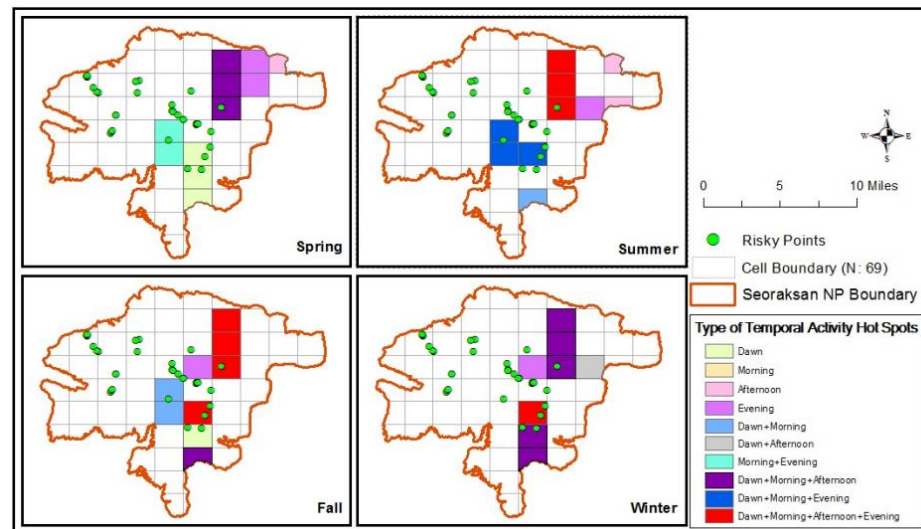


Figure 2.7: Results of GPS-Based Mobile Exercise Application (Kim, Thapa, & Jang, 2019)

The findings can be utilized by the management of the national park to accurately monitor the Spatial-temporal visitations during specific seasons and times.

2.3 Existing Web or Mobile based solutions to tackle Landslides by Disaster Management Centre - Sri Lanka.

The DMC in Sri Lanka is the governmental body which manages disaster mitigation activities and operates national emergency centres. The DMC is a subsidiary of the Department of Public Administration and Disaster Management (DPADM). The DPADM integrates the policies under National Emergency Operation Plans (NEOP). The DMC initiates campaigns according to the policies of the DPADM. The DMC focuses its motives regarding or related to the hazards profiling categories. One of main items in the hazard profiling category is Landslides. The DMC sets up its operations to address the areas of preparedness, mitigation, prevention, relief, rehabilitation and reconstruction. DMC works along with relevant stakeholders to achieve its objectives. In an event of a natural disaster, the DMC creates campaigns and establishes safe locations for the victims to evacuate (Jayathne, 2016). According to the situation report of the DMC on September 2019, the DMC has established 13 safety locations and 129 families had

been temporarily located in those locations (Disaster Management Centre - Sri Lanka, 2019).

2.3.1 Solution 01:

The DMC web site is an active website which keeps updates about possible disaster situations in Sri Lanka. The DMC website constantly updates time sensitive information, such as, early warnings and weather forecasts. The Website issues dynamic alerts and news related to natural events which could lead to possible casualties. This web alert system on the website focuses on urging preparedness for a possible disaster event and to mitigate possible casualties. Figure 2.8 below demonstrates a screenshot of the DMC website. Website also publishes information regarding donation campaigns, relief programs and donation gathering activities that take place to help prevent a natural disaster. People can get information or participate in DMC activities to provide relief to the victims through their website (Disaster Management Centre - Sri Lanka, 2019).



Figure 2.8: Web alert news system by DMC website (National Building Research Organisation - Sri Lanka, 2019)

2.3.2 Solution 02:

The "RiskInfo" website is a web project initiated by the DMC as demonstrated in Figure 2.9 shown below. The "RiskInfo" web site provides descriptive datasets that are related to the aftermath of natural disasters. This website has divided all of the possible disasters

into categories. Users can search for the vital data related to natural catastrophes on this website (RiskInfo - Sri Lanka, 2019).

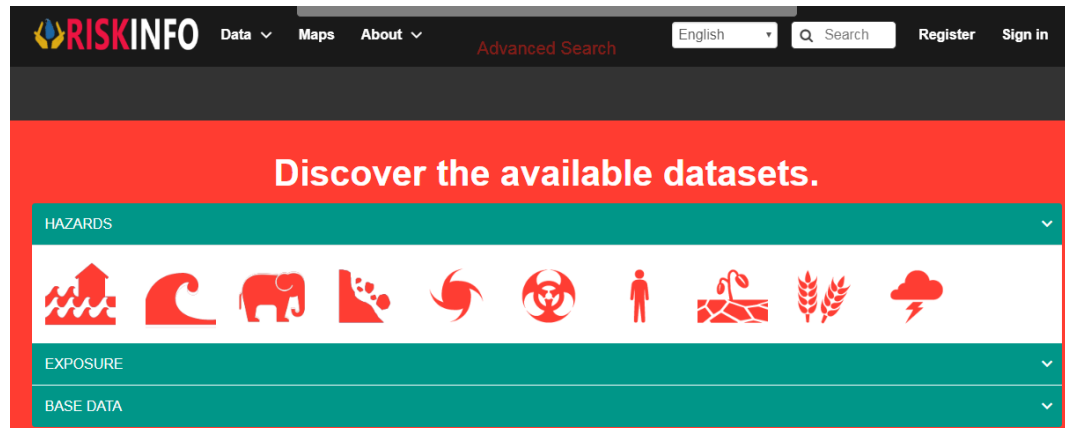


Figure 2.9: Homepage of “RiskInfo” website by DMC (RiskInfo - Sri Lanka, 2019)

2.3.3 Solution 03:

The Disaster Emergency Warning Network (DEWN) mobile application is a mobile platform which was collaboratively created by DMC, Dialog telecom company and Microimage mobile media company. In 2004, the Tsunami that hit Sri Lanka caused the highest number of human losses due to a natural disaster (Ahmed, Mulligan, Donovan, & Barton, 2017). In the aftermath of this tragedy, the DMC initiated several programs collaboratively with other private organizations to increase awareness about natural hazards. This mobile application was funded by the Dialog telecom company and it was developed by the Microimage mobile media company. The DMC uses this application to send alerts related to Landslides, Floods, rising water level, weather conditions and other natural disaster related real-time alerts. With the increased mobile connection usage in Sri Lanka, which was 26.1 million mobile connections in 2015, DMC realized sending mobile notifications through this application is an effective and economical communication method (Global System for Mobile Communications - Sri Lanka, 2015). Alerts related to Landslides are fetched from the National Building Research Organization (NBRO) which is the governmental body for Landslides research activities (National Building Research Organisation - Sri Lanka, 2019).

Figure 2.10 below exhibits several User Interface (UI) screenshots of the DEWN mobile application. The application provides a description about possible events and their details.

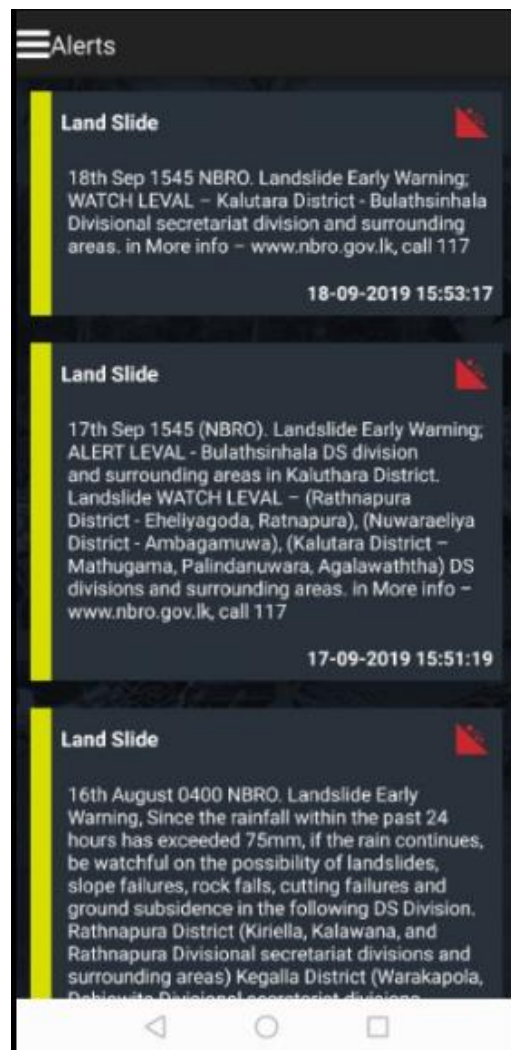


Figure 2.10: Screenshot of DEWN mobile application (Global System for Mobile Communications - Sri Lanka, 2015)

2.3.4 Solution 04:

The NBRO, the governmental research body, is responsible for executing programs related to sustainable building construction. The research on Landslides is one of main objectives of the NBRO. The NBRO utilizes their resources to understand the nature of Landslides in Sri Lanka and they try to find solutions to prevent them, mitigate them or work on early detection (National Building Research Organisation - Sri Lanka, 2019). Their website provides valuable information related to the risk management of

Landslides, Landslide related findings, alerts, procedures and safety steps to undertake while carrying out construction project in an area which is recognized as a Landslide hazard area. The NBRO is the official institute to sketch the possible Landslide hazard locations onto the maps and distribute the information to the general public (National Building Research Organization - Sri Lanka, 2019). Figure 2.11 below shows the “Landslide Maps” page of the NBRO website. Their website publishes information and alerts related to Landslides.

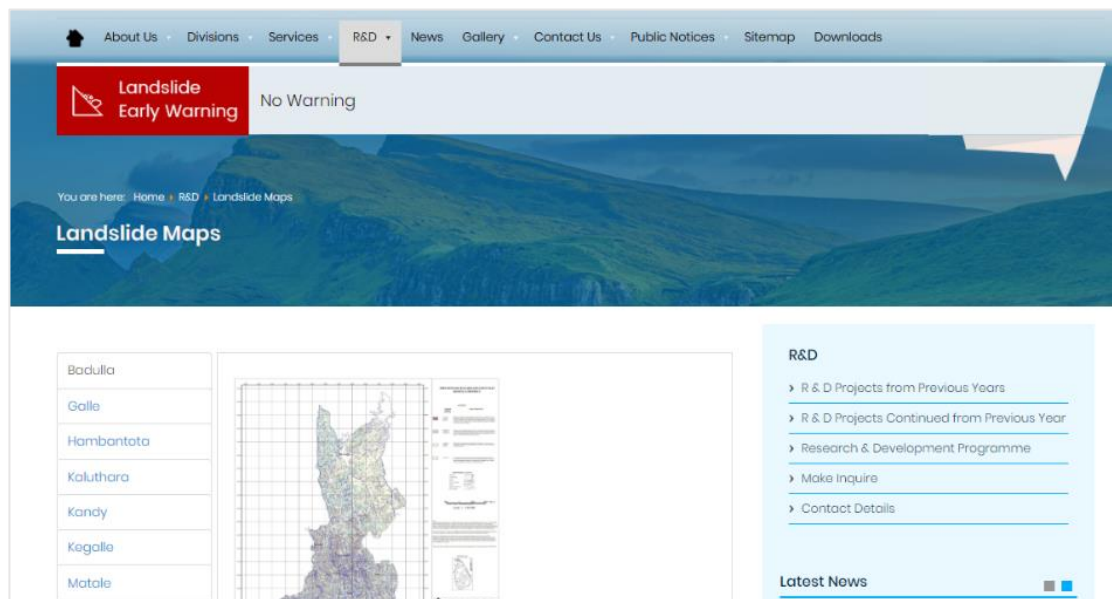


Figure 2.11: “Landslide Maps” page of NBRO website (National Building Research Organization - Sri Lanka, 2019)

As mentioned in the Research question, this study aims to investigate the possibility of utilising web and mobile technology to address the Landslide issue in Sri Lanka. The preceding literature review assists to formulate the following research question “Are we able to address the Landslide issue in Sri Lanka utilising a web-based mobile application that has been developed using front-end and back-end languages?”

2.4 Chapter Summery

This chapter describes several technological advancements and concepts related to web and mobile technology and several web-based mobile solutions which have been created to tackle real world issues. This chapter also describes several technology-

based solutions that have been initiated by governmental authorities in Sri Lanka to tackle the key issue, namely, the Landslides disaster.

3. Design and Development

Following the literature Review in the previous chapter, design and development focuses on the actual development of the solution according to the in the research objectives. The desired methodology and development techniques need to be established in order to conduct the design and development process.

3.1 Research Approach

The proper construction of the research design is determined by the research methodology. According to the research objectives, designing a prototype to investigate the issue of Landslides using a web-based mobile application within the scope of the study is required. The methodology is a theoretical approach to analyse the principles, processes and properly investigate the outcomes of the project (Ranjith, 2019). The research methodology determines the stages of the solution. The stages may start with identifying the issue and proceed to evaluate the solution. The desired research type varies, depending on the nature of the study (Bairagi & Munot, 2019). Depending on the outcome of the research, the solution could be a mathematical model, Information System (IS), Application, Theory, Algorithm or any other artefact.

According to the fifth edition of book “Research Methodology: A Step-by-Step Guide for Beginners” by Ranjith Kumar, Figure 3.1 below illustrates the basic flow of a traditional research methodology.

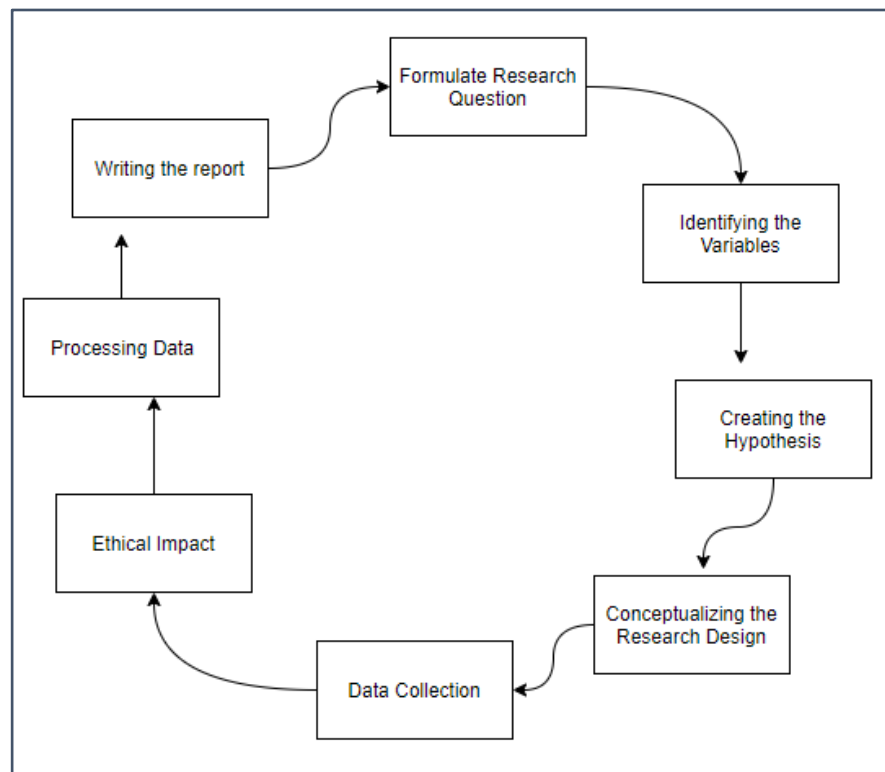


Figure 3.1: Flow of a traditional Research Methodology (Ranjith, 2019)

Adapting a suitable methodology will depend on several assertions. The desired methodology must be able to produce a working prototype of a mobile application which uses a map-based application. Correct principles, procedures and practices must be adopted to support the objectives of the research which are mentioned in the *Chapter 1*. Determining the merits and usefulness of the prototype must be carried out from a pragmatic process since it is a crucial phase for this research. The Evaluation process must help to identify the limitations, weaknesses and further required modifications. The Evaluation process acts as a terminal to modify the solution. The Research methods must be focused on pursuing research objectives which are involved with an artefact (Azasoo & Boateng, 2015).

DSR, an artefact-based methodology, comprises research methods which support paradigms, and quantitative and qualitative research methods which could guide this research to create a pragmatic solution which can justify the research question (Peppers,

Tuunanen, Rothenberger, & Chatterjee, 2008). Considering the above aspects, the DSR methodology can be considered as a viable option for this research.

Figure 3.2 shown below depicts a research design flow created by Julius Quarshie Azasoo and Kwame Osei Boatang, for their study “A Retrofit Design Science Methodology for Smart Metering Design in Developing Countries” (Azasoo & Boateng, 2015). This modified diagram was developed using the stages of traditional DSR.

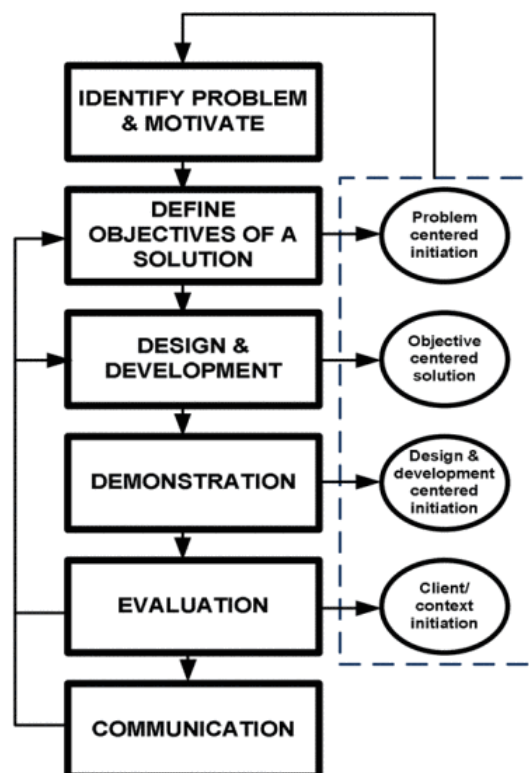


Figure 3.2: Flow of process for Retrofit DSR Methodology (Azasoo & Boateng, 2015).

The research question focuses on creating a prototype rather than a theory or a concept. Even though tackling Landslides disaster is the goal of the application, the research focuses on creating the solution using HTML (Hypertext Mark-up Language), CSS (Cascading Style Sheets), JavaScript and ASP.net which are web-based languages. HTML5 and CSS3 are the newest versions of HTML and CSS. According to the restriction implemented by *the research objectives*, this prototype will not use any geospatial development platforms or tools to build the prototype.

Figure 3.3 shown below illustrates a DSR methodology diagram which is modified to reflect the nature of this research. The initial part of the research design focuses on finding the factors which could act as the input/variables for the application.

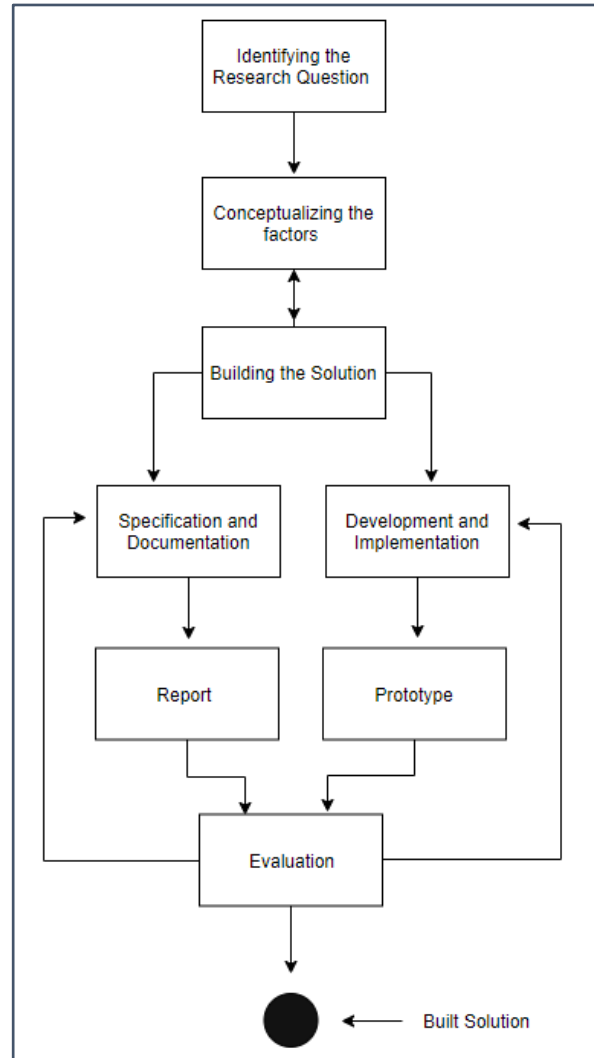


Figure 3.3: Modified DSR Methodology for this thesis (Source: Author)

Afterwards, the methods to retrieve the data required (for the factors) are identified and executed. Then the solution is drafted into a technical documentation known as the User Requirement Specification (URS). Then the prototype is built and documented. This research does not develop a complete feasible application. It focuses on the technical design (Merriam & Tisdell, 2016) and creating a prototype which can be evaluated into a pragmatic solution.

3.2 Conceptualizing the factors

In order to create a solution, the relevant elements need to be addressed. The factors related to Landslides in Sri Lanka, including the strategies and techniques put in place to tackle this disaster along with the technical approach of the solution must be investigated.

It is important to identify the factors which could influence a landslide. Identifying these factors is vital to determine the methods that need to be used in the application to gather the data related to the factors. As mentioned in *the literature review*, there are number of diverse leading factors that can cause a landslide. These factors can be categorized as geological, endogenic, exogenic, meteorological, physical (T.McColl, 2015) and human factors (Haigh & Rawat, 2012). Some of these factors are correlated to one another. These factors can create a Landslide while miscellaneous human factors (Alexander, 1992) can influence a landslide. Examples of the factors related to Landslides in Sri Lanka are illustrated in Figure 3.4 below.

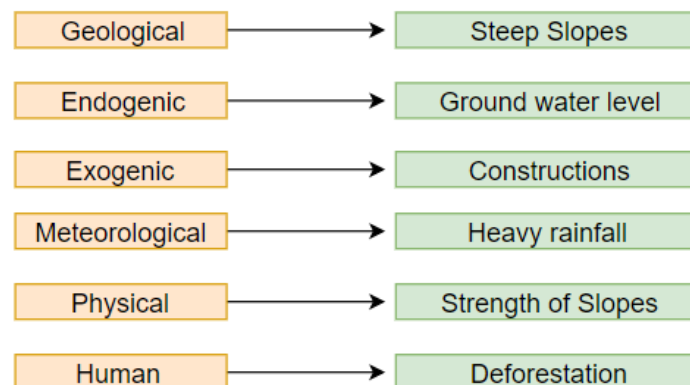


Figure 3.4: Examples of factors behind rain-induced Landslides in Sri Lanka (Source: Author)

Sri Lanka undergoes the monsoon rain season between March to December due to monsoon cyclones. The south-western areas and the central provinces of Sri Lanka face land sliding due to heavy rains. Since rainfall is the primitive factor which triggers a landslide in Sri Lanka thus it is known as a rain-induced land sliding (Ratnayake & Herath, 2015). This factor is an assertion and it needs to be measured using quantitative

units. Rainfall is measured using precipitation in millimetres per day (Ariyakumara, Prasadani, & Ekanayake, 2010). According to a research study conducted by NBRO using 15 major landslides and 25 minor slope failures, a Range of 150mm/day - 220mm/day was reported as the range of precipitations which influenced those hazards (Ariyakumara, Prasadani, & Ekanayake, 2010).

Slope inability is a geotechnical problem in some provinces in Sri Lanka due its geographical establishment. The hydrological characteristics of the soil and the endogenic factors are the root cause of this slope inability. 'Sabaragamuwa' is the political province in the South-Western area of Sri Lanka while "Madyama" is the central province in Sri Lanka. These provinces have numerous large-scale slopes, steep slopes and escarpment slopes (Saroja, Menikpura, & J.Gunatilake, Morawakkanda Landslide - Geology and Soil Properties, 2019). Morphologically, these slopes are present in various locations along with the diverse land cover which consists of numerous terrain factors (Weedaga, Rathnayake, & Wanasundara, 2019).

Figure 3.4 above shows that the deforestation is a human-made factor. There are several other major humans-made factors, such as, mining the land for gems (Gunathikala, 2007), creating engineered slopes for harvesting and agricultural activities, landfill dumping or the construction of roads (Hewawasam, 2010). Rainfall can be considered as a direct factor for this natural disaster while human made factors can be considered as indirect factors. Heavy rain may create small mudflows which weakens the soil and decreases its resistance to shearing. These mudflows are also known as natural drainage. These mudflows can also indirectly influence land sliding as well (Gunathikala, 2007).

Figure 3.5 below illustrates a diagram from a journal article extracted from “Geo-environmental Disasters Journal – 2018”. This research was carried out by E. N. C. Perera, D. T. Jayewardene, P. Jayasinghe, R. M. S. Bandara and N. Alahakoon. Spatial statistics demonstrate the impact of human activities on land sliding. While the areas highlighted in yellow are the landslide effected areas, the other highlights show areas with various human activities (Perera, Jayawardana, Jayasinghe, Bandara, & Alahakoon, 2018).

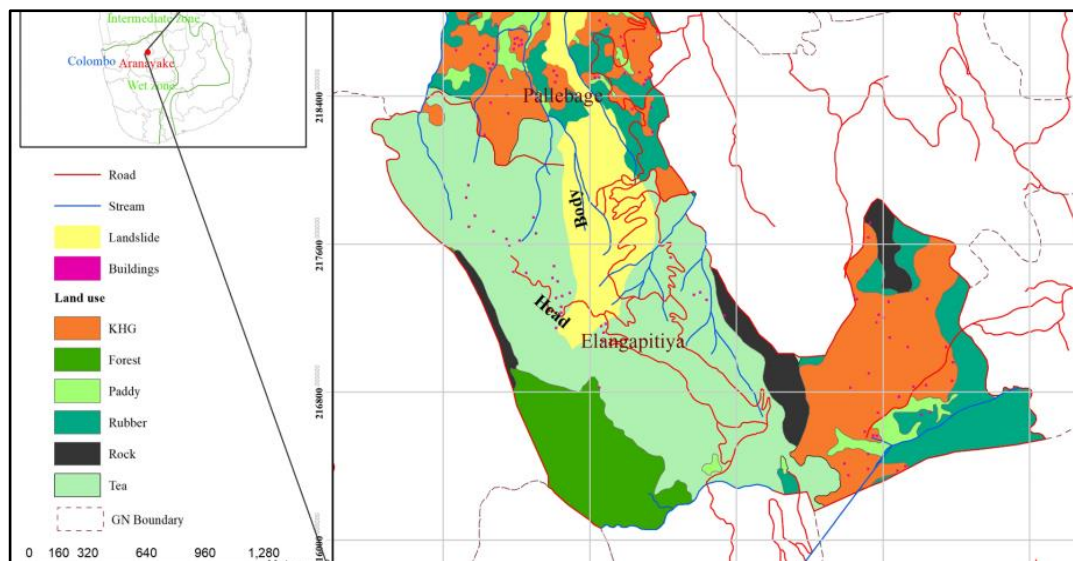


Figure 3.5: Human-made factors effect on Landslides (Perera, Jayawardana, Jayasinghe, Bandara, & Alahakoon, 2018)

3.2.2 Disaster Management Techniques in Sri Lanka

As mentioned in *the Introduction*, due to the land sliding phenomenon in Sri Lanka, people suffer injuries or lose their lives, lose their houses and commercial properties/crops or suffer damages every year. The infrastructure of the country gets destroyed or damaged, the national economy suffers from the temporary downfall and the whole country suffers from the social and economic calamity caused by the landslides (Perera, Jayawardana, Jayasinghe, Bandara, & Alahakoon, 2018).

According to the policies of DMC as mentioned in literature review, it is important to coordinate with the various stakeholders and involve them in their disaster management activities. The Public sector is the main stakeholder in the event of a natural disaster. The Public sector can help with resources and they provide support to those who are

affected by the disaster event (Jayathne, 2016). This contribution can be initiated parallel to the relief, rehabilitation and reconstruction activities of the DMC. The Public sector can contribute resources, such as, food and nutrition, healthcare products/ services and other materials related to basic needs. They also provide security and protection for the people by creating safe locations for the victims to locate to in a disaster event.

3.2.3 Technological Approach for finding the solution

The precipitation of rainfall is measured using millimetres in height on a square meter during a certain time duration (mm/day) (Ariyakumara, Prasadani, & Ekanayake, 2010). This variable can be understood using a weather-related API. AccuWeather is a widely used weather forecasting and historic weather data providing service which provides a platform for the developers to fetch the data through an API. The API can be programmed through JavaScript and the data can be transmitted as a JSON file. Then the data can be submitted to the application database on the server side (AccuWeather API, 2019).

According to the literature review, the south-western province and the central province have numerous slopes. The terrain factors and land cover properties (National Building Research Organization - Sri Lanka, 2019) of these areas must be analysed in order to understand the potentially dangerous areas. The NBRO has recognized potential hazard areas and published spatial data as shown in Figure 3.6 below.

Field data related to deforestation, sand erosion of rivers, mining activities, unplanned cultivation and destructive construction works can be depicted in the map using markers/pins. Users of the application can create markers and those markers can be validated by users through the concept called social proofing. Users can validate the marker by approving it, if the user determines it is genuine. An eighty percent (80%) approval rate can be considered as a valid approval rate.

Figure 3.7 below demonstrates a basic marker on a google map. These markers can be customized through modular programming concepts of JavaScript and Google map API (Google Map API, 2019). GLC is the rain-induced Landslide map data catalogue created by NASA. GLC can be included in the application to depict the historic Landslide events (NASA, 2018).



Figure 3.7: Instance of a marker on Google Map (Google Map API, 2019)

In the event of a Landslide, people can create markers/pins on the map which can act as events or campaigns. These events have attributes to create interaction among users. These objects are used to create activities to gather resources and distribute them to the victims. Resources can be foods, medical supplies, medical services, monetary funds or any other required material or service (Jayathne, 2016). These markers can be safe locations for the victims to assemble in a land sliding event. These markers/objects can be customized by users according to their role and can be shared through social media.

People can participate in these activities by logging into the application and signing into the activities. Proper resource management is one of the main goals of these campaigns.

The data that is relevant to the factors of Landslides and the activities that are part of the aftermath of a Landslide can be stored in a database. This data can be used to make factual assertions and to check the efficiency of the campaigns/donation activities.

This data can be summarized as datasets using charts in the mobile application. These charts and reports can be programmed using the ChartJS Framework. ChartJS is a JavaScript framework that has been developed for creating charts and reports (ChartJS, n.d.).

All of the data extracted from the APIs, Web sources and markers is stored in a SQL (Structured Query Language) Server using the ASP.net Model-View-Controller (MVC) framework (Microsoft, 2019). Using the web application as a tool, a Web API (Microsoft, 2019) can be created to share the data that is related to the Landslides in Sri Lanka.

3.3 Chapter Summery

This chapter describes the desired methodology, and the reasons for its selection. DSR is the selected methodology and the steps of the research process are explained in this chapter. This chapter also conceptualizes the factors related to the research subjects in order to form the required application solution.

4. Building the solution

The application needs to be developed according to the best mobile application development strategies and practices. Suitable SDLC needs to be selected and the requirements of the application need to be properly established.

4.1 Application Development Approach

SDLC is the standard process and structure to develop a quality software product (Kneuper, 2017). Due to the nature of this research, some specifications may need to be reformed or revised. Due to that, Prototyping model could be the ideal SDLC for this research. Iteration is the repetition of a process in order to generate a sequence that relates to the outcome of the artefact until the potential result is achieved (Kneuper, 2017). Figure 4.1 below depicts the standard flow of an iterative prototyping SDLC. This application will have several requirements which will need to be revised in order to get the best result. For example, there are several factors that are related to a landslide that are collected through the field data given by the users. Since these factors could change, the prototype must be able to adopt the alterations. The proposed mobile application will have numerous requirements. The application can be changed further by adding more requirements for future purposes.

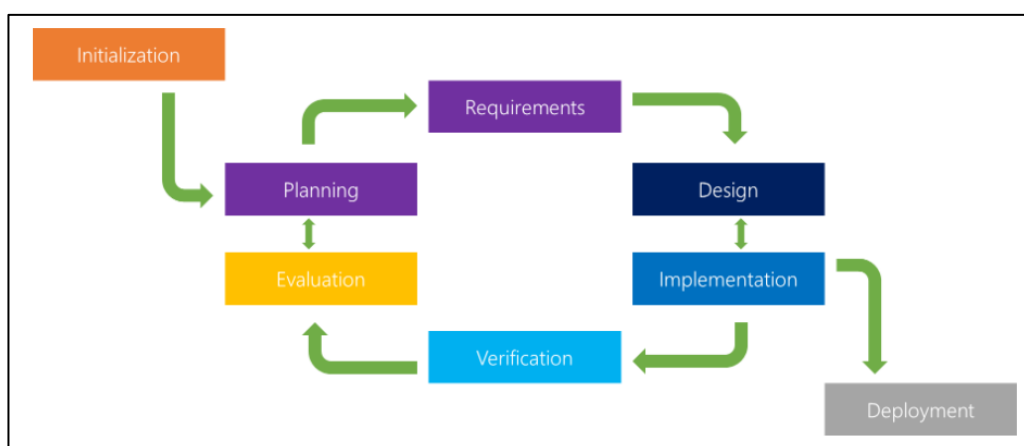


Figure 4.1: Standard iterative prototyping SDLC diagram (Powell-Morse, 2016)

The SDLC must have the capability to improve the application with fewer difficulties. Prototyping is a model building process by improving the features of the

product. The model can be a component, class, unit or an object (Ardagna, et al., 2018). The product/artefact can be created from a technical design or a URS. Prototyping SDLC helps to refine the product until it meets the desired requirements. The artefact can be improved and restructured by any party irrespective of or unrelated to the initial developer if the artefact has a strong SDLC and a URS. SDLC will generally have four different steps regardless of the nature of the product (Peffer, Tuunanen, Rothenberger, & Chatterjee, 2008 ; Soegoto & Cica, 2018). The four steps have been explained below.

1. Identify basic requirements: The basic requirements of the application are adequate for this initial step. This process will need minimal data input and minimal information will be processed as the output. Rules, restrictions, security issues and end-period processing are disdainful at this point (O'Connor & Basri, 2018).

2. Develop an initial prototype: This process will be carried out to create an initial program. The program can include UI, such as, screens, the basic functionalities of the program and some outcomes. The basic connectivity functions can be executed at this step, such as, the database connections, cloud connections and user integrations (O'Connor & Basri, 2018).

3. User review: This step will initiate the iterative process of the prototyping. The end users will be involved with this step. The testing phases are carried out at this stage. According to the suggestions of the end users and the results of the test cases, the program will get reviewed (O'Connor & Basri, 2018).

4. Revise the application: The implementations that are related to the reviews are carried out at this last stage. After the implementation, the process will roll back to step three. The prototype will be evaluated repetitively until the final product is decided on (O'Connor & Basri, 2018).

The URS is the technical document which illustrates the comprehensive functionalities of the application. The URS is also used as a guideline for planning, creating milestones,

creating timetables, and costing and testing. The URS can be written in technical and non-technical languages. The URS is used by developers, non-technical staff members as well as clients. It is compulsory to create the document in a way that anyone without software engineering knowledge can get an understanding of the application, its requirements, deliverables, constraints and other related functionalities (Ribeiro, Pereira, Rettberg, & Soares, 2018).

An effective understanding of the application can be achieved through URS. Model based approaches, such as, the Unified Modelling Language (UML) or the System Modelling Language (SysML) can be used to create a visual-based technical representation of the application. Even though ER Diagrams and Dataflow Diagrams (DFD) (Rumpe, 2016) can be considered as components of the modelling languages, these visual based languages may not be able to tackle the functional or non-functional constraints, such as, the time related issues or the relationship between the hardware and the software. Each of the modelling languages have their advantages and weaknesses. The UML diagrams can be used along with the specifications to clarify every aspect of the application (Ribeiro, Pereira, Rettberg, & Soares, 2018).

4.2 Requirement Specification of the Mobile Application

This section will demonstrate the URS of the mobile application. As illustrated in Figure 4.2 below, the URS has been broken into three parts. These are the functional requirements, the non-functional requirements and the UML diagrams.

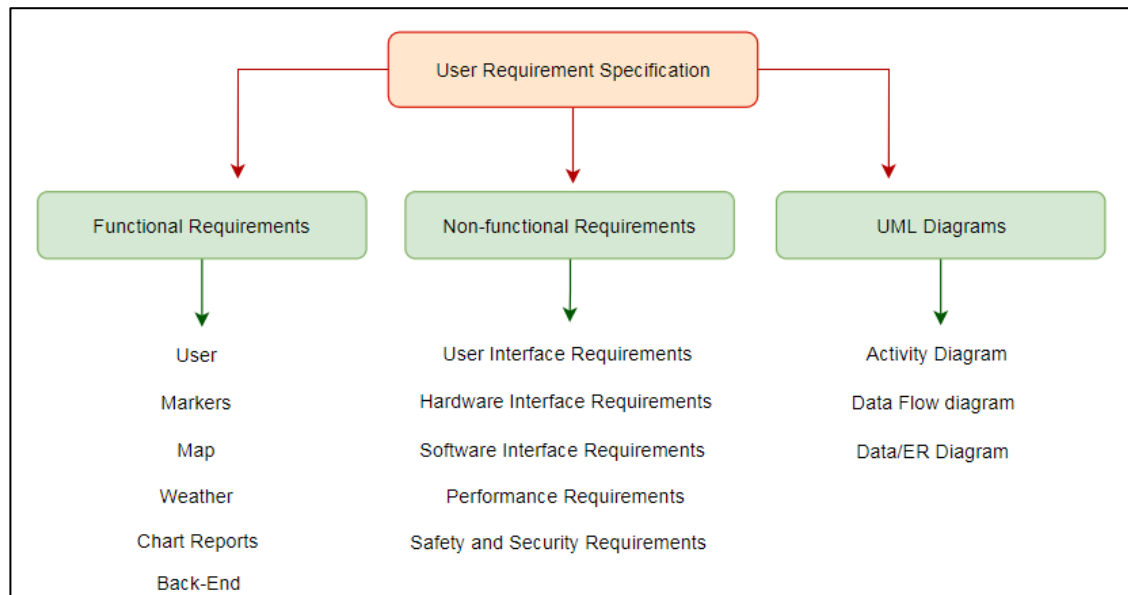


Figure 4.2: Structure of URS (Source: Author)

4.2.1 Functional Requirements of the System

Functional requirements demonstrate the behaviour of the application. It focuses on the Inputs and Outputs of the events/functions and the objectives of the application components. Overall it explains what the system is supposed to achieve or is capable of achieving (Chung, Nixon, Yu, & Mylopoulos, 2000).

A) Functional Requirements – Users

- Users can register into the system. After a user creates an account, the User can log into the system. Users can change their login and personal details after their initial registration. Registration should be carried out with a minimal detail requirement, for example, Username, Password, Full Name, Location/Address and Email are the only required details.
- Any user can create a “Marker” related to a land-slide factor
- Any user can create a “Campaign” both public and DMC
- Any user can create an activity or get assigned to an activity for a campaign
- Any user can navigate the spatial map to browse any information

- Any user can access the reporting section to generate a report related to all the events that occurred.
- Any user can publish their real-time location. If the address of the user is located in an area that is considered a high-risk zone, the user will be shown on the map in a red colour circle as a 'defector' user. If not, by default, the user will be referred to as an 'observer' and will be shown on the map as a blue circle.
- Any user can validate the Markers.

B) Functional Requirements – Markers

- *Landslide factor Markers* are a geographical pin about an event, activity or occurrence which is a suspicious activity related to a factor of a landslide. Titles for the markers will be given to the user. User must choose a most related title among the given titles. Instances are Deforestation, Mining, Construction and Soil erosions. Images for the markers need to be uploaded by taking an image through the camera. Users cannot select an image from their gallery. Users cannot change the location of the marker rather than the current GPS location. Verification needs to be done to validate that the marker is a true marker. Validation is done by social proofing of the marker. The status of the marker will be changed as the marker is validated. People can validate the marker using two buttons that are given to verify it as a true marker. Those buttons are labelled as "Approval" and "Disapproval" buttons. Approval and Disapproval does not happen right away; it happens after adequate social proofing. It will be shown in a grey colour until the market is validated.
- A *Campaign* is a geographical marker/pin about an event, campaign or an activity related to a social welfare program initiated to help victims. A User can create two types of Campaigns. One is a public campaign and the other is a DMC campaign. A Public campaign is hosted by registered users to contribute donations, labour and other resources to victims. A Safe location is also a type

of campaign where victims can temporarily stay until the danger related to the catastrophe goes away. A Public campaign can be itself a safe location. Users can determine the nature of the campaign and request other users to join. DMC campaign is a campaign hosted by DMC. A User can create a marker to show a campaign or a safe location on the map. A User can also give contact information, an official online link and a brief description about a DMC campaign.

- The user can store his or her credit card details on the application to donate money to a DMC campaign. The donation that is sent via an online transaction can only be given to a DMC campaign.
- The users can create an activity for both the public campaigns and the DMC campaigns. An activity can be gathering materials to give as a donation. The materials could be medical supplies, foods, clothes or any items that are related to basic needs. A donation can also be providing a service event, for example, providing medical services to injured victims in a safe location.

C) Functional Requirements – Map

- The entire application is a map-based application. The map should contain the map properties to the highest potential that the application can produce. Map properties are political provinces with borders, towns/cities/villages with borders, land cover information (bare ground, forests, roads), terrain features (slopes, valleys), markers (activities related to landslides, campaigns) and NBRO identified slope areas which could trigger a landslide (Expected to have a landslide or Moderate risk of an occurrence) (National Building Research Organisation - Sri Lanka, 2019).
- Additionally, GLC by NASA needs to be included in the map as markers to depict historic Landslide events (NASA, 2018).

D) Functional Requirements – Weather

- Weather details are programmed to cities / towns / villages. Once the title of the city/town/village is clicked, a popup screen will display an interactive table of figures which shows the rain precipitation for two weeks.
- The table will demonstrate one-week historic figures and one-week forecast figures from the current date.

E) Functional Requirements – Chart Reports

- The Main Menu will have a separate button for a report generation screen.
- The User has the capability to customize a chart report to divulge the information/data that is related to the activities/events of the application.
- Locations (villages, cities, towns), weather figures, hazard zones, markers and durations are the customizable items which can be generated as a report. Reports can be generated as line charts.

F) Functional Requirements – Back-End

- All retrieved data from weather API, markers and other sources are stored in the database of the application server.
- The data must be transmitted as a JSON data file to provide a web service to any party who requires data related to Landslides in Sri Lanka. This web service or web API is used to generate the report functionality of the application as well.

4.2.2 Non-Functional Requirements

Non-functional requirements focus on the requirements, which impact the system or the application as an overall product. These are also known as global requirements and play a vital part to facilitate the implementation of the application and the success of the application (Chung, Nixon, Yu, & Mylopoulos, 2000). This research breaks non-functional requirements into User Interface (UI) requirements, Software Interface

requirements, Hardware Interface requirements, performance requirements and safety and security requirements.

A) User Interface Requirements

UI is required to create a functional human computer interaction. This is the digital interface where the direct interaction between the user and the application exists. It is vital to create this digital design according to the UI standards recognized by accepted international organizations (Shneiderman, Plaisant, Cohen, Jacobs, & Elmqvist, 2017).

I. Initial screen:

This is the first screen of the application. The application will rout to this screen first and anyone can view this screen. This is an animated screen with the logo and the application title. This screen will automatically redirect to the *Login screen*.

- The initial screen/page will display the Logo and Application name.
- The right bottom of the screen/page will display the name of the person who developed the application and for which purpose it was developed.

II. Login and Register screen:

These two screens are authentication screens. Username and password of the user are required, to redirect to the main application screen. If a person does not have login details, then that person can create login details through the register screen.

- The Login screen/page should display the *username* and *password*.
- A *check button* is given to remember the *user-login* details by the application. If that option is clicked, then the next time a person opens the app, it will not be required to display the login screen.
- The Login screen should be provided with a *link/button* to navigate to the register screen if the user is not registered.
- The register screen should provide *input boxes* for *Full name*, *Username*, *Location/Address*, *Password* and *Repeat password*.

- The register screen should have a *Google Captcha validation* to verify that the register process is done by an actual human being.
- Table 4.1 below demonstrates the validation requirements for the registration.

Table 4.1: Register screen/page validation (Source: Author)

All input boxes	Cannot be null.
Full Name:	This should have a minimum of 2 Words.
Username:	This should be a minimum of 6 letters and the input must be checked through the database to check if that username has not been previously registered.
Location/Address:	The address is checked through Google Geolocation to verify it is an existing location.
Password:	The password must be a minimum of 6 words, must contain at least one upper case letter and one number. The characters need to be hidden from the view of the register screen.
Repeat password:	This must be exactly equal to the Password value in the Password input box. Characters need to be hidden from the view of the register screen.

III. Main Home Screen:

This is the main home screen. This is the primary geographical application screen. This interface runs on top of Google Map API.

- After login, the Application will direct to the homepage. The Homepage will have a main menu icon on the top left side.
- The Homepage will be a complete map-based application.
- The Map will consist of following properties:
 - Political provinces with borders, towns/cities/villages with borders and land cover information (bare ground, forests, roads) will have graphical features as given by Google Map API.
 - Terrain features (slopes, valleys) are highlighted with colours and specific features as programmed by Google API.
 - Markers (activities related to landslides, campaigns) are pop-up screens with functions and they are marked on the map by unique icons.

- NBRO identified slope areas which could influence a landslide will be highlighted by coloured polygons on Google Map. Moderate risky areas are coloured by yellow while high risky areas are coloured by brown.
- GLC will be shown in the map as markers. Those markers will be red colour pins which resemble the default pin icon of the Google markers.
- Upon clicking the menu icon, the main menu will be displayed. Personal information, notifications and user specific information will be positioned on the top left. The menu items will be positioned on the left middle.
- The personal information section will have user-icon, username, user-location and notification icon.
- The notification icon will be a small green coloured bell. Every time a notification comes, the phone will be vibrated once. The amount of notifications received, will be shown in a small red coloured circle.
- The menu items will be *CREATE*, *FIND*, *REPORTS* and *SETTINGS*, respectively.
- *CREATE* and *FIND* will have collapsing sub menu items. The functionality of the *CREATE* button can create markers and the Functionality of *FIND* can find markers.
- The *SETTINGS* button will open a screen to customize the content and features of the application.
- Upon clicking *REPORTS*, it will open a screen which has the functionality to generate a customized visual presentation of the events/activities of the application.

IV. *Create marker screen:*

This is the screen to create markers. The User can choose the intended marker type and input the data related to that marker. The first menu item of the main menu is the *CREATE* button which will open the create marker screen.

- Upon clicking *CREATE* it will open the map and create a pin to the current GPS location of the user.
- The Map screen will have a *CONFIRM* button bottom-middle to confirm the location. Upon clicking the *CONFIRM* button it will open another screen to input the details about the marker. That screen will have two large buttons.
- One button is to create a “Markers related to land sliding” and the other is to “Create a campaign”.
- If the user chooses a marker related to Landslides, a screen will appear with functions related to that marker. The top section of the screen will have a large *Camera button* to take real pictures of the event/activity/occurrence related to land sliding. A minimum of one image is needed and a maximum of ten images is allowed. Upon taking the images, the screen will create a carousel of images. The User can select the type of marker. The type can be deforestation, mining activity, river erosion, soil instability, construction works, unplanned cultivation or other factors. The User can create a description about the marker and confirm the marker.
- If the user chooses a marker to create a campaign, a screen will appear with functions related to that marker. The top section of the screen will have a large *Camera button* to take real pictures of the campaign or a banner of the campaign. An image is not compulsory and a maximum ten images is allowed. Upon taking the images, the screen will create a carousel of images. The User can select the type of the campaign. The type can be a Public campaign or a DMC campaign. The User can create a description about the campaign and create activities. If it is a DMC campaign, the contact method of the campaign and an official online link regarding the DMC campaign must be added. Activities can be added to the campaign. An activity is an event with an actual time and place to collect, donate or contribute resources. In order to launch a campaign, a minimum of one activity is required. Campaign object has a button

to add an activity. Upon clicking “*Add an activity*” button, a screen related to adding an activity will pop up in another screen where the user can input the details about the nature, constraints, time and location related to the activity. The Campaign can be saved as a draft or it can be launched instantly. The Creator of the campaign can launch a draft campaign by clicking the “Launch” button.

V. *Viewing Marker Screen:*

This is the screen to view the stored markers. The icons of the markers will be displayed on the Google map according to the location. Upon clicking the desired marker, this marker screen will appear with the details of that selected marker.

- Any Marker on the map can be viewed by clicking the marker on the map. Alternatively, a marker can be searched using the *FIND* button on the menu. Upon clicking the *FIND* menu item, it will collapse a list of marker types. Each marker type will have its own instances of markers related to each marker type.
- If the marker is a marker related to Landslides, and the user has seen the occurrence/event/activity in the actual geographical location, then the user can approve the marker. If the user identifies that it is a not a correct marker, then the marker can be disapproved.
- If the marker is a campaign, the User can add himself/herself into the campaign activity. Also, the user who is the creator of that marker can create an activity in a campaign. Upon creating the activity, a notification will go to the creator of the campaign. If the activity got approved, then the activity will go live, and other users can join it.
- Users can comment on markers related to land sliding and activities related to campaigns and share them on the social media platforms of Facebook and Twitter. *Comment Boxes* are given to each of the markers and activities. Social media share buttons/icons are also given to the markers and activities as well.

VI. *Reports Screen:*

The Report screen is the screen where users can generate chart reports based on their selected variables. The Report screen can be found on the main menu which appears on the left side of the application.

- The Report screen will have the elements to select as the variables. The Variables are the locations (cities, towns, villages), weather figures, hazard zones (slope areas), markers and durations. The Chart type will be a line chart. The Elements will be shown as checkboxes and the location can be typed into a textbox. At the Lower middle, there will be a CONFIRM button to generate the chart report.

VII. Settings screen:

The settings screen allows you to update and modify the metadata, terms and features of the application. Further customization to the application can also be created using the settings screen. The Report screen can be found on the main menu which appears on the left side of the application.

- Upon clicking the *SETTINGS* button, another screen will pop-up. It will have two sections. The First section will have the personal details of the user. Each personal detailed item will have an *EDIT* button to the right side. Upon clicking it, the user can change the details on the same screen. After updating the changes, the *SAVE* button located in the bottom of the screen needs to be clicked in order to save the changes.
- The Lower section will have the following buttons. There will be a '*KEEP ME PUBLIC*' button which has an on-off switch. The User can make it public and show their real-time location on the map using that button.
- There will be a *LOGOUT* button to log out from the application. Upon clicking it, the user will be redirected to the login screen.

B) Hardware Interface Requirements

There are hardware Interface requirements that are involved with the requirements which need to be accomplished in order to facilitate the hardware interaction. The hardware Interface is involved with the networking and the device compatibility. These are essential features for an effective application.

I. Mobile Access:

- The application will run on a smartphone that has Dual-core 1.2 GHz CPU with 1GB Random Access Memory (RAM). These CPU and RAM requirements can be considered as the minimal requirements that are necessary (Ung, 2019).
- The application will have a graphically enhanced UI interface. It is required to have a touch screen mobile phone with a minimum of 480 x 800-pixel resolution. A thin-film-transistor (TFT) or Liquid-crystal-display (LCD) screen is recommended (Hara, et al., 2018).
- The application is a real-time application, connected to WWW. GPS connectivity is compulsory. A-GPS (Assisted Global Processing System) is not accepted (McNamara, 2008). The smartphone needs to have minimum HSPA (High Speed Package Access) mobile broadband connectivity (Tapia, Jun, & Karimli, 2009).
- Smartphone is required to have an inbuilt camera with minimum 5MP.

II. Server:

- Green web hosting service is the desired hosting service as it uses sustainable web server techniques. “GreenGeeks” is the chosen commercial green hosting service. Back-end development is created through the Dot.Net framework using Internet Information Services (IIS) server and SQL Server. So, the hosting server must support Microsoft server-side applications (Nagel, 2018).

C) Software Interface Requirements

The Software Interface requirements are involved with the way the application interacts with other application platforms. It is woven around the capability of the application to operate and it exists on a root Operating System (OS), it transmits the data among the servers and interacts with distinctive APIs. The OS, Software development languages, frameworks and tools can be considered as a part of the Software Interfaces.

I. Mobile Access:

- The Mobile application can be accessed in the Android OS environment, iOS environment and the Windows mobile OS environment. Any smartphone with one of above operating systems can run the application (Hansen, 2001).

II. Development:

- The Mobile application is developed using web-based languages and APIs. The Front-end development languages are, namely, HTML5, CSS3, JavaScript, jQuery and JSON or XML (Extensible Mark-up Language). The back-end of the application is developed using ASP, CSharp and Microsoft SQL Server along with IIS Server (Galloway, Wilson, Allen, & Matson, 2014). Visual Studio-2019 is the desired Integrated Development Environment (IDE) and Model-View-Controller (MVC) is the software development architecture (Nagel, 2018).
- The Mobile application is compiled using Adobe PhoneGap or Ionic frameworks (PhoneGap, 2016).
- This is a web-based application. It requires access to the internet with a minimum HSPA connection (Tapia, Jun, & Karimli, 2009). This application gets connected to third party APIs over the internet such as AccWeather (AccWeather, 2019) and Google Map (Google Map API, 2019).

D) Performance Requirements

Performance Requirements are involved with the actual execution of the application. The Features of the performance requirements are involved with application loading time,

connectivity speed and efficiency of the application (Chung, Nixon, Yu, & Mylopoulos, 2000).

- This application requires high-speed internet, and the commercial mobile industry has moved away from 3rd generation broadband internet connectivity (Tapia, Jun, & Karimli, 2009) to 4th generation broadband connectivity. This application will work adequately on a moderate smartphone with minimum requirements. It will be compulsory that the mobile network service providers or Internet Service Providers (ISP) have high speed internet.
- The Servers of the mobile application need to have a strong response time. APIs and Web services used for this application must connect through efficient Content Delivery Networks (CDN) (Cloudflare, Inc., 2019) and Servers.

E) Safety and Security Requirements

The Web application will always face cyber related attacks and malware issues. It is required to implement safeguards to the application to counter these infiltrations. Safety is measured by the security methods that are implemented.

- The back-end of the application along with the Web servers must be secured with up to date security standards (Ebert, Brasse, & Metzker, 2016). Users will store their sensitive information in the database of the web server. The Web server must run on HTTPS (Hypertext Transfer Protocol Secure) rather than HTTP (Krause, 2016).

4.2.3 UML Diagrams

Unified Model Language (UML) is a visual-based terminology to demonstrate the functionalities of a product or an application. A graphical representation can be used to illustrate the events of the software application. UML is comprised of several subsets of diagrams (Torre D. , Labiche, Genero, & Elaasar, 2018).

The Activity diagram is a UML diagram which illustrates the flow of activities of the application. The System may have a number of activities which may or may not be

interconnected. A Diagram can be drawn to demonstrate the flow of each of the activities (Torre D. , Labiche, Genero, & Elaasar, 2018).

The diagram illustrated in Figure 4.3 shown below explains the activity diagram for the user account creation and login process. In order to get to the application, the User must be a registered user.

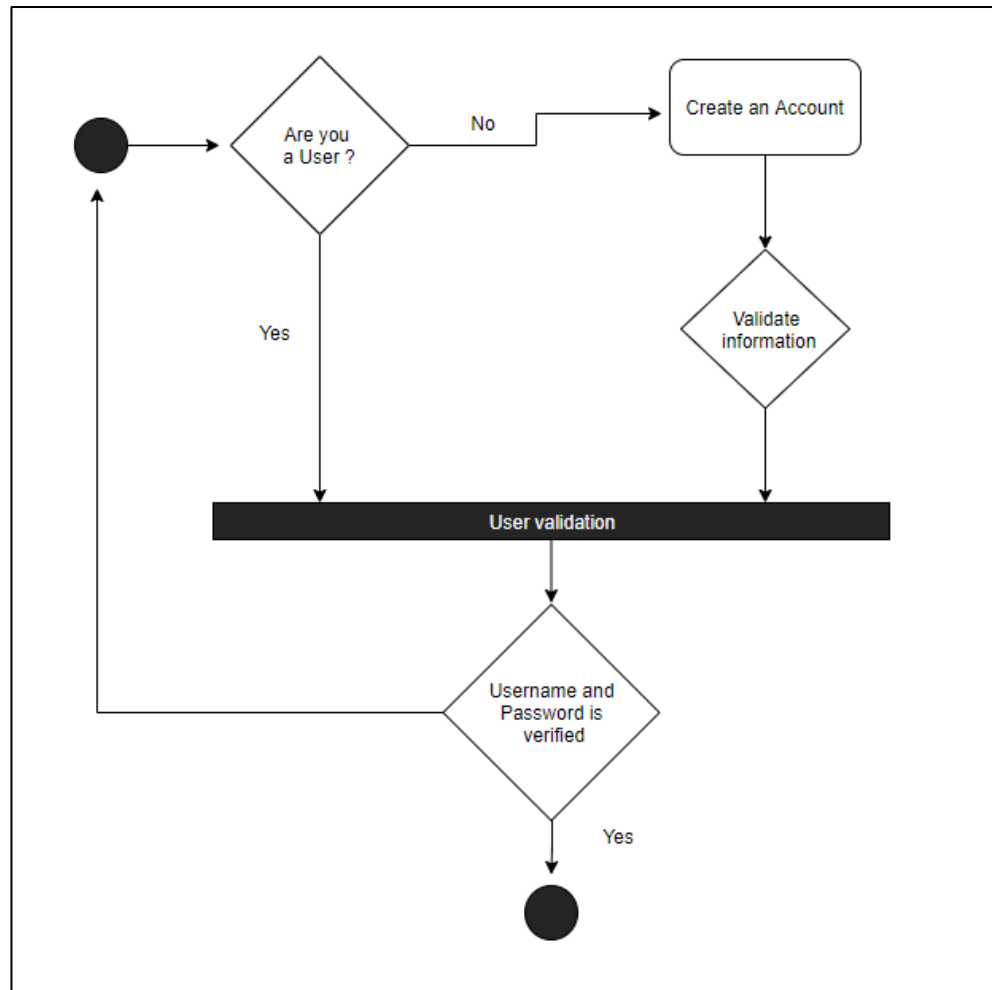


Figure 4.3: Activity diagram for user login and user account creation (Source: Author)

The user's information needs to be stored and extracted accordingly. Once someone opens the application, the system checks if s/he is a registered user or not. This validation is done through a user validation process by sending a request to the server and getting the user's details as the response. If the user is not a registered user, then an account needs to be created with the correct information.

Figure 4.4 below demonstrates an ER Diagram for creating the weather details of a location on the map. The Location is an entity which has the properties and methods. The Location is an entity with properties which are the data types and it has the capability to execute the methods. "WeatherDays" is a property with the data type "AvgDList" which is modelled by another entity called the "AvgDList". The Location entity can save the weather details into the "WeatherDays" property by using the "getWeather()" method.

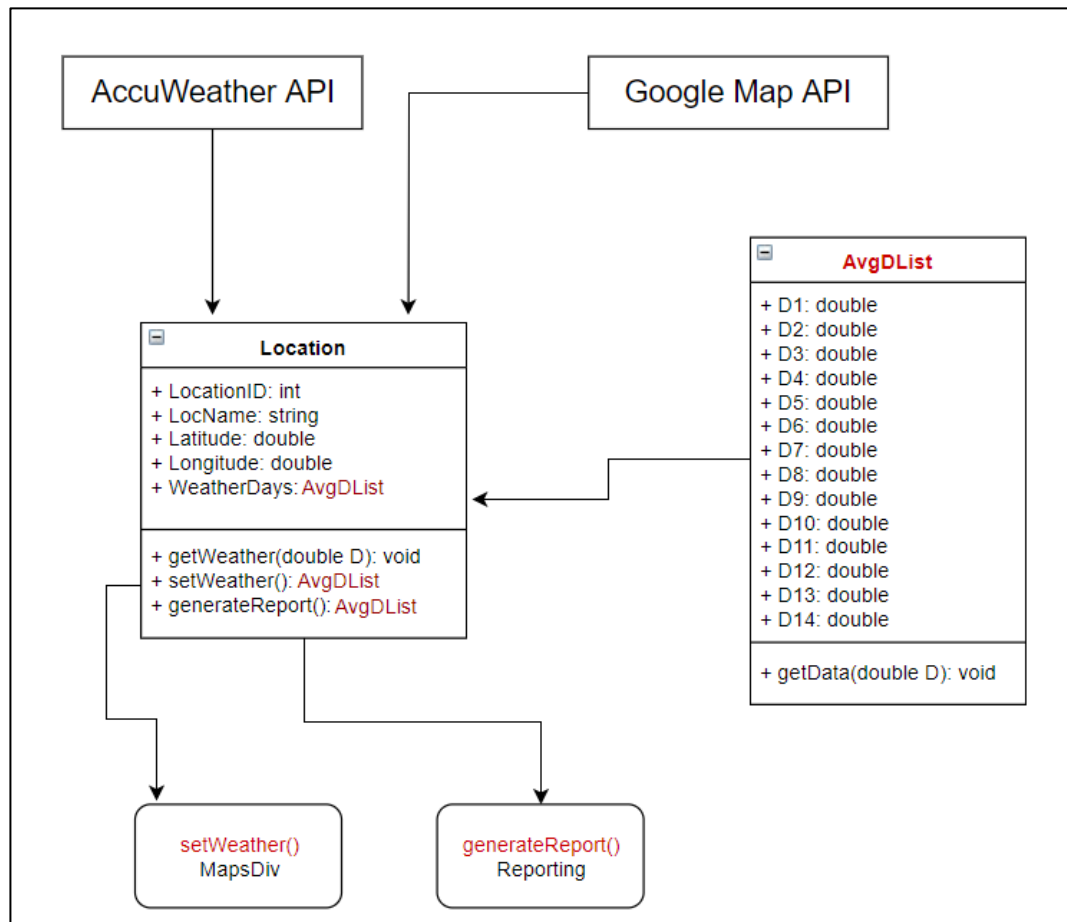


Figure 4.4: ER Diagram for Weather details of a location (Source: Author)

Correctly recognizing properties and methods increase the efficiency involved with developing the application. The ER Diagram helps the programmer to quickly do the coding as the developer can simplify the application by following an ER Diagram. Simplification will reduce unnecessary coding and lead to a normalized and fast development (Roques, 2004).

The diagram in Figure 4.5 below illustrates the Database diagram for this application.

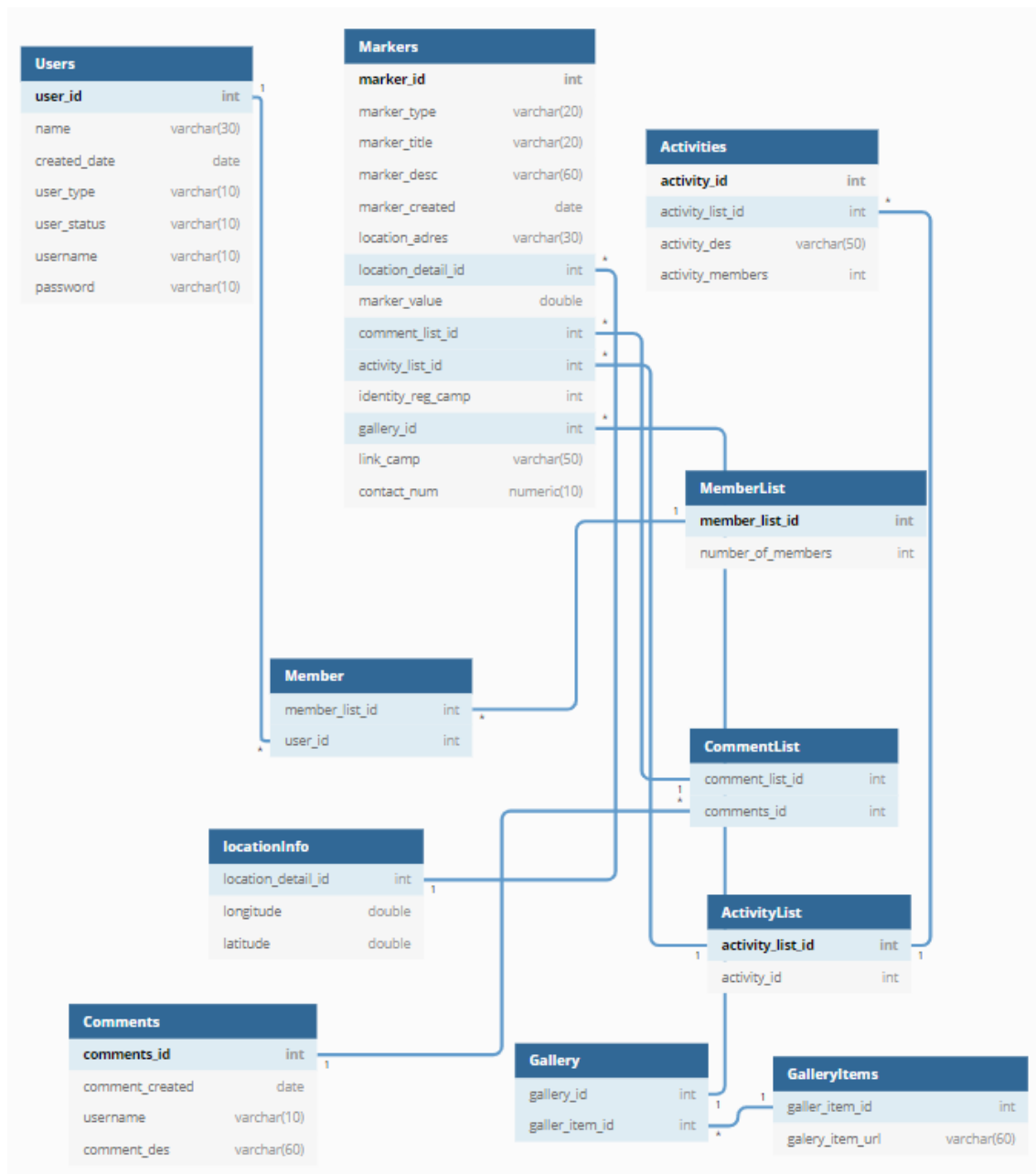


Figure 4.5: Database Diagram (Source: Author)

Objects in diagram are created as entities, and they are connected to each other based on their functionalities. For instance, “Markers” is an object and it has “comment_list_id” as a property. The “CommentList” is another object/entity which has “comment_list_id” as one of the properties. Markers and CommentList have a relationship based on the functionality so that Users can create comments on a marker.

The Database stores and manages the data of the Application. Modern database tools are Object Oriented Principles (OOP) driven tools and the data structure of the application should be developed based on the objects of the application.

The Database diagrams help developers to improve the database efficiency as it helps to reduce data redundancies (Rob, Coronel, & Crockett, 2008).

4.3 Chapter Summery

This chapter discusses the proposed web-based mobile application in detail. The SDLC is explained and the URS is described in this chapter. The URS is illustrated in detail, in order to explain the functionalities and the requirements of the proposed solution.

5. Implementation

This application is a web-based mobile application. This application can be developed using the native application development method or the web-based application development method.

Mobile applications run on mobile and hand-held devices. Those devices could have various operating systems and the application should be able to run on most mobile operating systems that are in use. The Applications can be implemented using the same languages and development methods that were used to develop the OS of the mobile or hand-held device (Hansen, 2001). This approach is known as the native mobile application development.

The mobile applications can also be implemented using languages and development techniques that used to develop web applications. This is known as the web-based mobile application development.

5.1 Choosing web languages for mobile application development

Java is one of the main languages that was used to create Android OS and the mobile application development for the Android OS using Java can be called the native application development. iOS is the mobile OS of Apple handheld devices and Objective-C is one of primary languages that was used to build iOS. The Mobile application development using Objective-C for Apple devices is referred to as native applications development (Doran, 2017).

The primary advantage of the native application development is the optimized performance of the application. Graphic related applications, such as, 3D games (Doran, 2017) and image processing software works faster and smoother. Since both the OS and Mobile application share the same development tools, the application performance optimization is higher. The applications load faster and the response time is lower. The access to the device hardware capabilities and features is robust because the Hardware (H/W) and Software (S/W) interfaces are developed using the same development tools

and languages. Geolocation, accelerometer and light sensors are several of the many capabilities of the device (Charland & LeRoux, 2011) which work smoother in native application development.

However, generally, the application works on native OS platform only. The same application development methods cannot be used to deploy the application for another mobile OS environment. In order to work in multiple OS platforms, native code needs to be recompiled using different Software Development Kits (SDK) and different tools and APIs are required to build the system. The process of creating the application for various markets requires additional skills and rebuilding the system is costly (Charland & LeRoux, 2011).

Mobile application development using web languages, such as, HTML5, CSS3 and JavaScript is web-based mobile application development. The layout of the application runs on a WebView and the WebView runs on a native OS platform. Industry players started competing against each other to create faster web browsers and this resulted in creating better JavaScript rendering engines for the browser. JavaScript is a browser-based programming language and JavaScript rendering engine is a JavaScript codes executing program which runs underneath the web browser. Optimizing JavaScript interpretation is vital to the success of the web browser (Panhale, 2016). Figure 5.1 below demonstrates examples of several rendering engines in web browsers.



Figure 5.1: Mobile Browsers and their rendering engines (TumariWeb, 2019)

Web browsers run on a Mobile OS platform and PhoneGap is a development framework which allows the use of HTML, CSS and JavaScript to create a WebView on the mobile OS platform (Myer, 2011). Figure 5.2 below demonstrates the root layout of the web-based development process on a mobile device.

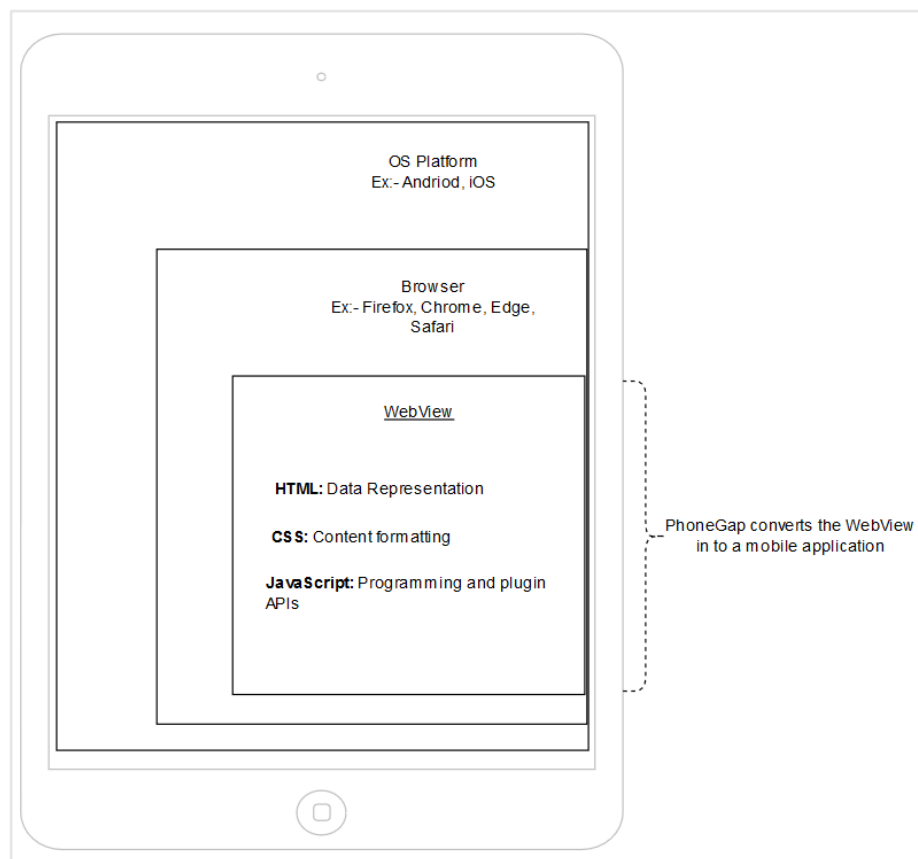


Figure 5.2: Mobile application development root layout for web-based development (Source: Author)

JavaScript can call native codes of the mobile OS using PhoneGap JavaScript API. PhoneGap JavaScript API can access mobile device features, such as, geolocation, accelerometer, battery level, camera or Media Capture (Charland & LeRoux, 2011).

The UI of the mobile application is rendered by HTML and CSS. HTML stands for Hypertext Mark-up Language and CSS stands for Cascade Styling Sheets. HTML creates the structure and the data representation of the application while CSS designs the visual format of the application. Some outdated web browsers do not have the capability to render some properties of CSS3 and HTML5 thus create issues related to the consistency of the interface. As an example, the flexbox properties of CSS were not supported by 27 or below versions of the Firefox browser. Issues such as this have been diminished by the new versions of the modern browsers (Collins, 2017).

The Source code of the application can be compiled into multiple platforms at once with PhoneGap. This makes cross platform compatibility easier and less expensive compared to native application development (Charland & LeRoux, 2011).

Connectivity to online content is much faster and creating a connection to a web server and transmitting a file using a web service is smoother and more consistent using a WebView compared to a native application view (Charland & LeRoux, 2011).

Considering the above advantages and the research question along with research objectives, this research uses web languages to create the mobile application for this research study.

5.2 Application development Architecture

Web development has two parts and they are front-end development and the back-end development. Front-end includes UI as well as User Experience (UX). The Front-end development focuses on the client-side development while the back-end development focuses on the server-side development (Krause, 2016).

The Application works as a portal from the mobile side where it opens a screen which loads from a web server. WebView or the screen acts as the client. HTML is the language which is used to convert the normal text into hypertext. CSS is a styling language which is used to format and represent the HTML content on the WebView. The current version of HTML is version 5.0 and the current version of CSS is version 3.0. The standards of HTML5 and CSS3 are mentored by the Word Wide Web Consortium (W3C) (Krause, 2016).

A bidirectional connection between the web application and the web server is created and the Internet uses protocols to standardize this process. HTTP is an application protocol which transmits HTML. HTTP is the base for WWW as it was initiated by Tim Berners Lee. A secure version of HTTP exists and it is known as HTTPS. S stands for “Secure” and the protocol is encrypted using a conceptual layer called Transport Layer Security (TLS) (Krause, 2016).


HTTP creates the request from the front-end through the application and the request is received by the server and it responds with the correct data. Some methods of HTTP are used to transmit data, such as, weather reports, spatial and geographic data through a software architecture style called Representational State Transfer (REST). REST is a part of the Web API which is a data transmitting system which transmits data representation file types, such as, JSON or XML (Krause, 2016).

As mentioned in (1) of Figure 5.3, UI is created using HTML5 and CSS3. The additional CSS based toolkit known as “Font Awesome” will be used to add icons and typography to the application. The User will interact with the application using the client side and this interaction is HCI. The Web design has been carried out using sustainable designing standards (Mighty Bytes Sustainability Web Designing, n.d.). It is recommended by W3C to use the best industry practice. The new industry practice is concerned with Web Content Accessibility Guidelines (WCAG), Sustainable HCI and Sustainable Web

Designing (Wille, Dumke, & Wille, 2016). This application should be implemented by employing optimal industry practices.

5.3.1 Login Screen

Figure 5.4 below demonstrates the login and registration screen of the application prototype. The name of the application is given as “Sustainable Sri Lanka”, however this name is a temporary working title only. It is mandatory to register before browsing the application.




**Sustainable
Sri Lanka**

Login

[Register](#)

Remember Me ☐

Created by [Chathura Silva](#)



**Sustainable
Sri Lanka**

Register

Register

Remember Me ☐

Created by [Chathura Silva](#)

Figure 5.4: Login and Registration screen of the application (Source: Author)

Div tag ‘cover’ in line-1 as illustrated in Figure 5.5 below is the default parent HTML tag to wrap all other tags of the application. This is valid for any screen throughout the application.

```

1  <div class="cover">
2    <div class="wrapper">
3      <a href="index.html"></a>
4      <div class="input-wrap">
5        <input type="text" name="username" id="username" placeholder="username">
6        <input type="text" name="password" id="password" placeholder="password">
7        <input type="button" name="login-submit" id="login-submit" value="Login">
8        <a href="register.html">Register</a>
9        <span class="memory-input">
10         <p>Remember Me</p> <input type="checkbox" name="remember-me" value="remember-me">
11       </span>
12     </div>
13     <div class="footer-info">
14       <p>Created by <a href="#"> Chathura Silva </a></p>
15     </div>
16   </div>
17 </div>

```

Figure 5.5: Login Screen: HTML5 (Author: Source)

5.3.2 Registration Screen

The User details are taken as inputs as illustrated in Figure 5.4 above and the data are sent to the database once the details are validated. Data are sent using a method called “post” to hide the sensitive data and it is fetched by another screen called “processRegistration” as illustrated in *line-5* in Figure 5.6 as shown below.

```

4  <div class="input-wrap register">
5    <form method="post" action="processRegistration">
6      <input type="text" name="fname" id="fname" placeholder="name">
7      <input type="text" name="location" id="location" placeholder="location">
8      <label for="user type">User Type:</label>
9      <input type="text" name="username" id="username" placeholder="username">
10     <input type="text" name="password" id="password" placeholder="password">
11     <input type="text" name="repassword" id="repassword" placeholder="confirm password">
12     <input type="button" name="login-submit" id="login-submit" value="Register">
13   </form>

```

Figure 5.6: Registration Screen: HTML5 (Author: Source)

5.3.3 CSS for General Screen with Login and Registration

Figure 5.7 shown below illustrates CSS which has been used to format the login and registration form shown in Figure 5.4 previously.

```

1  /* Input Forms */
2  .input-wrap {
3      margin: 0 10px;
4  }
5
6  input[type="text"] {
7      border: 1px solid #068c8c;
8  }
9
10 input {
11     width: 100%;
12     font-family: 'Josefin Slab', serif;
13     font-size: 1.2em;
14     box-sizing: border-box;
15     padding: 5px 10px;
16     margin-bottom: 15px;
17     height: 2.5em;
18 }
19
20 input[type="button"] {
21     margin-bottom: 5px;
22     cursor: pointer;
23     background: #0cb3b3;
24     border: 0;
25     color: #fff;
26     font-weight: 700;
27 }
28
29 .input-wrap > a {
30     text-align: center;
31     display: block;
32 }
33
34 .input-wrap {
35     margin: 0 10px;
36 }
37
38 .memory-input {
39     display: -webkit-flex;
40     display: -moz-flex;
41     display: -ms-flex;
42     display: -o-flex;
43     display: flex;
44 }
45
46 .memory-input p {
47     width: 60%;
48     text-align: right;
49 }
50
51 .memory-input input {
52     width: 10%;
53 }
54
55 /* Footer */
56 .footer-info {
57     position: absolute;
58     bottom: 0;
59     padding: 5px;
60     left: 0;
61     right: 0;
62     background: #071212;
63     z-index: 200;
64 }
65
66 .footer-info p {
67     margin: 0;
68     width: 100%;
69     text-align: right;
70     color: white;
71     padding-top: 3px;
72 }
73

```

Figure 5.7: CSS for Login and Registration (Author: Source)

WCAG is used to measure the accessibility level of the application. Users with eye sight disabilities must be able to use this application. UI related issues, such as, insufficient contrast between font-colors, background-colors and smaller font-sizes could create accessibility issues for users with eye-sight issues. The Application in this thesis is developed in accordance with accessibility standards outlined by W3C. This application uses reponsive design as the design method. This web-based deisgn can be viewed from any Android, iOS or Windows Mobile smartphone or hand-held device thus this design framework enables ubiquitous computing (Krumm, 2018). The Application will be displayed with minimal accessibiltiy issues from any of above mentioned devices. WCAG helps this artifact in the sense of measuring the accessibility level and facilitating Quality Assurance (QA) (Wille, Dumke, & Wille, 2016).

S/W and H/W are the main parts of any application development process. In this scenario, a software application is developed to run it on the mobile phone which is a hardware device. Live ware (L/W) is one of less talked about concept of IT yet it is also an important one. All these technological advancements are done to help people. The Interaction between people and the computer application process must be efficient in the sense of accessibility and effectiveness (Dix, 1998). Accessibility focuses on connecting people with the application correctly while the benefits given to the people by the application justify the effectiveness. Correctly connecting with the application is required to get the optimal benefits. Due to the above reasons, it is certain that UI, UX and HCI play a huge part in the application development process (Bernhaupt, et al., 2017).

This mobile application uses web-based UI designs. UI and UX designs need to be implemented in a way that the design methodology fulfils the optimal design practices that are used by the industry.

The Internet uses a vast majority of the electricity consumption around the world. Even so, less than 10% of the energy production around the world is generated by renewable energy. The annual internet carbon footprint is approximately 830 Metric Tons per year. Fast loading websites which consume less storage capacity along with conductive information delivery, can minimize bloated websites which take more time to load and more time to find information. Developing web design sustainably (O'Toole, 2013) can reduce energy waste in four key areas. These four key areas include Findability, Performance Optimization, Sustainable Design and Green Hosting (Mighty Bytes Sustainability Web Designing, n.d.).

“Finding” focuses on the ability to get the information quickly with less data, less bandwidth and less time consumption. “Performance Optimization” focuses on speeding the load time thus reducing energy and carbon footprint. Efficiency can be achieved through instantaneous page loading, normalized HTML, CSS and JavaScript coding. “Sustainable Design” focuses on promoting accessibility, reducing larger content and

responsive designing which supports mobile-first web design. “Green hosting” focuses on storing web content and the database in a Web server which uses renewable energy (Mighty Bytes Sustainability Web Designing, n.d.). This prototype adapts sustainable web design strategies and the application back-end is hosted in “GreenGeeks” Web server which uses eco-friendly server strategies (GreenGeeks, 2019).

5.4 JavaScript as the front-end development programming language

As illustrated in (2) of Figure 5.3, JavaScript plays a vital part in the Application architecture. JavaScript is a functional programming language which is loosely based on OOP concepts. It is a web front-end language where it uses the browser to interpret the coding into an executable program (Grover & Kunduru, 2017).

The Front-end events of this application are created using JavaScript. PhoneGap enables a specific JavaScript API to access and manipulate the features of the mobile application. As an example, if a user creates a marker, he needs to use the Camera to take pictures of the location. PhoneGap JavaScript API enables this Camera feature.

JavaScript has two approaches in this application front-end. The first purpose is to execute UI related functions. An example would be showing an error message if the login verification failed (Rauschmayer, 2014).

The second purpose is to manipulate and represent the data which is received through the Web services. Weather data, spatial data and marker data could be given as examples of the JavaScript related data. JSON, a data objects structuring and transmitting file type, is derived from JavaScript. JSON is strongly connected with JavaScript (Grover & Kunduru, 2017).

This application will use additional JavaScript frameworks for application development. Figure 5.8 below illustrates several JavaScript frameworks used in this application and their functionalities.

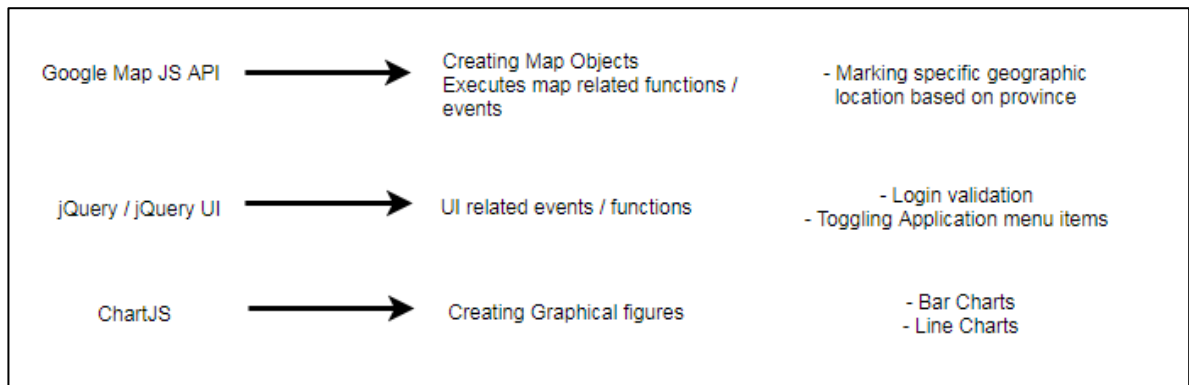


Figure 5.8: JavaScript Frameworks used in this Application (Author: Source)

This application is a map-based application. Most of the actions and events that occur in this Mobile interface will be based on a well-structured Map. The map is constructed using UI based JavaScript frameworks and APIs. This application prototype uses several JavaScript frameworks and front-end APIs. Google Map JS API, Geolocation JS, Geocoding JavaScript API, jQuery, ChartJS (ChartJS, n.d.) and jQuery UI are the JavaScript frameworks used in this application. This project uses Google Map JS as the desired framework to create the interactive mobile-friendly Map. This application should be able to adequately perform on any phone with minimum requirements. Due to the adaptability of Google Map, it is viable to use the well documented Google Map JavaScript API as the desired Map API (Dewsbury, 2008).

Even though JavaScript is a lightweight language, due to its multi-paradigm, dynamic and declarative characteristics, using Vanilla JS (Duckett, 2014) coding could result in an outstretched coding structure. The definition of Vanilla JS is using the pure functions and methods of JavaScript. jQuery is a JavaScript library with minimalized functions and method. The Document Object Model (DOM) in HTML can be manipulated and animated by jQuery (Felke-Morris, 2019). DOM traversal and event-handling are supported by jQuery. This application uses jQuery to implement some of the components as an alternative to pure JavaScript. Even so, this does not mean pure JavaScript is replaced by jQuery.

5.4.1 jQuery implementation

Figure 5.9 below demonstrates the Menu screen, Settings screen and its components. The Functionality of the events has been implemented using jQuery and jQuery UI frameworks.

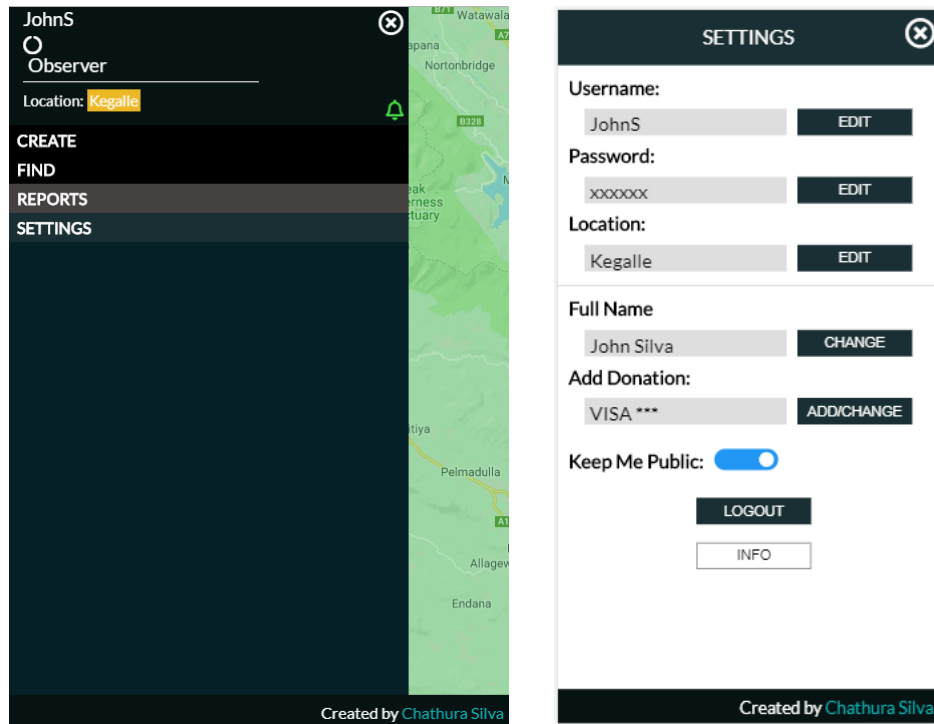


Figure 5.9: jQuery-based Menu Interface (Author: Source)

The UI based functionality of the mobile application is programmed by the jQuery framework. Figure 5.10 below demonstrates several jQuery coding components. The comments have been added in green colour to the coding structure for the purpose of depicting the functionality of that code component.

```

1
2 // Buttons Toggle
3
4 $(".menu-wrap").click(function() {
5     $(".menu").toggle("slide");
6     $(".menu-wrap").hide();
7 });
8 $(".close-btn").click(function() {
9     $(".menu").toggle("slide");
10    $(".menu-wrap").show();
11 });
12 $(".menu-h4-1").click(function() {
13     $(".menu-items-1").toggle("slide");
14 });
15 $(".menu-h4-2").click(function() {
16     $(".menu-items-2").toggle("slide");
17 });
18 $(".markers-span").click(function() {
19     $(".markers").toggle("slide");
20 });
21 $(".zones-span").click(function() {
22     $(".zones-1").toggle("slide");
23 });
24 $(".f-markers-span").click(function() {
25     $(".f-markers").toggle("slide");
26 });
27 $(".f-zones-span").click(function() {
28     $(".f-zones").toggle("slide");
29 });
30

```

```

30
31 // Settings buttons
32
33 $(".settings-btn h4").click(function () {
34     $(".settings-wrap").show();
35 });
36 $(".set-close").click(function () {
37     $(".settings-wrap").hide();
38 });
39 $(".content-set-wrap.info-settings button").click(function () {
40     $(".wrap-info-details").show();
41 });
42 $(".set-close.info-close-btn").click(function () {
43     $(".wrap-info-details").hide();
44 });
45
46 // Markers buttons
47 $(".markers").click(function () {
48     $(".markers-wrap.mrk-edit").show();
49 });
50 $(".f-markers").click(function () {
51     $(".markers-wrap.mrk-view").show();
52 });
53 $(".markers-wrap .set-close").click(function () {
54     $(".markers-wrap").hide();
55 });
56
57 // Adding Zone
58 $(".zones-1").click(function () {
59     $(".zones-wrap-add.add-zone-event").show();
60 });
61 $(".zones-wrap-add.add-zone-event .set-close").click(function () {
62     $(".zones-wrap-add.add-zone-event").hide();
63 });
64

```

Figure 5.10 jQuery coding for mobile UI functionalities (Author: Source)

5.4.2 Google Map Integration

The most important aspect of the Application is data visualization using Google Map API since this is a map-based application. The mobile application is required to create an API Key in order to use Google Map API. It is a mandatory technical requirement implemented by Google (Google Map API, 2019). Figure 5.11 below depicts the API script with the API Key and Figure 5.12 below depicts the default zoom position of Sri Lanka in the prototype interface.

```

145 <script src="https://maps.googleapis.com/maps/api/js?key=A...&callback=initMap"
146   async defer>
147 </script>
148

```

Figure 5.11: Google Map API Key integration (Author: Source)

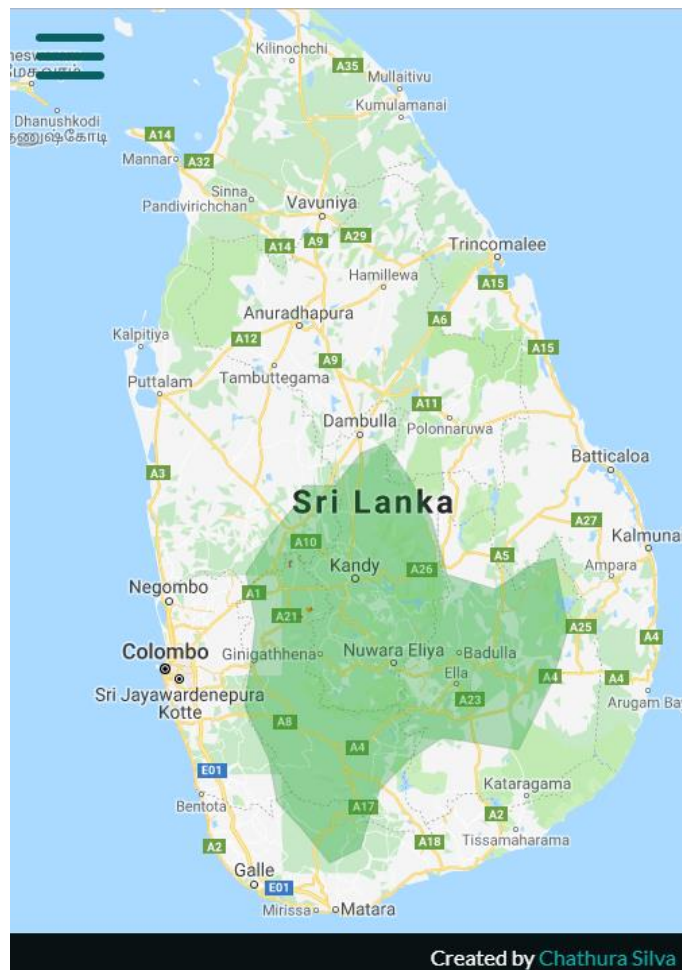


Figure 5.12: Sri Lanka default view in prototype interface (Author: Source)

Figure 5.12 above has highlighted, the south-western and central provinces using a transparent green colour polygon. Polygon is loaded into the Google Map using a GEOJSON file. GEOJSON is a JSON file which consists of geographical data and the metadata related to it. Figure 5.13 below depicts the “areas.geojson” file declaration in JavaScript and its basic structure. The ‘Coordinates’ are the geographic data and the ‘colours’ and ‘line-strokes’ stored under ‘features’ are the metadata related to the polygon.

```

1 // Fetching the geojson file
2 map.data.loadGeoJson('http://hbonetwork.com/mobile-app/areas.geojson');

```

```

{
  "type": "FeatureCollection",
  "features": [
    {
      "type": "Feature",
      "properties": {
        "stroke": "#df0000",
        "stroke-width": 2,
        "stroke-opacity": 1,
        "fill": "#df0000",
        "color": "#df0000",
        "fill-opacity": 1
      },
      "geometry": {
        "type": "Polygon",
        "coordinates": [
          [
            [80.45914649963379, 7.166385542095552],
            [80.4583740234375, 7.168897760609973],
            [80.45704364776611, 7.171069328161938],
            [80.45609951019287, 7.1702603140095835],
            [80.45558452606201, 7.169280979165579],
            [80.45549869537354, 7.167577783117585],
            [80.45914649963379, 7.166385542095552]
          ]
        ]
      }
    },
    {
      "type": "Feature",
      "properties": {
        "stroke": "#ff8000",
        "stroke-width": 2,
        "stroke-opacity": 1,
        "fill": "#ff8000",
        "color": "#ff8000",
        "fill-opacity": 1
      },
      "geometry": {
        "type": "Polygon",
        "coordinates": [
          [
            [80.45914649963379, 7.166385542095552],
            [80.4583740234375, 7.168897760609973],
            [80.45704364776611, 7.171069328161938],
            [80.45609951019287, 7.1702603140095835],
            [80.45558452606201, 7.169280979165579],
            [80.45549869537354, 7.167577783117585],
            [80.45914649963379, 7.166385542095552]
          ]
        ]
      }
    }
  ]
}

```

Figure 5.13: Structure of GEOJSON file (Author: Source)

5.4.3 JavaScript Markers creation

Figure 5.14 below is a combination of three of the screenshots for the Application prototype. The screenshot exhibits two Landslide factor markers. One is a construction activity which affects a slope and the other is a medium-scale deforestation created by humans.

The Markers are visualized as small balloons with a specific colour and a letter assigned to it. Google Map API recognizes balloons as icons. The Balloon/Icon will be shown in a grey colour until the marker gets validated. Image which was used to create model 'Construction activity marker' was taken from Sany web hydraulic excavator manufacture web site (Sany Excavators - Sri Lanka, 2017) and Image which was used to create model 'Deforestation marker' was taken from Biodiversity-Sri Lanka website.

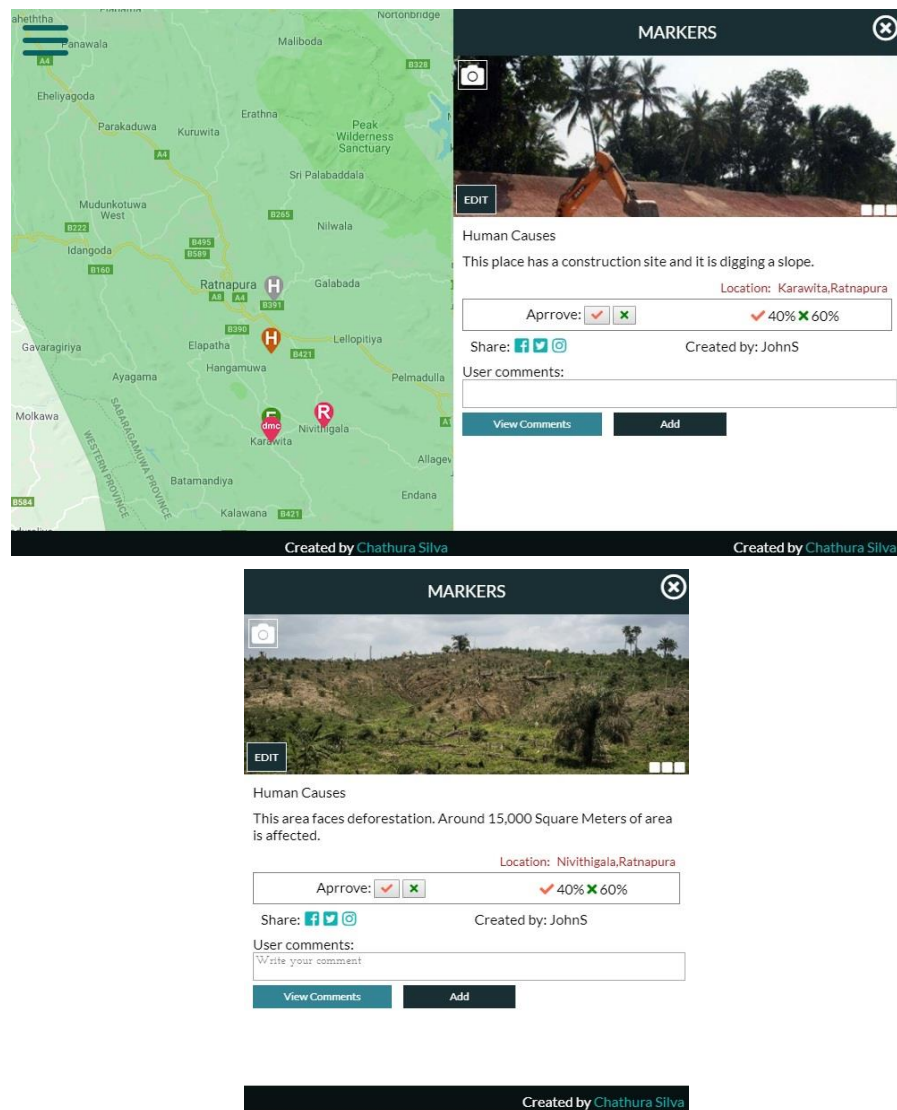


Figure 5.14: Landslide factor marker Screens and their icons (Author: Source)

Figure 5.15 below states the JavaScript coding that is related to the markers above. These instances of the objects are created with static dummy information. Once this

application gets practically developed, these values will be passed from a JSON file from the database using the loop functions for each instance.

```

6  // Marker - Construction
7  var marker01 = new google.maps.Marker({
8    position: {lat: 6.591922, lng: 80.417245},
9    icon: 'http://hbonetwork.com/mobile-app/e-m.png',
10   map: map,
11   title: 'unplanned construction'
12 });
13
14
15 // Marker - Deforestation
16 var marker02 = new google.maps.Marker({
17   position: {lat: 6.592178, lng: 80.417355},
18   icon: 'http://hbonetwork.com/mobile-app/h-m.png',
19   map: map,
20   title: 'Deforestation'
21 });

```

Figure 5.15: JavaScript coding as related to markers (Author: Source)

Data input by the users and the generated data/Information by the application will be fetched by the database through JSON file format. Figure 5.16 below demonstrates the data flow that related to markers.

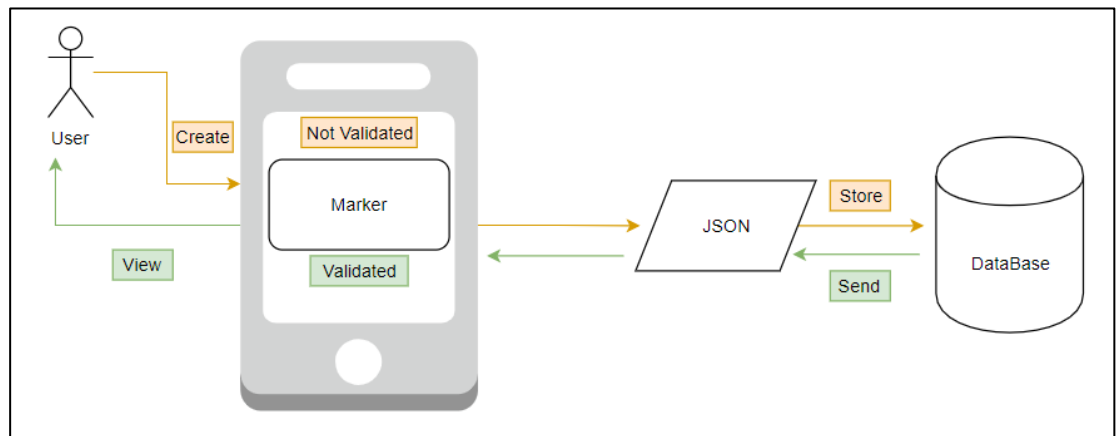


Figure 5.16: Markers data flow (Author: Source)

5.4.4 JavaScript Campaigns creation

Campaigns are a type of marker. However, for clarity, it is not mentioned as a marker but a campaign where people can help the victims of a potential or a disaster that has already occurred. Figure 5.17 below demonstrates the two instances of campaigns.

These campaigns are visualized like markers but with one specific pink colour balloon/icon.

If it is a campaign that belongs to DMC, it is marked as 'dmc' using simple letters. If it is a campaign created by users, then it is marked as 'R' using a capital letter. Since it is a Google marker/Pin, JavaScript coding structure is similar to the coding structure of the markers related to Landslides. HTML5 will create the screen for each marker. Image which was used to create model 'Resource Gathering Centre' campaign marker was taken from 'Help a Child in Sri Lanka' donation web site (Help a Child-Sri Lanka, 2019) and image which was used to create model 'Disaster Management Centre' DMC campaign marker was taken from governmental web site of Ministry of Disaster Management (Ministry of Disaster Management - Sri Lanka, 2019).

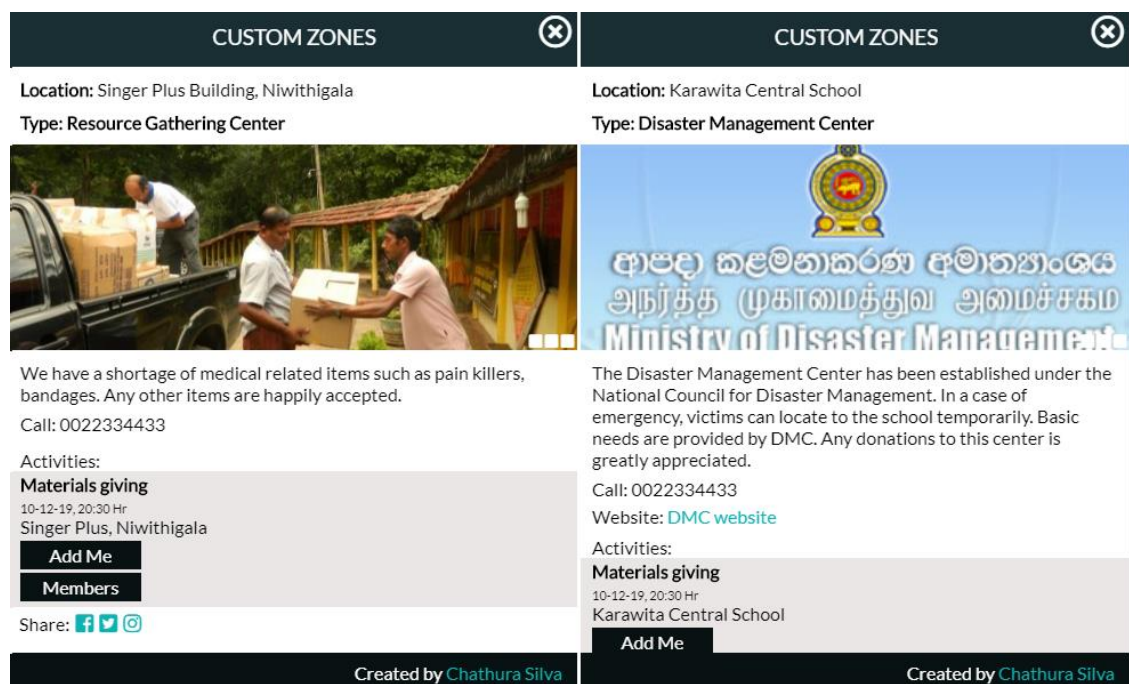


Figure 5.17: Rescue and DMC Campaigns (Author: Source)

Figure 5.18 below demonstrates HTML coding for a marker while Figure 5.19 demonstrates additional HTML structure for a DMC campaign.

```

5 <div class="zones-wrap-add view-zones" id="zoneViewID02" style="display: block;">
6 <div class="set-close">
7 <i class="far fa-times-circle"></i>
8 </div>
9 <h3>custom zones</h3>
10 <div class="member-wrap">
11 <div>
12 Location:
13 <span class="location-zone-view">Singer Plus Building, Niwithigala</span>
14 </div>
15 <div>
16 Type:
17 <span class="type-zone-view">
18 Resource Gathering Center
19 </span>
20 </div>
21 </div>
22 <div class="gallery-wrap">
23 <div class="gal-img">
24 
25 
26 
27 </div>
28 <div class="gal-btns">
29 <i class="fas fa-square"></i>
30 <i class="fas fa-square"></i>
31 <i class="fas fa-square"></i>
32 </div>
33 </div>
34 <div class="zone-view-cnt">
35 <div class="descrip-zones-view">
36 We have a shortage of medical related items such as pain killers, bandages. Any other items are happily accepted.
37 </div>
38 <div class="contact-links-zones">call: <span>0022334433</span></div>
39 <div class="activity-view-zone">
40 <div>Activities:</div>
41 <div class="activity-zone-display">
42 <div class="type-zone-view">Materials giving</div>
43 <div class="date-view">10-12-19, 20:30 Hr</div>
44 <div class="location-view-zone-ac">Singer Plus, Niwithigala</div>
45 <div class="btn-add-me-activity activity-adding-me">add me</div>
46 <div class="btn-add-me-activity members-show-me">Members</div>
47 </div>
48 </div>
49 </div>
50 <div class="activity-social-view">
51 <div class="social-media">
52 <label for="share">Share:</label>
53 <span><i class="fab fa-facebook-square"></i></span>
54 <span><i class="fab fa-twitter-square"></i></span>
55 <span><i class="fab fa-instagram"></i></span>
56 </div>
57 </div>
58 </div>

```

Figure 5.18: HTML coding for a marker (Author: Source)

```

2 <!-- Additional Section: Disaster Management Centre -->
3 <div class="register-provincial">
4 <p>Event / Zone Registration</p>
5 <input type="text" class="external-contact" placeholder="Enter Registration Number" name="external-contact" />
6 <input type="text" class="external-contact" placeholder="Registered Person Name" name="external-contact" />
7 </div>

```

Figure 5.19: additional HTML structure for a DMC campaign (Author: Source)

5.4.5 Hazard areas visualizing

According to the *Conceptualizing the factors* section in chapter 3, the areas that are identified by NBRO as hazard prone slopes need to be visualized on the map. Visualization is done through a GEOJSON file.

Using the sketched maps created by NBRO (National Building Research Organization - Sri Lanka, 2019) to visualize the hazard prone slopes, which are mentioned in *Chapter 3*, those sketches need to be converted into GEOJSON data using a parsing tool called “getjson.io”. Then the data can be parsed into the GEOJSON file of this prototype, which is the ‘areas.geojson’ file. Figure 5.20 below demonstrates the visualization of hazard prone slopes on the prototype. Moderate hazard locations are coloured in orange while high risk locations are coloured in brown.

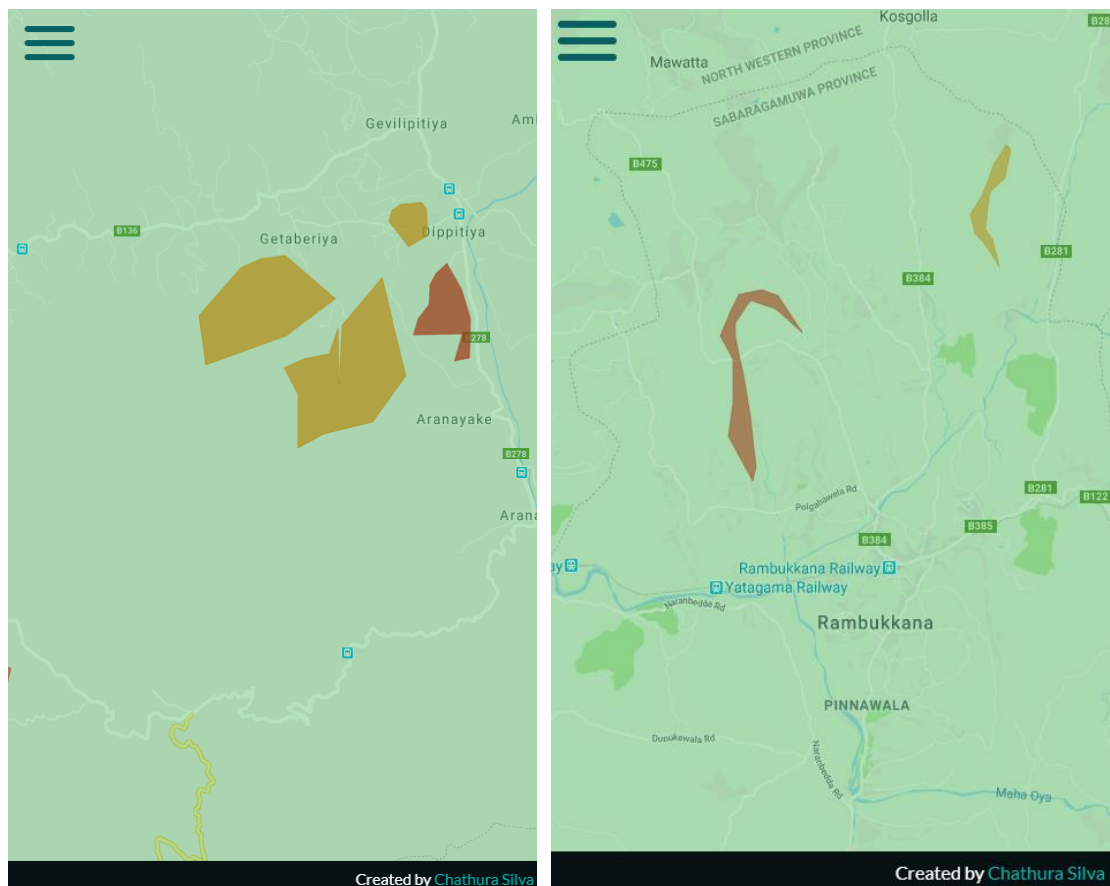


Figure 5.20: Hazard zones visualization on map (Author: Source)

5.4.6 Creating Markers for previous rain-induced Landslide events

NASA GLC has a GEOJSON file (NASA, 2018) which can be used to create markers for historic rain-induced landslide events. Figure 5.21 below shows markers of previous Landslide events in Sri Lanka depicted in the prototype using NASA API.

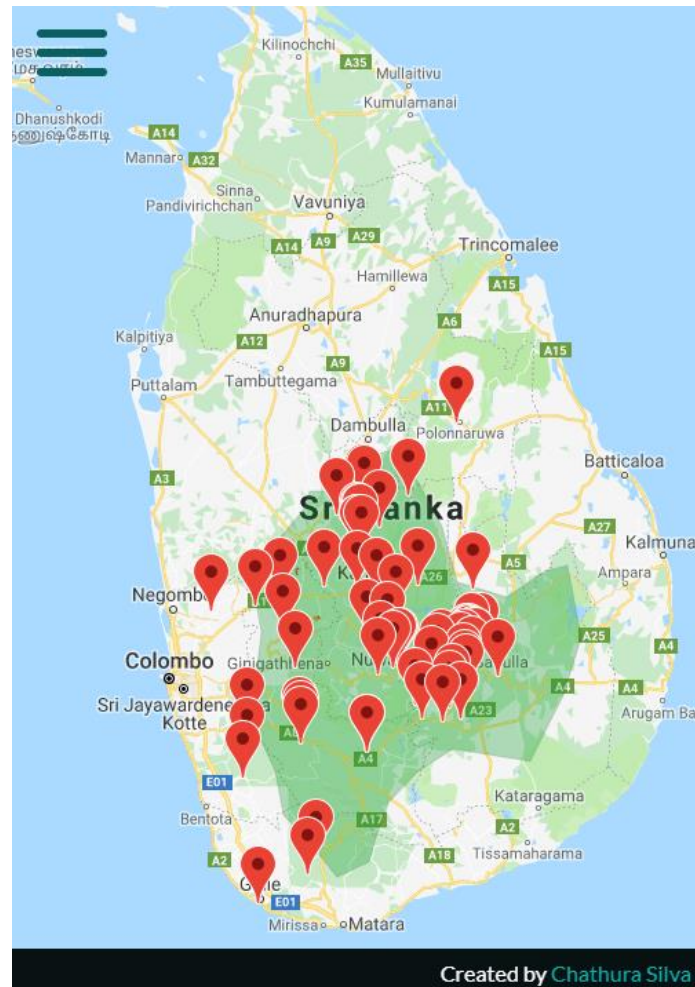


Figure 5.21: Previous Landslide events in Sri Lanka (Source: Author)

5.4.7 Reports creation

Figure 5.22 below demonstrates a report visualization using the ChartJS framework. The ChartJS framework has been used to manipulate the data. ChartJS uses data structures that are loaded as JS objects. The JSON file type is a collection of JS objects. Figure 5.23 below shows an image of the coding structure that extracts the data into ChartJS functions/methods and displays the generated Chart as a HTML canvas.

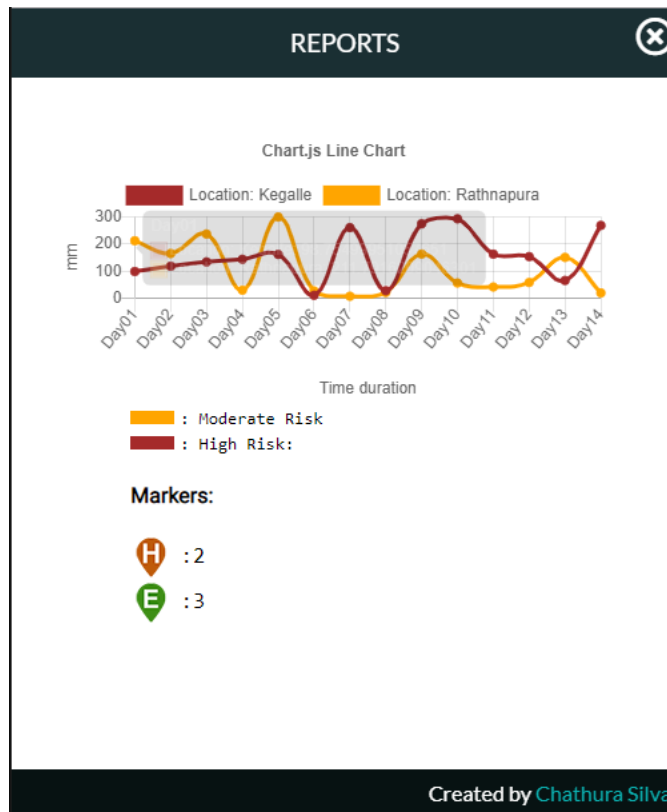


Figure 5.22: Report screen example using dummy content (Source: Author)

```

var DURATION = ['Day01', 'Day02', 'Day03', 'Day04', 'Day05', 'D
var config = {
  type: 'line',
  data: {
    labels: ['Day01', 'Day02', 'Day03', 'Day04', 'Day05', '
    datasets: [{
      label: 'Location: Kegalle',
      backgroundColor: 'brown',
      borderColor: 'brown',
      data: [
window.onload = function() {
  var ctx = document.getElementById('canvas').getContext('2d')
  window.myLine = new Chart(ctx, config);
};

```

Figure 5.23: Section of ChartJS data structure (Source: Author)

5.4.8 Weather Map API integration

AccuWeather is a widely used commercial weather reporting service which has won a reputation as an accurate, detailed and consistent weather data provider for web and mobile application projects (AccWeather, 2019).

A user account with AccuWeather needs to be created to retrieve this service and the desired programming language, method of communication and the time period of data requirement need to be provided.

There are several sub APIs that are provided by AccuWeather service. Locations API is used to get the locations of the required locations, Forecast API is used to get the forecasting of those locations and current conditions and API is also used to get the current weather situation for the specific location. A truncated version of the hourly forecast and the forecast for the upcoming seven days is rendered and provided by the web service. These data are transported as a JSON or an XML file and this information is captured by the mobile application. The Location API is stated at the top of the API data chain since it is the primary requirement. Figure in 5.24 below demonstrates the data flow of the API references (AccuWeather API, 2019). The “LocationKey” is used as the primary ID for this weather data retrieval process.

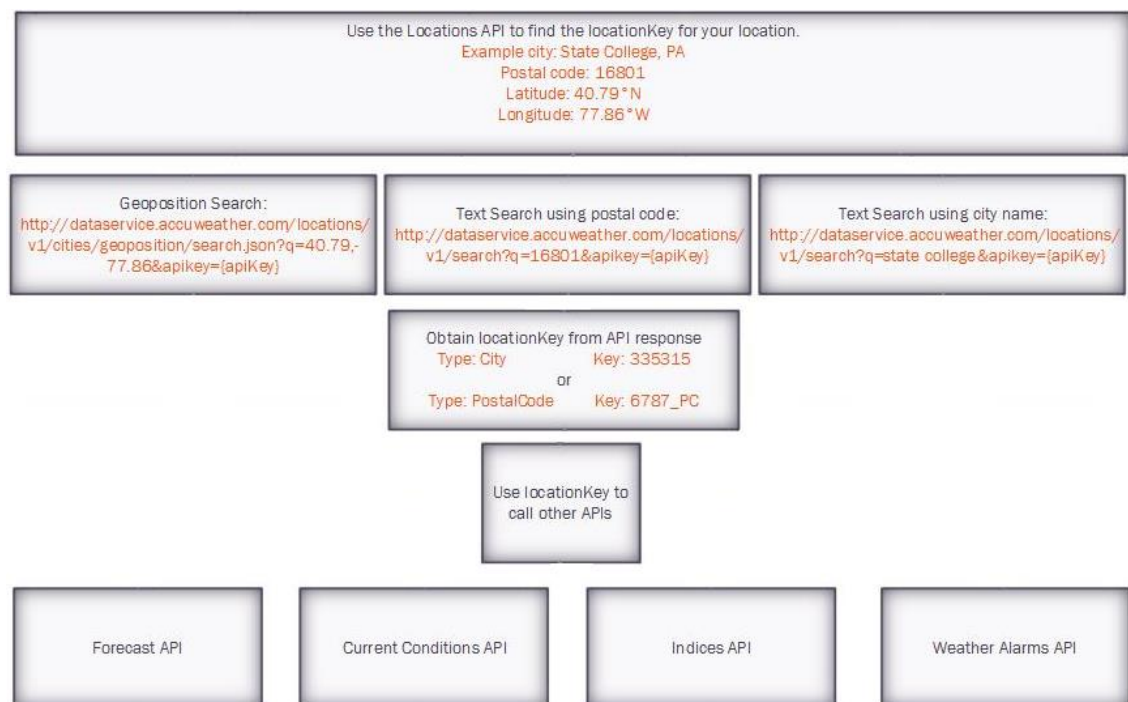


Figure 5.24: API flow of AccuWeather (AccuWeather API, 2019)

The AccuWeather data array holds several weather unit-types, for example, Precipitation, Rain, Snow and Wind as illustrated in Figure 5.25 below.

The Millimetres of rain is the unit which is required for this Application. However, if necessary, AccuWeather is comprised of all the related weather data. JavaScript apprehends the JSON/XML data, which is basically data arrays and it visualizes the data onto the Google map relevant to the locations.

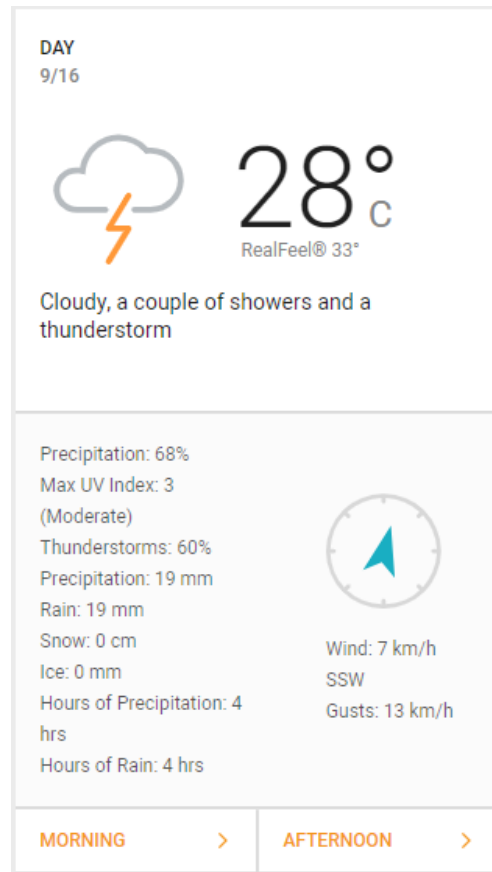


Figure 5.25: Sample of AccuWeather data (AccuWeather, 2017)

5.5 ASP.net and SQL Server as the Back-end development languages

The Data plays an important part of a mobile application. Security, clarity, storing, modifying and retrieval need to be considered while choosing a good solution for data management. Due to the diverse nature of this solution, data should be queried as a large volume of unstructured data or Big data (Reddy, 2018).

This application will retrieve the data from several external hosts/databases through web services. There are two objectives related to retrieving data from external parties.

- Store the needed data in a private database
- Convert the data into information and store the reformed data

- Use data to create a different information/data and delete the data retrieved from the third party

One form of data retrieval that happens in this application is creating markers through users who are registered with this application. The objective of retrieving data from users is to store the user-given data in a private database.

This application initiates the events of the data management through Internet Enabled Devices or in this scenario smartphones (Graham & Dutton, 2014). This application generates the combined data units in images and texts. This type of data can be considered as unstructured and diverse data (Reddy, 2018).

Choosing Microsoft (MS) SQL Server is the best solution since this application processes dynamic unstructured data which requires security. MS SQL server has good security features. Also, data manipulation and learning methods are easier with Microsoft SQL server (McQuillan, 2015). Visual Studio(VS) is the Integrated Development Environment (IDE) of Microsoft and VS can be used in parallel with SQL server since VS has tools built into IDE to use SQL server (Sur, 2013).

ASP (Active Server Pages) is a server-based scripting language which is often used to manipulate, retrieve and store data using the Dot.NET Framework. The Dot.NET Framework is the Microsoft software development framework which includes features, such as, extensive class libraries and language interoperability which are required to develop software applications (Chiaretta, 2018).

5.5.1 Data Retrieval and database

This application needs to connect to external web sources to gather the data. The data could be directly used by the application and stored in the application database for future need.

There are two technical ways that the application will use the data from external sources. The first way is to directly create or connect to a JSON/XML file and create an interactive visualization of the data on the application. One example would be using Google Map

API. The second method is to manipulate the data and create improved data and visualize and illustrate that information on the Application on request. An example would be creating a chart report to depict the rainfall in a certain town during a certain period. Users create markers and campaigns and that data are sent to the database that corresponds with the created user details.

Figure 5.26 below illustrates data retrieval from data from different sources. This application will have a direct connection to the external data and will demonstrate that data as content or as a visual on the application. Depending on the data requirement, the data could be stored in a Database. Data for campaigns and markers should come from users. However, if achievable, consent can be given to an agent of DMC to create DMC campaigns on behalf of MPADM.

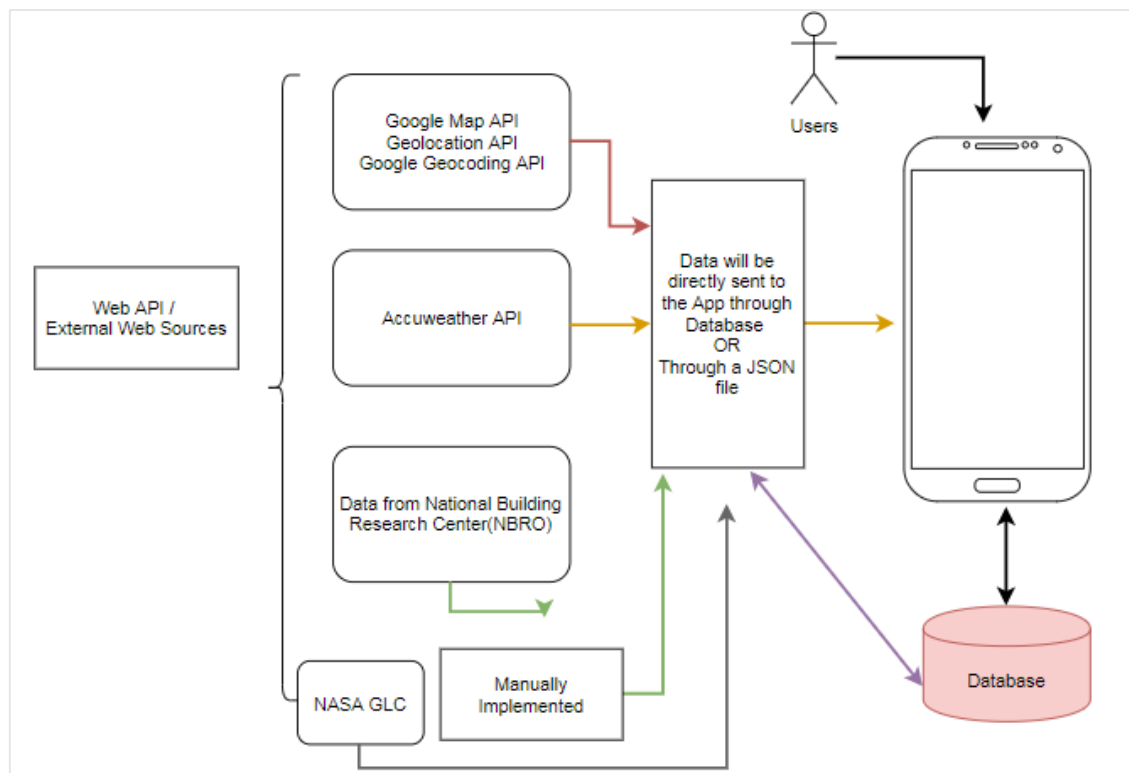


Figure 5.26: Data retrieval from sources (Source: Author)

According to the developed URS, any user can create a DMC campaign pin/marker because the objective of any disaster campaign despite one that has been created by the private sector or DMC, is to deliver resources to victims. A link to a DMC related

campaign link can be added to the application. That DMC website link could provide valuable information.

The data from NBRO is used to create the relevant spatial polygon on the map to depict the potential hazard areas. This data will be created as a form of JSON with the properties of the latitudes and the longitudes. This data can be passed into the Google Map API to depict them interactively on the map. Google Geolocation and Geocoding is used to store information related to the location, the markers, the campaigns and the users.

5.5.2 Database creation

As depicted in Figure 4.26 above, the database holds the complete data related to the application. Data entities are stored as tables in a database. Structured Query Language (SQL) is a modelling language which can be used to manipulate the data in a database. The data from the tables is passed into the ASP.net using a Data Model called ADO (ActiveX Data Object) .net. ADO.net (Sur, 2013) is a data access technique Microsoft developed to manipulate the data from the databases in a convenient way. SQL and ADO.net are used to fetch the data into the ASP.net framework as variables (McQuillan, 2015).

The following Figure 5.27 below demonstrates the database tables structure for the database while Figure 5.28 below depicts the tables and Entity classes related to the tables.


```

1 Table Users {
2   user_id int [pk] // primary key
3   name varchar(30)
4   created_date date
5   user_type varchar(10)
6   user_status varchar(10)
7   username varchar(10)
8   password varchar(10)
9   create_markers void
10  create_activities void
11  validate_markers void
12  create_comments void
13 }
14
15 Table Markers {
16   marker_id int [pk]
17   marker_type varchar(20)
18   marker_title varchar(20)
19   marker_desc varchar(60)
20   marker_created date
21   location_adres varchar(30)
22   location_detail_id int
23   marker_value double
24   comment_list_id int [ref: > CommentList.comment_list_id]
25   activity_list_id int [ref: > ActivityList.activity_list_id]
26   identity_reg_camp int
27   gallery_id int
28   link_camp varchar(50)
29   contact_num numeric(10)
30 }
31
32 Table CommentList {
33   comment_list_id int [pk, ref: < Markers.comment_list_id]
34   comments_id int
35 }
36
37 Table Comments {
38   comments_id int
39   comment_created date
40   username varchar(10)
41   comment_des varchar(60)
42 }
43
44 Table ActivityList {
45   activity_list_id int
46   [pk, ref: < Markers.activity_list_id]
47   activity_id int
48 }
49
50 Table MemberList {
51   member_list_id int [pk]
52   number_of_members int
53 }
54
55 Table Member {
56   member_list_id int [pk]
57   user_id int
58 }
59
60 Table Activities {
61   activity_id int [pk]
62   activity_list_id int
63   activity_des varchar(50)
64   activity_members int
65 }
66
67 Table Gallery {
68   gallery_id int
69   galler_item_id int
70 }
71
72 Table GalleryItems {
73   galler_item_id int
74   galery_item_url varchar(60)
75 }
76
77 Table locationInfo {
78   location_detail_id int
79   longitude double
80   latitude double
81 }

```

Figure 5.27: Database tables logic Structure (Source: Author)

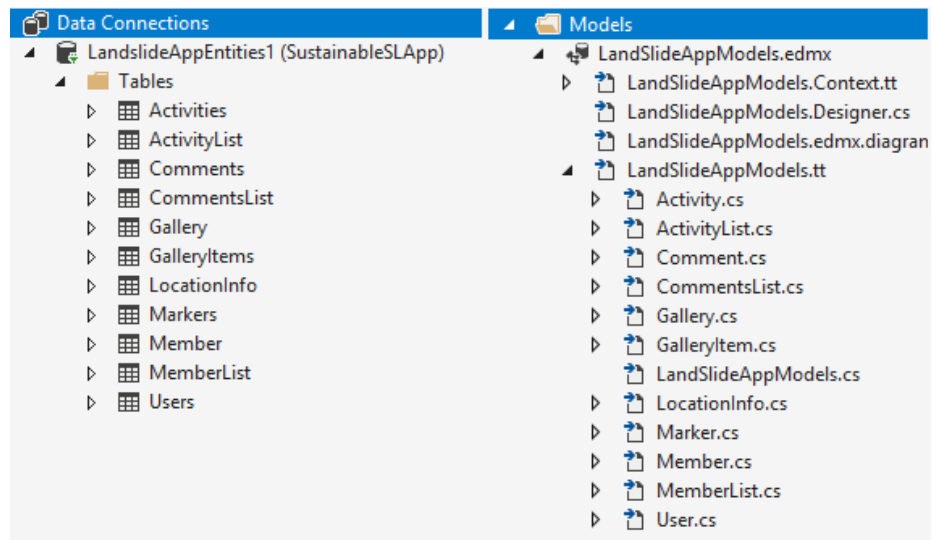


Figure 5.28: Database tables and Data Models (Source: Author)

5.5.3 ASP coding structure

This application executes numerous data related events. ASP coding establishes the connection with MS SQL server and retrieves the complete data and stores it into a

JSON file. Then the JSON file is used to transmit and restructure the data in the application. Figure 5.29 below demonstrates the coding structure of ASP.net to make the connection with the database and pass the “Markers details” into a JSON file. CSharp is the widely used Class based programming language of Microsoft. Even though ASP is used to create the web applications, the back-end coding is implemented using CSharp (Chiaretta, 2018).

```

40 private LandslideAppEntities db = LandslideAppEntities();
41 - references
42 public ActionResult getMarkerDetails() {
43     List<Marker> MarkersList = db.Markers.ToList<Marker>();
44     return Json(new { data = MarkersList }, JsonRequestBehavior.AllowGet);
45 }

```

Figure 5.29: Passing Markers data from the database into a JSON file (Source: Author)

5.5.4 Web API Creation

Web API is a web service which can provide data as its service (Medjaoui, Wilde, Mitra, & Amundsen, 2019). This application has a database which has data related to Landslides in Sri Lanka. Data can be coordinates of previous Landslide events, coordinates of locations of hazards prone zones, markers related to human made events like deforestation and historic weather details. These data are stored in the server. Even though the application provides an interface to view the data through the application, the data can be fetched as row data through the Web API without using the application. The data can be used by other third parties, such as, developers for their purposes.

Since this is a prototype, creating a complete API is not viable. Even so, the structure of the Web API has been shown below in Figure 5.30 as a diagram.

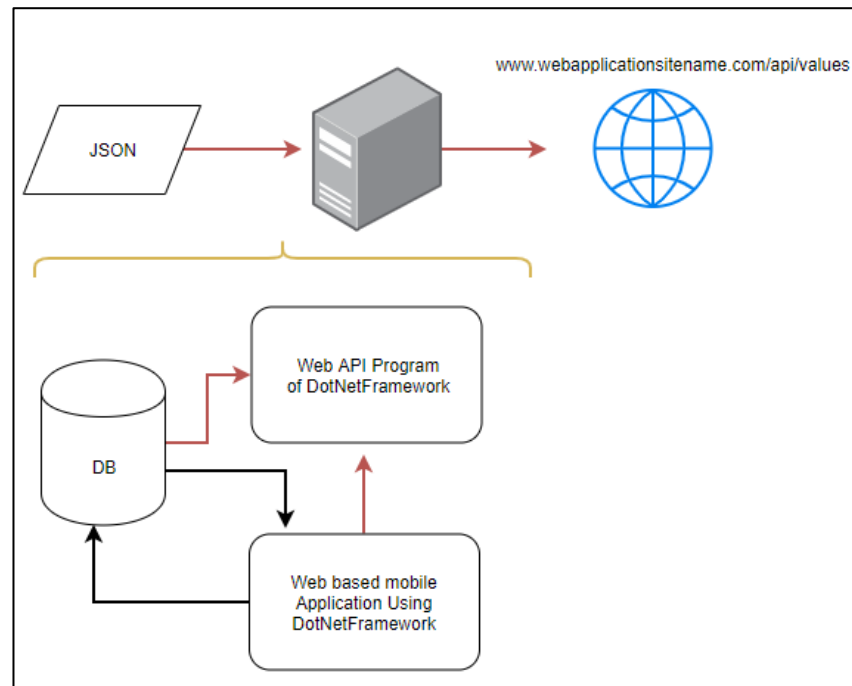


Figure 5.30: Structure of Web API (Source: Author)

This application connects its backend through ASP.net. ASP.net can be used to create a Web API which can generate responses to requests. Users can request data through a URL as shown above and the Web API generates the correct data and sends it to the client.

Fiddler is a web proxy debugging program which can be used to test Web APIs (Fiddler Proxy , 2019). Figure 5.31 below demonstrates a screenshot from a program called Fiddler which has fetched “areas.geojson” file through the application URL.

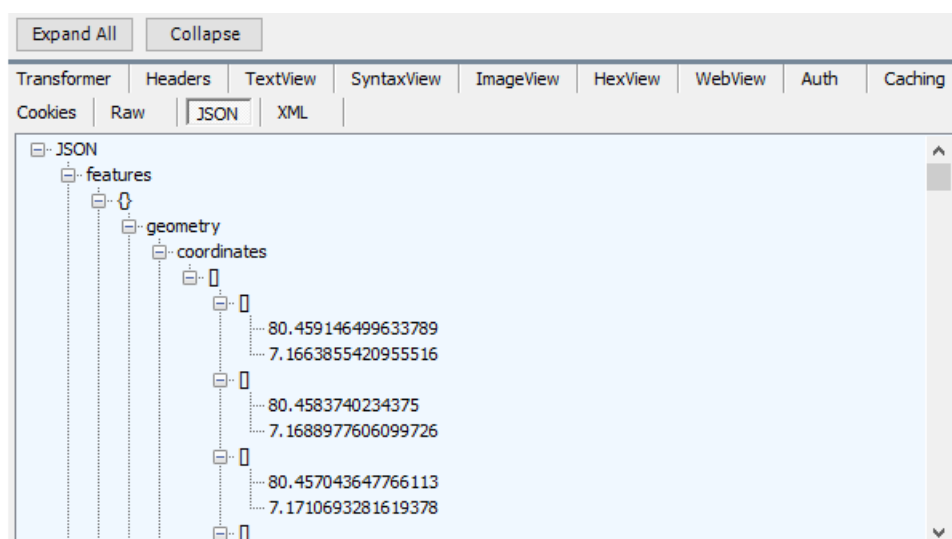


Figure 5.31: Screenshot of Fiddler querying “areas.geojson” file (Source: Author)

5.6 Application Testing

Proper testing is highly important for a successful application development. Nearly hundreds of adequate testing cases are required to conduct the testing phase of a mobile application. Each input for a test case may have different values which could produce different outcomes (Kuhn, Wallace, & Jr., 2004).

Even though triggering errors and faults in the application is the goal, it would be difficult to determine the degree of interaction required to achieve that goal as this application is a prototype only. This prototype uses empirical and theoretical data as an input to process the outcome. Testing using theoretical data is the viable option for this research due to the fact that this application is an initial prototype (Kuhn, Wallace, & Jr., 2004). Empirical data can be used in a situation where the application is actually deployed to the general population.

There is a variety of testing methods that could be used however for the purpose of this application, the Testing phase breaks down to three components, specifically Performance, Usability and Security testing.

Security testing is concerned with integrity, confidentiality, authentication and validity of the data which is being processed (Wysopal, Nelson, Dustin, & Zovi, 2007). Performance testing focuses on determining the responsiveness, reliability and interoperability of an application. This prototype uses the “GreenGeeks” server as the hosting server. The bandwidth, data transfer rate and latency depend on the ISP (Internet Service Provider) apart from the strength of the hosting server. Performance testing evaluates the effectiveness of the application and identifies the bottlenecks of the system (Erinle, 2015). Table 5.1 below demonstrates a test case table sample for Performance Testing.

Table 5.1 Test case table sample for Performance Testing

Test Case:	Application Login		
Description	This process simulates a normal login activity a user performs on the application.		
Data Requirement	A valid Username which is a unique name. It cannot be duplicated. A valid password which is comprised of minimum 8 characters, one of them needs to be capital letter. Two minimum numbers are required as well.		
STEPS			
Step Number	Step Description	Expected Result	Waiting time
01	Open the application from the phone applications dock.	Main screen of the application appears then leads to the login page.	2 seconds
02	Entering username	Username appears with the correct display format.	Less than a second
03	Entering Password	Password appears as Asterisk characters.	Less than a second
04	Clicking the login button	If the username and password are correct and get validated correctly, the screen will take you the Map screen.	6 seconds
05		If the username and password are incorrect or do not match with each other, then the same screen will show a text displaying “Username and Password are incorrect”.	4 seconds

Usability testing focuses on the complete solution or the entire aspects of the application. S/W and H/W both are considered in usability testing. H/W has a strong connection to the performance of the application as well. The H/W requirements that were established in the URS must be addressed in this phase (Barnum, 2010).

Usability testing is inspected by users while the UI and UX design of the application has been carried out using sustainability web designing concepts which were mentioned in the UI and UX section of the implementation section. The adaptation of these concepts are used by the researcher/developer as a tool for usability inspection (Barnum, 2010).

The final stage of this research focuses on the evaluation since the evaluation phase is a unique part of the DSR methodology. Indirectly, some aspects of the evaluation are connected to testing. An ethically approved questionnaire is created to present it to the participants. In this scenario, the participants may act as the usability testers to some of the questions in the questionnaire because those questions have features that are related to the usability testing.

A prototype of the application could be viewed online, and the participants can do the experiment on the application through a browser. The questionnaire could facilitate identifying the faults and constraints of the prototype as it relates to usability and functionality. This method could be considered as a remotely monitored usability testing technique (Maramba, Chatterjee, & Newman, 2019). The output will be the feedback that the participants will give.

5.7 Chapter Summery

This Chapter demonstrates the implementation process of the prototype interface. This chapter also includes a discussion about choosing the correct front-end and back-end languages and other programming techniques. This chapter exhibits the technical development of the prototype using the coding examples and screenshots of the prototype.

6. Evaluation

The evaluation is executed based on a Questionnaire that has been created to get feedback from ten participants who have been selected randomly from the Southern Western province. The aim of the Questionnaire is to acquire suggestions and inputs related to UI, UX, accessibility, limitations/weaknesses, additional functionalities and to find out more about the further advantages of the prototype. Only the substantial and qualitative suggestions are discussed implemented into the prototype and the other suggestions are only discussed in the evaluation phase.

6.1 Questionnaire

The questionnaire is comprised of ten qualitative questions which can be used to measure the outcome of the technical solution. The purpose of the questionnaire is to discuss the effectiveness, benefits, weaknesses, further development and limitations that are related to this technical solution. Each question has been explained below.

When conducting the interview, creating a campaign was considered as 'creating a zone' and creating a Landslide factor marker was considered as 'creating a marker'. Changing the name 'campaign' into 'zone' and changing the 'Landslide factor marker' into 'marker' was done prior to finalizing the report. Because both are markers by nature, the aim was that it would increase the clarity of reporting.

Q1) Was the application easy to use?

This question is used to test the usability of the application. The HCI of the application must be accessible and easy. This application is created using the best UI standards and it is responsive. Responsiveness is a development term that is used by the web development industry which stands for being able to view the site or screen from any portable mobile device properly (Jain, 2014). The participants who volunteered for this study may or may not have knowledge about Web technologies. So, the question is formulated in an easy manner to identify if the application is easily usable and eye catchy.

This question also focuses on the learning curve that a user takes to properly understand the interface. Proper interaction is needed for executing functionalities of the application without any turmoil. This question is partially related to usability testing (Redondo, Bravo, & Ortega, 2009).

Q2) Did you face any slowness of the application?

As mentioned in the research objectives, this application is developed using Web languages. This application does not use native languages, such as, Java (for Android) or SWIFT (for iOS). Due to the nature of HTTPS for creating a web request through the web portal and due to the behaviour of HTML5 and JavaScript, the web-based applications may tend to create a slow response compared to native application development methods. The reasons for using web languages as the building tool for this prototype have been discussed in *Chapter 5*, If the application is built according to best practices, it will not create an issue. This application should be created according to the software and hardware interface requirements which are mentioned in the URS. If the application platform is properly implemented, then the application will not slow or lag. The Internet speed of the user environment is a dominant factor for the speed of the web-based prototype.

Q3) Were you surprised by some actions of the Application?

The term 'surprise' is used to grasp if the user gets astonished by the behaviour of the application. Best practice is that most of the time web applications should behave conventionally when it comes to its behaviour because the user expects them to have the same behaviour since that is how the user sees those elements behave in other platforms. If the user feels that those elements of the application behave differently, the User may feel negatively about the application (Nielsen, 2004). Indirectly this has a connection to the learning curve of the application as mentioned in Question 01. If the user gets surprised by the application, simultaneously it will require time to learn how to

use the application, in other words, it will take time to understand the functionality of the application.

Q4) Do you think the application will be able to achieve its expectations? If it's NO, please state the reasons.

This is an important question which aims to foresee the success of the application. This question expects a personal assumption from the participant. The answer will also be used to determine the likelihood of the success of the application as a factual assertion. As a practical solution it should fulfil the objectives of the research question. The word "Expectations" is used to express the objectives in an informal manner.

Q5) Do you think this application provides security and reliability to users and other resources? Please state the reasons whether it's a Yes or No.

Security is the main concern of the application and the application should implement security strategies to protect sensitive information, provide access to specific information and provide a safeguard to the application. If the users feel it is insecure to access the application or input their sensitive information, users will hesitate to use the application and the application would not succeed to deliver the desired objectives.

Safety Requirements in URS should be implemented to provide security for the application. The functional requirements of the application should also be implemented in such a way that it will help the security requirements to achieve the target. For example, the Personal information required by the application should only be limited to the information required to execute the functions of the application. If the user needs to be informed about an event that occurs in the application, sending an email would be enough since email is a sufficient method. Requesting a mobile number or postal address is not required. The user can select the opt-in or opt-out option through a button to turn-on and turn-off the functionality to publish the real-time location of the user through GPS technology.

The second part of the question asks the participant to state their assumptions related to the security and reliability. There are two types of security implementations. The first type can be seen by the users, and even though the latter type cannot be seen by the users it must be implemented in the back-end of the application. The participants can give their opinions by experimenting with the application and use the existing knowledge they have about the basic security safeguards that they have seen implemented on other applications. They can give their assumptions regarding the modifications that are required to be implemented into the application.

Q6) Are there any aspects of the application you think which were not reliable? You can state your comments regarding markers and zones or looking at overall structure of the application.

This research uses Landslide factor markers (markers) and Campaigns (zones) as a tool to investigate the Landslides related issues. This question aims to get the perspective of the participants regarding what they think of the Landslide factor markers (markers) and Campaigns (zones). It is not assumed that the users have knowledge about map applications that use field data. The guidelines in the questionnaire and the PIS (Participant Information Sheet) would help them to grasp an idea about what the objectives of the application would be, including the functionality of the Landslide factor markers (markers) and Campaigns (zones). The reliability of the Landslide factor markers (markers) and Campaigns (zones) plays a strong part in the application and the evaluation needs to have the perspective of the users to conclude information and create a discussion about the delivered prototype. In terms of 'looking at the overall structure of the application' this illustrates that the comments must be made regarding the connection that the Landslide factor markers (markers) and Campaigns (zones) have relating to the objectives of the application.

Q7) What are the limitations you see in this application? You can state regarding its benefits, problems in the technical aspect of the application.

This question focuses on the limitations of the application. Limitations have two variations. One is the limitations that are related to getting its benefits and other one is limitations which are related to web and mobile technologies. Identifying limitations related to technologies would be helpful to identify bugs, anomalies and the inconsistencies of the applications. The input of the participants can be used to modify the application. Limitations related to the benefits would be helpful to change the functional requirements of the URS, so the benefits which are accrued by the application could go higher. The limitations that are identified related to the mobile technology could be used to modify the implementations, so the actual result is more accurate. These implementations are necessary if the limitation affects the security and the results of the application.

Q8) What are other additional functionalities you think can be added to this Application?

Additional functionalities can be used to provide more assurance for the application regarding fulfilling its objectives. If a function suggested by a participant, helps to improve the UI/UX and increases the effectiveness of the application then those functionalities can be implemented if those functionalities don't affect the URS and the objectives of the application.

Q9) Apart from the benefits, do you think there are other good qualities this application processes? You can give your opinions regarding to any social, technological or any aspects.

This question is created to evaluate the advantages of this application regarding the social, technological or any other aspect conveyed by the participant. Even if the benefits and the advantages are similar by nature, the idea behind this question is to get the perspective of the participants regarding the positive outcomes of the application. The

phase “other good qualities” is used to make the participants think a bit more deeply rather than stating the mentioned benefits of the application in the Questionnaire and the PIS.

Q10) Apart from the land sliding issue. Do you think this application can be modified to achieve other purposes or goals? State your examples.

After letting the participants think about the different advantages of the application, this question requests participants to give their opinions if this application can be modified to achieve other objectives/goals which are not directly related to a landslide. At the same time, it can be assumed that these goals may or may not be indirectly connected. These modifications could help to enhance the usefulness and productivity of the application.

6.2 Questionnaire process

The questionnaire has been given to ten randomly selected participants who reside in the south-western province in Sri Lanka. The south-western province is the most highly affected area in terms of Landslides as depicted in the *Introduction*. It was assumed the community that resides in the south-western province has been exposed to this catastrophe more generally and their insight would be much more effective. Ethical approval was required to conduct this study and it has been approved by Auckland University of Technology Ethics Committee (AUTEC) under application 19/193. All of the documents related to conducting the questionnaire has been approved by AUTEC.

The recruitment of the participants was carried out through Facebook as the medium. The AUTEC Approved advertisement was published on a Facebook page. The advertisement is a web banner which conveys the nature, requirement and contact method of the study. The requirement is testing the prototype in order to answer the questionnaire. Interested candidates were able to send their interest through the contact method which is the email of the researcher. Upon receiving the initial feedback from the candidates, the researcher randomly selected ten candidates as participants. As the advertisement explained people who live in south-western province are qualified for

participation. Then the researcher sends the consent form and Personal Information Sheet (PIS). Once the signed consent form was received, the researcher forwarded the questionnaire along with the URL to test the prototype. A maximum of two weeks was given to the participants to return the completed questionnaire.

The following tables illustrate the answers given by the participants. One question has ten answers given by the ten participants. Each table is assigned to one question. Ten tables are aligned from question 01 to question 10 respectively.

In terms of the feedback from the Questionnaire (the answers given by the participants), the significance of creating a zone means 'creating a campaign' while creating a marker means 'creating a Landslide factor marker'.

Table 6.1: Feedback given by participants for question 01

Participant	Answer
01	Yes
02	Yes, I understand the expectation of the application
03	Yes
04	It was resembled a web page. It was easy though ...
05	Yes
06	Yes
07	Yes, it was good. Picture quality of the Markers could have been better.
08	It was ok. It is like lot of mobile application.
09	Yes
10	It was great.

Table 6.2: Feedback given by participants for question 02

Participant	Answer
01	Little bit ... it was a website rather than an application
02	No, I didn't recall that ...
03	No, only the loading time
04	No
05	No, I was OK.
06	No, it took bit time to load the Map, but I think it is normal for any application.
07	Well I think it depends on the internet speed
08	No.
09	No

10	I don't think so
----	------------------

Table 6.3: Feedback given by participants for question 03

Participant	Answer
01	After a while I got familiar with the application
02	It took some time to understand the application
03	No
04	It was a new application to use.
05	It took some time to understand some of the functionalities of the application.
06	It took bit time to understand the application. The help guide helped a lot.
07	No
08	No, it was easy to use the help guide.
09	I wasn't surprised as it was common application type
10	It bit took time to understand it but as a person who uses google map daily basic I' m confident about Markers.

Table 6.4: Feedback given by participants for question 04

Participant	Answer
01	I think so ... It is a good try It needs to be more developed
02	Yes, I think it will be if it gets finished completely.
03	Maybe, it needs more developments
04	Yes, I think it is an important application
05	Yes, I think it will benefit Sri Lanka and help people. It will create a platform to help victimized people in the Sabaragamuwa.
06	I think it is too early to tell. I think the application needs to be launched first. People use mobile phones and addicted to applications. Because of that I think the user interaction or sending awareness of a project like this would be practical if it is correctly.
07	I think it's a good effort and if the application is attracted by the customers then it will be effective and will deliver a good result
08	I think so and I think this is important application. I think it needs to be popular and socialize among people.
09	Yes, But It cannot be just fulfilled by implementing an application. It needs to have marketing strategies and popularity media assistance for that as well.
10	Yes,

Table 6.5: Feedback given by participants for question 05

Participant	Answer
01	Because it has a login method, I think the system is secure ... is it reliable that people who there are real

02	We need to be sure that our credit card details providing are stored securely. I do not think I like the fact that everybody would know the current location of myself.
03	It has login system, only few details required to login. So It's good that I dnt have to give lot of information
04	It depends on the user as well. The way how he creates input and the way he gives information. And the application should validate the information as well.
05	It is difficult to think from this side. But I think the weather details that the application gets must be reliable. I think Sri Lankan Meteorology cannot be properly relies on. Because the application has a great responsibility to give a correct answer about a upcoming disaster.
06	We give our information to application. That information must be stored properly. It is up to the developer to implement the security standards. It is difficult to say. Application accesses our real time location using GPS. This information is very sensitive.
07	I think it is practically can be done. I believe the application will be able to deliver that result.
08	Yeh, I think this has a password method and we can opt in or out to give the Realtime location of me. So, I think it is secured. Markers get verified by the people who actually witnesses an actual marker.
10	It must be implemented from the side of the developer. It is difficult to predict from this side. It must be told to the users by the developer using the Application that how the security been implemented.

Table 6.6: Feedback given by participants for question 06

Participant	Answer
01	How to determine that the markers are real and currently existing
02	Markers need to be certified that they are correct. There's a confirmation button for it. Is this information is enough for it. I think Raining is the main reason. Also to what degree you think markers can be reliable. Even when you say deforestation, to how length ... how to determine this specific marker will trigger the actual impact.
03	How the markers can be verified. People may create bogus almsgiving centers to get items.
04	I think markers need to be checked if it is correct or not. It also needs to be checked if they are in the correct location. Zones needs be verified otherwise people may use the application to get unnecessary advantages for personal gain.
05	I think Makers are a good idea. Zones must be reliable one as people may cheat to get materials from people. Also are there any governmental organizations like Disaster Management Center where we can get information to help markers or locations.
06	Markers should be authenticated in some manner. When creating a Rescue zone by users, I do not think everybody should be allowed to make it as they wish. I think there should be a control mechanism for that.
07	I think its good and straight forward. I do not think we have to verify everything as this is as a social experiment. There are no legal obligations or anything.
08	I think its good and straight forward. I do not think we have to verify everything as this is as a social experiment. There are no legal obligations or anything.

09	Its just not for Land sliding at the end but the web application strategies are correct but the overall this gives actual map-based information about the status of the country and what happens to its environment. So, the human's activities need to be verified.
10	Markers needs to be sure that they are correct. Weather reports must be sure that they are correct as well. Rescue Zones need to be certified that they have a postal address. Other vise people may cheat.

Table 6.7: Feedback given by participants for question 07

Participant	Answer
01	It is partially done. It is like a website. It helps to save lives of people. It not that attractive to use.
02	Benefits: It will give information about dangerous places of the country and let know people about dangers activity people does. Will help save human lives or resources Problems: Need be completely working. Will people use it often. Thts not sure
03	Limitations: I understand about markers and campaigns but if people leave their homes or be in alert on Heavy rain time if everything becomes normal, will the application give information related to that. I do not see a option or a method for that.
04	Application needs to be fully completed and tested if lot of people are using it. Locations need to be checked if the points are correct or not. But it will help Sri Lanka as people are using mobile phones a lot and it will help to get information about dangerous locations of the country. This is a website not a web application.
05	Limitations: The application is not finished mobile app. Map of the Sri Lanka could be more specific. Benefits: It will help to distribute gifts and donations to the victims and their families. People will be able to see actual catastrophe happens in Sri Lanka and how the environment is being destroyed by the people. Problems: It is difficult to predict the result unless the application is launched completely.
06	Limitations / Problems: I'm not convinced that just using these markers, it is easy to predict a disaster. I need to be convinced that the Weather data are correct as well. Benefits: Every year nearly hundreds of people die or suffer from this disaster. Government is not powerful enough to find a solution by itself. Corruption of the government also a factor for that. I think it is a good that as the society, we try to find a solution for that. I think that's why technology is there for.
07	Limitations: It only looks for Land sliding only. Land slide may create other environmental issues as well. Benefits: It will help to save lives of human being.
08	I think its only see some aspects of a land sliding causing issues. There could be more issues which could create a land slide. I do not know other methods, but I think there could be more.

09	Limitations: It only looks at the issues related to land sliding when it can be used to fetch other vital information about the country. Related to human's activities, weather and environment.
10	Limits: It makes the assumptions just based on Markers and Weather. It needs to be promoted. Good things: It helps the environment, gives the people a good understanding about what happening in the country.

Table 6.8: Feedback given by participants for question 08

Participant	Answer
01	People can be appointed with different titles. Everybody acts like similar.
02	Connecting to governmental web sites or governmental media
03	Rain, Earthquakes, Roads on the hill side. Also this application needs to be promoted rather than just being an application.
04	It doesn't give more information about Realtime events of the location. Application should be modified to reflect that.
05	This information should be stored within the application, so in the future that information can be used to calculate the predictions about future occurrences of the disasters.
06	If there were other methods to get data which could to help the App to predict about a natural disaster rather than just markers, I think it should be included as well. I think it will make the reliability of the application higher. Also, I think as users, we should be able to communicate with each other as well.
07	As I mentioned before you may be able to predict other natural occurrences as well. I think Heavy Rainfall creates flooding as well. Flooding is a good issue in the area of Sabaragamuwa as well. I live there so I know.
08	I think the people must be able to communicate with each other. People should need to communicate like social media platforms.
09	I think people need to able to comment about the weather activities as well. I think its not reliable to depend on weather data predictions. People can provide actual weather conditions.
10	This information can be shared or give to other Data platforms which could help to solve issues in the country or needs the information for other purposes. It's something needs to be implemented into the application. It's cannot be seen by the users, but the developer can use it for other sustainability issues. Social Media integration needs to be much more than this. Application it self will not be enough to solve the issues. There must be a way take this application among to the general publication and make this application popular.

Table 6.9: Feedback given by participants for question 09

Participant	Answer
01	It helps the name of the country. It is cable to identify locations which are dangerous

02	People always use garbage social media applications. This may help to use social interaction to a good cause.
03	Will help poor people and victims of the society Help us to participate in a good cause.
04	As Sri Lanka is a poor country this application will help the community to share materials in a case of emergency. There are lot of poor and innocent people in these areas. If there was a potential issue, there life would be spared from this. This application integrates with the Public Service system in a such a such situation. This will benefit the government as well.
05	This proves that the people in the country try to solve issues of their society without getting political help. When technology is getting stronger and stronger, it proves people have the power to innovate new ideas. This application may help future generations to think out of the box.
06	I think it is a good idea to find any method to help the victims. As a person lives in those areas, even people aware about a potential disaster there is no one influence them to exercise an action. I think this app will be an eye opener for people, specially youth. I think youth are more invested in technology.
07	Social impact: Lot of people in Sri Lanka uses Mobile phones. Sri Lanka has 4G good internet coverage. So, I think this thinking new. This is for the welfare of the country. I think this will motivate people us, young generations to do something good for the country. And I think this can be used by any country. It is a great gift for all over the world.
08	Social: It helps to reduce casualties and help the victims Technological: Google maps is the most used web service in the world. So using google maps is a good thing
09	Social: It helps the society and the country not just by reducing victims or supporting people but people who live in a safer environment will have the capability to know about what happens in the country. Since people live in a mobile age, information spreading, and digital involvement will be great. Technology: Sri Lanka has high speed connections even in the areas where there no proper electricity supply. Mobile network is great that a mobile application can create an effect.
10	Benefits: - it is helpful to the people and to the environment. People will get a knowledge about what happens in the country as in Sri Lanka people destroy the forests and environment. People will have social media platform to share this.

Table 6.10: Feedback given by participants for question 10

Participant	Answer
01	Dengue mosquito issue locations
02	I think deforestation itself will be good. As we are a poor country, if the rescue centres are properly created, they can be used to achieve help to any poor peoples who suffering from any catastrophe.
03	Dengue issue People affected from political issues Deforestation
04	I think the application gets information about Deforestation. Also bad effects of the land mining can be considered as I'm around those areas where people suffers these kind of issues.
05	This can be used to create markers for other negative effects of the environment and the people.

	Sri Lanka faces a huge problem of sand stealing from Rivers. People mine sand from the Rivers and lagoons to sell it for construction. That creates issues such as river erosion. I have seen lot of incidents happen related to that. I think we can use these markers in an informal manner to create an awareness among people. Other environment destructions can be monitored using this application.
06	I think any human activity which could destroy the nature can be monitored using these type of application
07	Flooding, Forest destruction, Healthcare related issues. Elephant attacks happen on the country.
08	Dengue and Cholera issues are healthcare related problems come along with Heavy Rainfall. I think those issues need to be addressed as well.
09	Deforestation, Governmental corruptions, social injustice etc.
10	As mentioned before. Evident about destruction happens in the country. Deforestation etc.

6.3 Findings and Discussion

According to the feedback given by the participants, the discussion is conducted to evaluate the effectiveness, benefits, weaknesses, further development and the limitations of the solution. Discussion is divided into ten sections, in order to reflect on the ten questions and to increase the clarity of the discussion.

Question 01:

While analysing the answers received by all ten participants, it can be comprehended as the Application was easy to use. Participant-04 stated that it resembles a web site. This is partially true due to this prototype is made using web languages. Participants-07 suggested that the quality of the markers could be better. It can be assumed that a participant would suggest that the quality of the icons is not clear. The size of the icons of the markers are 40px by 40px and it can be considered as an optimal size for the icons as popular CSS frameworks use 32px by 32px as the default width and height (Jain, 2014). Changing the icon quality can be done through a small code modification.

Question 02:

When it comes to developing a web-based application, it is compulsory to take account of the latency of the network. The mobile application makes a http request to a server

every time a new event is triggered. This application internally accesses several databases and APIs. This prototype is basically a web site and it needs to be transformed into a mobile application using the PhoneGap framework. However, loading a website or a web-based application would not be any different as both send an http request to a server and the server responds to it. Participant-06 has expressed that it took bit of time to load the map. The map API used in this research is Google map. Google map is the most used navigational map API in the world according to the survey by The Manifest-USA (Panko, 2018). The sluggish nature of the map could be due to a cache issue of the browser or due to the slowness of the internet speed. This application is hosted in “GreenGeeks”, a reliable green hosting service which uses Solid State Drives (SSD) drives to store the information and the requests come through HTTP/2 protocol. GreenGeeks has a set of proprietary tools known as “PowerCatcher” which makes the Application load faster (GreenGeeks, 2019).

Question 03:

A mobile application by nature has different functionalities depending on the nature of its objectives. But the behaviour of the application should act similarly in order to keep the proper development standards of the application. This application is not a completed solution; it is a basic prototype. In order to express the objectives of the application, a help guide has been provided with the application and according to Participant-08 and Participant-10, the help guide has been useful. Even though it seems participant-10 is familiar with the map-based solutions, it still has taken some time to understand the application. It can be assumed it would take a minor learning curve to understand this application. Overall, every participant was able to apprehend the functionalities of the application.

Question 04:

As mentioned in the research objectives, this is a prototype of a solution. Participant-01, 02 and 03 have realized the nature of the prototype and suggested that the application

needs to be developed completely in order to be able to determine its success. Anyhow, the thesis covers the complete solution even though the complete application was not built. Anyhow, this is a meaningful prototype in the sense of using a web-based mobile application to address the Landslide issue for the welfare of the society and it seems that all the participants have understood the importance of the application.

Participant-05 has clearly stated that he believes 'it will be a platform to help victimized people'. Even though the comment of Participant-06 is unclear, it seems that the participant believes due to the increased interaction that people have with a mobile device, it could lead to a positive outcome if the application was implemented fully.

Participant-07, 08 and 09 believe creating a functional application would not be the sole reason for a successful application. Even though the development of the application and methodology was successful, actual objectives can only be fulfilled if the application can be practically used by the people in Sri Lanka. The success of the application depends on the post-production aspects as well. The above mentioned Participants have suggested that marketing strategies and media assistance are also factors to publicize the application among users who can gain a benefit from this solution or contribute to the solution. Overall it seems the participants have a positive vibe towards the application but the actual utilization of the application towards the social welfare of Sri Lanka depends on finalizing a complete solution and marketing the solution towards the desired focus group. In this scenario the focus group is the community of Sri Lanka.

The use of the correct digital marketing strategies and plans could be included into the URS as a section. But it does not imply the URS has been modified into a market driven requirement for the engineering (Vakkalanka & Engu, 2012). URS requires some aspects to be included into the project to advertise the application. At this stage creating a marketing plan for the prototype is only discussed.

Question 05:

Participant-06 and 02 were concerned about publishing their real-time location on the application. This prototype has an option to opt-in or opt-out the real-time location if needed.

The above mentioned participants may have failed to notice that option given in the settings as shown in Figure 6.1 below. Participant-08 has identified that option and has given a positive answer.

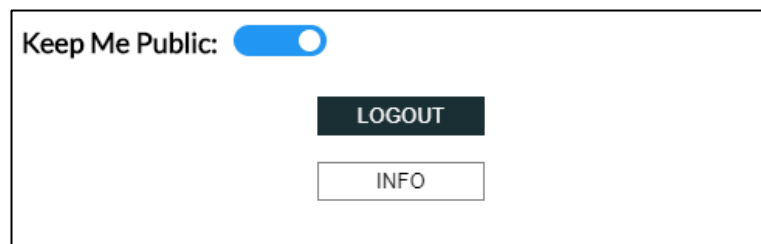


Figure 6.1: Opt-in and Opt-out option for real-time location for the users (Author: Source)

Participant-2 has concerns about giving Credit Card details. Credit card donations can be made to DMC campaigns through online transaction facility built into the application. The actual implementation of the online transactions is not fully developed. Basic credit card security validations have been implemented to ensure the security of the information using ASP.net back-end framework (Microsoft, 2019). The requirement of a new login request, in order to confirm the continuing process for doing the payment can be implemented as a security functionality. The hosting service has an SSL certification to ensure that the data that was transmitted within the client-side and server-side is secured. As an alternative, a different payment processor, such as, PayPal or Google Pay can be implemented.

Participant-04 has expressed that the application should validate the information. The Application has implemented methods to validate the information, such as, the use of Google address locator to confirm the physical address of the user and the server-side information validation using ASP.net to confirm the information, such as, an email address. If required, an option of integrating a mobile number into the registration form

to validate registration or other information can be added as an option. Nevertheless, the mobile number does not need to be added into the database as information about the user.

Participant-05 was intrigued about the reliability of the weather-related data. AccuWeather Inc. uses big data from meteorological and oceanographic sensors to forecast the weather (Adams, 2019). AccuWeather has been collaborating with several academic research studies related to weather and forecasting. Instance would be, “System and method for forecasting probability of precipitation” which was invented by Joel N. Myers, Michael A. Steinberg and James T. Candor (Myers, Steinberg, & Candor, 2008). Precipitation is the primary detail required for the above research and it had used AccuWeather. Due to the mentioned factors above, using AccuWeather can be considered as a viable option.

Participant-06 has stated that the given information about users must be stored in a secure location while Participant-09 has conveyed that it is required to use secure database strategies, but it is not visible from the view of the user. “GreenGeeks” hosting service uses HTTP/2 network protocol and that protocol increments the security over the connection as HTTP/2 requires modified encryption over transmission (GreenGeeks, 2019). The GreenGeeks server has real-time security scanning, checking for malware signatures, secured virtualized file system, advanced clustered threat analysis and proactive server monitoring to secure the database and files (GreenGeeks, 2019).

Participant-09 believes that Android applications are less secure by nature. This application can be converted into an Android, iOS and Windows Mobile application. Android is partially open-source and it is a fact that Android applications face malware attacks. Android has inbuilt security features that reduce the frequency of security threats. It has a feature called “Sandbox” which isolates the app data from other applications so malicious penetrations can be avoided. Google, as the developer of

Android, has increased security implementations to their application store in recent years (Misra & Dubey, 2013).

The comments of Participant-01, 03, 07 and 08 demonstrated that they were happy with the security strategies which were implemented to their best of their knowledge.

Question 06:

Some participants were satisfied with the Landslide factor markers (markers) and Campaigns (zones) while several participants had doubts about the reliability. Participant-2 questioned the depth of the Landslide factor markers (markers). These selected markers are considered as factors to influence a Rain-induced Land slide. The depth of the factors is not considered as a major part of the thesis since it is geological in nature. This is a web-based mobile solution which grasps web sources to provide a way to demonstrate the information related to Landslides in Sri Lanka. Grasping every aspect related to Landslides is not the focus of the research. The focus of the research study is limited to the research objectives. There are numerous factors which are linked to Landslides such as hydrologic factors, strength of the soil and so forth. This solution tries to grasp primary factors related to Landslides in Sri Lanka as researched by NBRO and investigate those web sources to fetch those data into the application.

Some of the participants had doubts if the Landslide factor markers (markers) and Campaigns (zones) are genuine. They wondered if some people could try to deceive users by creating bogus Campaigns (zones) to embezzle materials by faking them as donations. Also, participants have stated that the reliability of the Landslide factor markers (markers) needs to be authenticated further. The following steps have taken to amend the URS to reflect the further modifications that are needed for the prototype regarding Landslide factor markers (markers) and Campaigns (zones).

Landslide factor markers (markers):

Previously the Landslide factor markers required an eighty percent (80%) validation. This

simply means that 8 out of 10 people should approve a marker in order to get it validated as a true event. This validation can be increased to hundred percent (100%) if required. The Landslide factor markers can only be added from the current GPS location. These constraints have been set to make sure that the Landslide factor markers are true and valid.

Users can have ranks and ranks can be upgraded into higher ranks. People who are actively participating with the application and stay on the application can upgrade their ranks. Active participation stands for exploring the country to find markers and creating markers if a disaster strike. Figure 6.2 below demonstrates the UI mock-up of the rank as it is displayed in the application. This application can create a special logging account/portal for government officials or government appointed personnel from the National Building Research Organization (NBRO) in Sri Lanka to create Landslide Factor Markers. In order to do that consent must come from the relevant governmental authority.

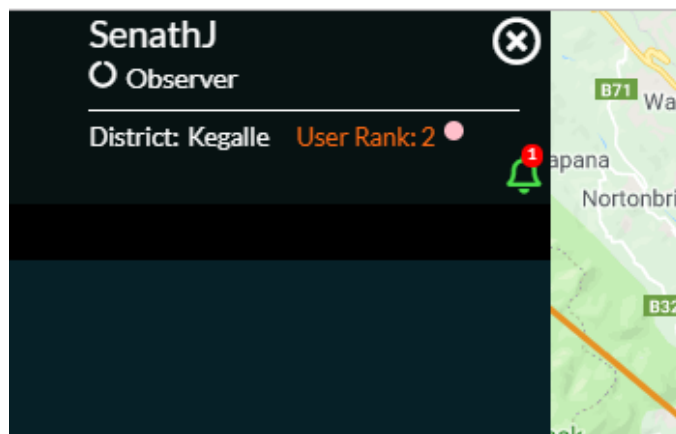


Figure 6.2: User rank and notification node of the UI of the application (Source: Author)

Convolutional neural network is a method of deep neural networking, which can be used to understand and classify visual content (Zhang, et al., 2018). Once a marker is created, uploading several images related to the markers is required. Vision AI is a Google AI and ML product which can identify objects, label them and classify those images into predefined categories (Google Vision API, 2019). Auto ML Vision is a part of Vision AI to automate the custom models.

Images that are uploaded into the application can be sent to Vision Artificial Intelligence (AI) API to validate the classification of the object. Even though this method can be suggested, the implementation requires more research and practical work.

The URL of the images can be sent to Google cloud as a request through jQuery; and Vision AI can validate the images and send back the category as the response to the request as shown in Figure 6.3 below.

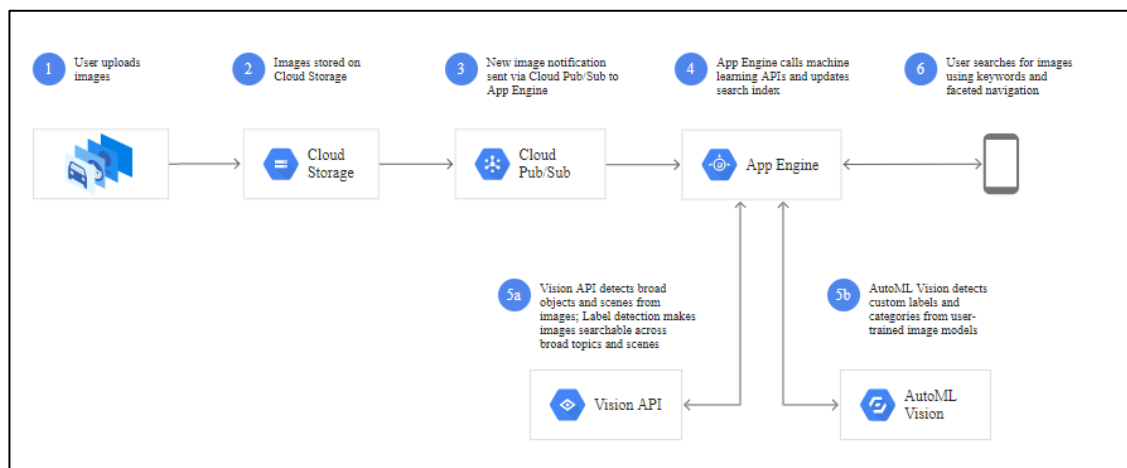


Figure 6.3: Vision AI process to identify an image (Google Vision API, 2019)

Campaigns (zones):

Verification and validation requirements for Campaigns (zones) need to be increased as well. Requirements need to be adjusted accordingly. Either DMC zones only can be created by officials of Ministry of MPAD in Sri Lanka or the Campaign (zone) needs to be approved by the relevant official.

Public Campaigns (zones) need to be registered under a provincial district office related to the location where the zone is situated. Registration number and the name should be submitted to the Application as shown in Figure 6.4 below.

Zone Registration

Enter Registration Number

Registered Person Name

Figure 6. 4: Verification details of the Rescue zone (Source: Author)

As an instance, in Figure 6.5 below shows a Campaign (zone) created in a location in Sri Lanka. The Campaign (zone) is situated in “Morakatiya” provincial area and it needs to be registered in “Ebilipitiya” provincial council as “Ebilipitiya” is the provincial council related to “Morakatiya”, established under Provincial council act No:15 of 1987 (Urban Council-Embilipitiya, n.d.).

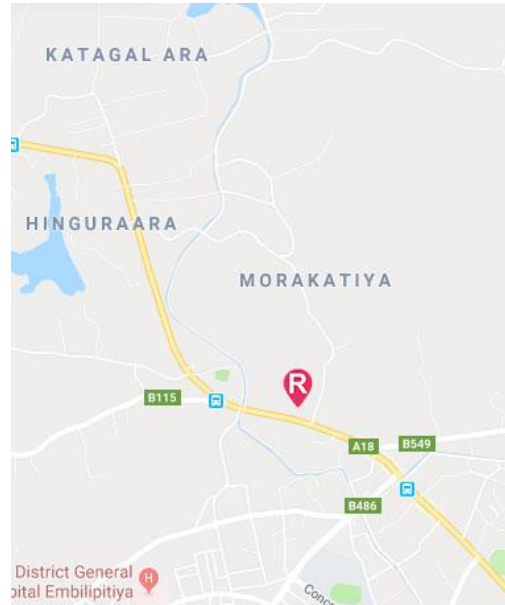


Figure 6.5: Personal Campaign mock-up - Morakatiya (Source: Author)

The application can verify the details by automatically sending the details to the relevant Provincial office personnel. It could be via email and the personnel from the relevant council can view the email with the information given by the creator of the Campaign (zone) and the personnel can verify the account.

Figure 6.6 below visualizes the mock-up of the verification part of the email. Physical address shown in the Figure 6.6 below is extracted using Google Geocoding API through GPS (Google Geocoding API, 2019)

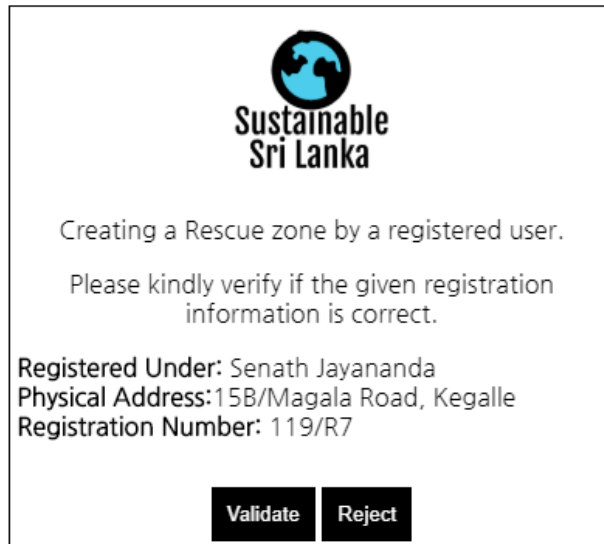


Figure 6.6: Mock-up of the verification email sent to the official (Author: Source)

Upon the verification, the Campaign (zone) will go live, or it will be rejected. The User will get a notification through the application. Notification can be found on the top left side of the menu as demonstrated in Figure 6.2.

In terms of the limitation of the implementation, it is required to have a Web API which has the email addresses of the provincial councils and the relevant divisions if the back-end actions of the application need to be done automatically. Otherwise a manual mechanism is required, in order to send the emails to the relevant authorities.

DMC Campaigns can be only created by an officer of DMC centre. The officer can be given a portal to create and main the activities of the campaign.

Question 07:

Participant-10 and 04 have stated that this application resembles a website. Web languages have evolved from a technological tool to develop web sites to create advanced web-based programming applications. The Web application can be viewed through the HTTP Viewer and the Web viewer is converted into a cross platform mobile application. This conversion happens through the mobile application development framework called PhoneGap.

Participants-02,04,05 and 06 stated that without creating a full solution, it will be harder to predict the actual impact made by the application. It also can be assumed due to the nature of the prototype that they are confused about some aspects of the application. This prototype is an artefact created using DSR methodology only to depict the URS of this research. Delivering a pragmatic working application is not the focus of the research.

Participant-06 and 10 have mistakenly identified if the application can predict a potential landslide event. This application does not have the capability to predict a Landslide. Since the research objectives emphasise that this application is a technological tool to demonstrate and visualize the data related to Landslides in Sri Lanka, at the same time people can interact using the Landslide factor markers (markers) and the Campaigns (zones).

It may or may not possible to predict a land slide due to the ambiguous nature of this natural phenomenon since the factors and their impact may differ from one geological location to another or due to the diverse nature of the causes of landslides (National Building Research Organisation - Sri Lanka, 2019). It is still necessary to conduct further research in the area of Geology and related sciences to investigate the best model or to improve the models that exist that have been created to predict a landslide. The technological tools which require to gather related data from the physical location to a digital platform also need to be thoroughly investigated. For an example, IoT is a technological concept which supports this requirement. IoT is a connection of devices through a series of layers to produce information gathered through these layers. Through the individual development of each of the layers of IoT, such as, electronics, sensors and mobility, data are gathered. One of the important layers is the Connectivity layer and it can be the network or a network of networks. Ultimately, the Internet is the widespread network. The transmission of information through protocols and interpreting it to UI is possible through the Web. The ideology behind this echo-system of IoT is to provide quality IoT-generated data (Alaya, Drira, & Gharbi, 2017). Several researchers from Matoshri college of engineering & research centre Nashik-Maharashtra in India have

created a conceptual system to grasp the data through sensors which are related to a land slide. This IoT based system uses soil moisture sensors, vibration sensors and accelerometer/gyroscope sensors to detect the moisture content of the sand, movements and the vibration of the land. Grasped data are then transmitted to a cloud-based server (Eknath, Dashrath, Pandurang, & Dlnkar, 2018). If the data is presented in the server, a modified version of this application can fetch the data and demonstrate it to the users through the application because the data is available through a web source. Even so, it is still necessary to conduct proper research to determine the correct integration strategy.

Another aim of this application is to find a way to help the Sri Lankan community through a web-based mobile application and to promote increased awareness of Landslides. This research aims to evaluate a method to increase the resource management of the community through the development of this application.

Participant-03 has raised an important question stating that after the post math of a landslide, if the displaced people who left their residencies decided to come back would the application help them in such a scenario. This assertion is made by DMC through NBRO (Disaster Management Centre - Sri Lanka , 2019). After their inspection on locations and decreased weather conditions, they release a public message through broadcast media or via the web. This application could add an additional functionality to send NBRO and MPADM notifications to the users. Figure 6.7 below demonstrates a mock-up of the UI where the messages received from NBRO and MPADM get displayed through the application. Figure 6.8 below shows an example of the news that can be retrieved from the MPADM website to display in the web application. The RSS (Really Simple Syndicate) Feed is a web feed method which can be used to fetch news via online. The DMC website supports RSS and it can be used as a technological tool in the application. However, since this application is a prototype to investigate a solution, according to the scope of this research, the implementation of this functionality is not an

intention. This can be considered as an additional functionality and additional functionalities are discussed in Question-08 in this Questionnaire.

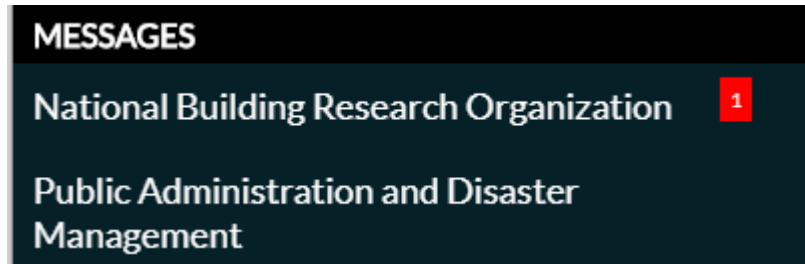


Figure 6.7: Notification location of Messages sent by Governmental organizations (Source: Author)



Figure 6.8: News alert released on DMC-Sri Lanka (Disaster Management Centre - Sri Lanka, 2019)

Participant-07 and 09 convey that this application could point to other environment and weather-related events. An assumption can be drawn from the comments made by Participant-7 and 08 that this technological tool can be used to analyse data relating to other society and sustainability related issues. This comment points to Question-10 in this Questionnaire, and it will be discussed in the final Question (10th Question).

Participant-01,05 and 06 have stated that this application will bring support to the community of the affected areas in the sense of giving them a relief and convenience at a time of a social disaster however the application needs to be fully finalized. This

application could be a tool to connect people who can help the helpless people through zones (Campaigns). As a citizen in Sri Lanka, Participant-06 has identified that the government is not strong enough to provide relief to the victims due to limited resources. The campaigns by the applications, alerting and connectivity with NBRO and MPADM will help the government through the time of a natural disaster and collaboratively can help each other to help the victims, if this prototype is correctly finalized and effectively utilized.

The intention of Question-07 was to find limitations in terms of benefits except some participants have commented about the benefits and stated their views on the advantages in Question-07. A discussion related to the benefits is evaluated through the Question-09 in this Questionnaire however since their views are relevant those comments are discussed below.

Participant-04 has identified that because this application is a mobile solution it is good for the country since mobile and broadband infrastructure is increasing significantly in Sri Lanka. Due to the rapidly increasing market share of the telecommunication industry in the country (Paul Budde Communication Pvt Ltd, 2018), a mobile application would be an effective communication mechanism to share information in Sri Lanka.

Participant-02, 05 and 10 have stated that this application will help to demonstrate how people have and do destroy the environment. It can be assumed that these comments have been made in regard to Landslide factor markers that are related to human causes. Human activities have a strong influence on the occurring natural disasters (Goudie, 2018) and this application could be a tool to gather data related to natural destructions.

Question 08:

Participant-01 has stated that users can be categorized into several categories. Separate categories suggest different privileges. Giving user ranking as discussed in Question-06, will grant them additional privileges. Therefore, giving separate categories is not required.

Participant-02 states that the application should be able to connect and communicate with a governmental platform. Governmental bodies related to natural disasters, such as, NBRO and MPADM could be linked to the application to share dynamic relevant information or data related to Landslides. They could have a web portal to access the application, similar to registered users. These functionalities have been discussed in Question-06 and 07.

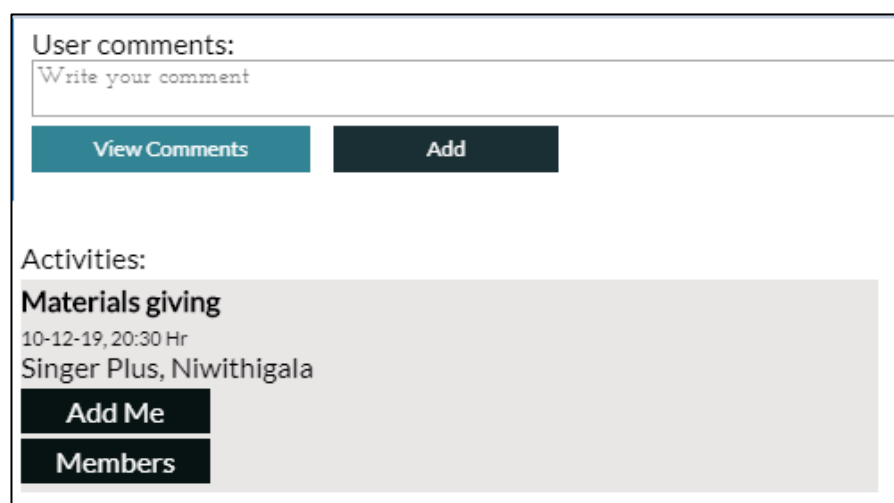
Participant-03 and 10 make a strong argument that the success of the actual application depends not only on the effectiveness of the application it also depends on the promotion of the application as well. This argument was brought on earlier question as well. In order create an actual impact on the society, and to create Landslide factor markers (markers) and Campaigns (zones) to achieve research objectives, the Application needs to be distributed and promoted to the society. The Application should be promoted through social media and other digital advertising/marketing platforms. It could be possible to get support from governmental bodies to promote the application, as they have a strong media platform to broadcast information related to natural disasters. The Application could be promoted in Schools and other community institutions as well as in public exhibitions in Sri Lanka.

Participants-10 and 05 have suggested that the data / information received by the application should be stored in the application for future purposes. "Purposes" illustrates that the information could be used by other digital platforms. This application has a database which is hosted in a Cloud based Green hosting virtual environment. Another aim of this research is to create a Web API to share restructured and generated data through the web server. The distribution of the data can be completed though any web-based data transmitting method, such as, JSON, XML or CSV (Comma-Separated Values). The API can share the gathered data / information related to land sliding among any party who requires it to use the API for their research or on a website/application. However, at this stage, the practical implementation of an API has not been carried out as this is still at the prototype stage. Due to this being just an interface actual

implementation is not developed but mentioned in the implementation section. Further modifications to the prototype and the validation of the data are required for that purpose. This is only a discussion of the functionality.

This prototype could also have a functionality to view reports related to the retrieved/generated data. It could be shown graphically, such as, via graphs and charts. Even though this functionality was not mentioned by a Participant, it is linked to the objectives of the application. The Data/Information related to the Landslide factor markers (markers) could be summarized through reporting as designed *in the 'Reports creation' of the Chapter 5*.

Participants-06 and 08 suggest the idea of implementing a messaging method between users. This application aims to keep the privacy of the users to its maximum level and communication is limited to fulfilling its objectives and functionalities. Users can communicate through limited questions and communicating methods related to events/functionalities. The URS of the application has created limitations to the communication regarding markers as shown in Figure 6.9 below to protect privacy and security. Comment censoring validations are implemented through jQuery framework to protect the application and its users.



The screenshot displays a web interface with two main sections. The top section, titled 'User comments:', contains a text input field with the placeholder 'Write your comment'. Below the input field are two buttons: 'View Comments' (teal) and 'Add' (dark grey). The bottom section, titled 'Activities:', features a grey rectangular box. Inside this box, the text 'Materials giving' is displayed in bold, followed by '10-12-19, 20:30 Hr' and 'Singer Plus, Niwithigala'. Below this text are two buttons: 'Add Me' and 'Members', both in dark grey.

Figure 6.9: communication methods by commenting and participating to activities (Source: Author)

Question 09:

According to the diverse answers given by the Participants, a summary can be drawn accordingly. This application can be used to help the victims and helpless people who face a catastrophe. This application can create a bridge between people who need help and people who can help them. In other words, it is a management of resources among people in the country. People who live in any location of the country, who are only aware about natural disasters as news, can actively participate by contributing to the welfare of the country. Participation would increase the thoughtfulness of the people as well.

It can be assumed that identifying the verified locations which are dangerous and notifying about crisis situations may help to increase awareness about Landslides in Sri Lanka. It is presumed that it will motivate, inspire and influence people to act earnestly and keep track of the danger.

Using a mobile application will be an innovative idea as the smart phone consumption, Social media consumption and infrastructure for high speed internet connections have been increasing over the years (Paul Budde Communication Pvt Ltd, 2018). Using mobile applications to solve social issues could be a tech savvy idea and it would motivate the youth of the country to think out of the box. This application uses web technological tools, such as, AccuWeather and Google Maps. These tools can be manipulated to achieve something innovative, interactive and useful.

Mobile phones use less energy and even in a time of power failure, compared to traditional digital broadcasting methods, such as, radio or television, Smartphones will be an effective media tool in terms of sharing information.

This application acts as a platform to retrieve information about various adverse activities that harm the environment. Instances include deforestation and mining of the soil. This application gathers data related to these occurrences. This data can be analysed to fulfil other purposes in addition to investigating land-sliding. Question-10 will discuss that aspect of the application.

A fully developed and modified application can gather data and keep track of dangerous areas. If this data can be accurately analysed, it could be used to make correct decisions regarding land sliding.

A modified reporting tool can be used to view statistics related to the events in the sense of seeing correlations, make comparisons, find a relationship among variables for the purpose of making factual assertions based on the visualized data. It could be an informative tool for the users to recap a summary of the impact created by a natural disaster, through an application where the users can actively participate in campaigns. This application could be developed to interact with governmental resources, such as, the DMC of Sri Lanka and the NBRO. Collaboration between personal resources with governmental resources could increase social sustainable development when it comes to natural disasters (Browne, Sustainable development goals : seven decades of UN goal-setting, 2017). This application could be helpful to the government as the governmental entities can use help in the event of a natural disaster. As responsible citizens of the country, people can collaborate and come together to help each other to overcome difficult situations by using this application as a tool.

The above discussed points are the key points that have been based on an analysis of the answers from the participants to Question-09 related to the advantages of the application.

Question 10:

After letting the participants think about the different advantages of the application, this question requested the participants to give their opinions if this application can be modified to achieve other objectives/goals which are not directly related to a landslide. Therefore, it can be assumed that these goals may or may not be indirectly connected to Landslides. This is because an additional aim of the research was to brainstorm ideas by asking the participants for their feedback to find out if there were any additional positive outputs related to the solution. According to the suggestions received by the

participants, the participants have realized deforestation and land mining could be considered as factors that influence a land slide and they are also environmental issues as well. The markers that are created could help to point out the locations where these activities happen.

Heavy rainfall which is the primary factor for land slide in Sri Lanka creates massive flooding throughout the south-western and central provinces, as investigated in *Conceptualizing the factors in chapter 3*, Flooding is also a natural phenomenon that destroys properties, human lives and subverts the natural balance of the society. Every year due to flooding caused by heavy rain, people lose their homes, properties, crops and even their lives in Sri Lanka (Wagenaar, et al., 2019).

Flooding pollutes the natural water sources, such as, rivers and wells. This is a breeding ground for a bacterium called Vibrio which spreads a bacterium which causes watery diarrhoea. This disease is called Cholera (Heyningen, 2018). The occurrence of these events may or may not interconnected.

If water collects on surfaces due to rainfall, it creates a natural breeding ground for a lethal mosquito called Dengue, which could be considered as one of deadliest diseases in the world (Falcón-Lezama, Betancourt-Cravioto,, & Tapia-Conyer, 2019). Cholera and Dengue are both fatal and could lead to death.

This could also be a platform to analyse the distribution of resources to the victimized people. Necessary input methods to retrieve feedback from the people who got affected and who contributed resources, can be implemented into the application. It will help to determine the success of a social cause as well as the weaknesses and anomalies associated to it.

Deforestation, Land mining, Flooding, Cholera, Dengue and Resource Distributions were the other goals the participants suggested in Question-10. Modifying the markers, connecting the other external web sources, collaborating with digital platforms that belong to the governmental and other relevant authorities that work to solve these

problems and linking web services through APIs to the back-end of the application will require further research, in order to investigate, based on an analysis of those initiatives, the ones that are feasible through an interactive web-based mobile application.

6.3 Chapter Summery

The Evaluation process is thoroughly depicted in this chapter in order to identify the effectiveness, benefits, weaknesses, further development requirements as well as the limitations of the solution. Feedbacks given by participants are exhibits on this chapter and the relevant discussion has been carried out. This chapter also demonstrates the conducted questionnaire process which facilitated the process involved in creating the evaluation.

7. Summery and Conclusion

This research has conducted an investigation into the rain-induced Landslides that occur in Sri Lanka by addressing this issue through a web-based mobile solution which was created as the research outcome. The south-western province in Sri Lanka suffers from Landslides which occur during the monsoon season. Due to the diverse and complicated nature of this issue, tackling this issue is difficult even with the effort that the governmental bodies have taken. Reason for this difficulty is due to the unpredictable factors and the limited resources.

This research investigates the factors which cause the Landslides in Sri Lanka through web sources and create a tool to visualize and analyse the data gained through a web-based mobile application. Due to the lack of use of technological tools in Sri Lanka by the government and other related parties, using a web-based mobile tool could be helpful. This solution interacts with users and give them a mobile interface to share information related to Landslide factors in Sri Lanka which gets validated through a social proofing process. Another functionality of this application is to create a web-based mobile interface where people can contribute resources towards the people who face such a disaster. This application is a prototype which was built using front-end and back-end technologies. This solution grasps data related to factors of Landslides in Sri Lanka through web sources, but this solution does not grasp every factor related to a Landslide due to resource limitations and diverse nature of Landslide factors. An example would be unavailability of web sources to get statistics of underground water levels in Sri Lanka. Underground water level is one of many endogenic factors related Landslides and investigating all the endogenic factors would be infeasible to the scope of this research.

The DSR methodology is used for this research for the data gathering, design, development and evaluation process. Creating a functional application is not the objective of this research but to create an artefact to demonstrate its functionalities is the goal. In order to achieve that goal, five research objectives have been created which formulate a research question. Due to the diverse nature of this solution it is required to

have a strong evaluation process and DSR is the desired methodology. Prototyping can be considered as the SDLC for this artefact, as the requirements may need to be added, removed or modified in a non-sequential manner. URS have been created to demonstrate the components of the application. This is strictly built using web languages including HTML5, CSS3, Pure JavaScript, JavaScript Frameworks and ASP.net while using external Web APIs, such as, AccuWeather, ChartJs and Google Maps.

The evaluation has been done by conducting a Questionnaire by choosing ten participants from the south-western area as the desired candidates. The participants are asked questions about UI, the accessibility of the application, learning curve of the application, benefits, weaknesses, limitations, and the further requirements needed for the solutions. The discussion is created using the answers given by the participants. The discussion delineates each key point and if the suggestions are not material enough to consider adding to the solution, justifications are given.

According the findings, this solution can be helpful to Sri Lankan community to increase the awareness of this issue, access information related to this issue interactively and able to actively participate to this issue through the application. But the application needs to be fully developed and shared among the community. Additional verification methods need to be implemented in order to increase the validity of the Landslide factor markers and campaign markers. According to the suggestions given by the participants of the Questionnaire, additional functionalities can be implemented to the application in order to address other issues which are indirectly connected to similar environmental disasters. This solution does not only visualize information, but these data can be stored in a green hosting server and can be utilized through a Web API.

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Appendices

Appendix A



Auckland University of Technology Ethics Committee (AUTEC)

Auckland University of Technology
D-88, Private Bag 92006, Auckland 1142, NZ
T: +64 9 921 9999 ext. 8316
E: ethics@aut.ac.nz
www.aut.ac.nz/researchethics

25 June 2019

Krassie Petrova
Faculty of Design and Creative Technologies

Dear Krassie

Re Ethics Application: **19/193 Tackling land sliding sustainability issue in Sri Lanka using a web based mobile application**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 25 June 2022.

Non-Standard Conditions of Approval

1. The committee observes that the term 'defector use' will require further clarification in the survey.

Non-standard conditions must be completed before commencing your study. Non-standard conditions do not need to be submitted to or reviewed by AUTEC before commencing your study.

Standard Conditions of Approval

1. The research is to be undertaken in accordance with the [Auckland University of Technology Code of Conduct for Research](#) and as approved by AUTEC in this application.
2. A progress report is due annually on the anniversary of the approval date, using form EA2, which is available online through <http://www.aut.ac.nz/research/researchethics>.
3. A final report is due at the expiration of the approval period, or, upon completion of project, using form EA3, which is available online through <http://www.aut.ac.nz/research/researchethics>.
4. Any amendments to the project must be approved by AUTEC prior to being implemented. Amendments can be requested using the EA2 form: <http://www.aut.ac.nz/research/researchethics>.
5. Any serious or unexpected adverse events must be reported to AUTEC Secretariat as a matter of priority.
6. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTEC Secretariat as a matter of priority.

Please quote the application number and title on all future correspondence related to this project.

AUTEC grants ethical approval only. If you require management approval for access for your research from another institution or organisation, then you are responsible for obtaining it. If the research is undertaken outside New Zealand, you need to meet all locality legal and ethical obligations and requirements. You are reminded that it is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard.

For any enquiries, please contact ethics@aut.ac.nz

Yours sincerely,



Kate O'Connor
Executive Manager
Auckland University of Technology Ethics Committee

Cc: silvachathura@yahoo.com

Appendix B

Coding Structure of the prototype Interface

- Home Screen:

```

2  <!-- INDEX PAGE -->
3  <!DOCTYPE html>
4  <html>
5  <head>
6      <title>Sustainable Sri Lanka</title>
7      <meta name="viewport" content="width=device-width, initial-scale=1" />
8      <link rel="stylesheet" type="text/css" href="style.css">
9  </head>
10 <body>
11
12 <div class="cover">
13     <div class="wrapper main-screen">
14         
15     </div>
16
17 <div class="footer-info">
18     <p>Created by <a href="#"> Chathura Silva </a></p>
19 </div>
20
21 <script src="https://ajax.googleapis.com/ajax/libs/jquery/3.3.1/jquery.min.js"></script>
22 <script type="text/javascript" src="custom.js">
23 </script>
24
25 <script>
26     setTimeout(function(){ window.location = "login.html"; }, 1400);
27 </script>
28 </body>
29 </html>

```

- Login Screen:

```

2  <!-- LOGIN PAGE -->
3  <!DOCTYPE html>
4  <html>
5  <head>
6      <title>Sustainable Sri Lanka</title>
7      <meta name="viewport" content="width=device-width, initial-scale=1" />
8      <link rel="stylesheet" type="text/css" href="style.css">
9  </head>
10 <body>
11
12 <div class="cover">
13     <div class="wrapper">
14         <a href="index.html"></a>
15     <div class="input-wrap">
16         <input type="text" name="username" id="username" placeholder="username">
17         <input type="text" name="password" id="password" placeholder="password">
18         <input type="button" name="login-submit" id="login-submit" value="Login">
19         <a href="register.html">Register</a>
20         <span class="memory-input">
21             <p>Remember Me</p> <input type="checkbox" name="remember-me" value="remember-me">
22         </span>
23     </div>
24     <div class="footer-info">
25         <p>Created by <a href="#"> Chathura Silva </a></p>
26     </div>
27 </div>
28 </div>
29
30 <script src="https://ajax.googleapis.com/ajax/libs/jquery/3.3.1/jquery.min.js"></script>
31 </body>
32 </html>

```

- Register Screen:

```

2  <!-- REGISTER PAGE -->
3  <!DOCTYPE html>
4  <html>
5  <head>
6      <title>Sustainable Sri Lanka</title>
7      <meta name="viewport" content="width=device-width, initial-scale=1" />
8      <link rel="stylesheet" type="text/css" href="style.css">
9  </head>
10 <body>
11
12 <div class="cover">
13
14     <div class="wrapper">
15         <a href="index.html"></a>
16         <h3>Register</h3>
17         <div class="input-wrap register">
18             <input type="text" name="fname" id="fname" placeholder="name">
19             <input type="text" name="location" id="location" placeholder="location">
20             <label for="user type">User Type:</label>
21             <span class="user-input">
22                 <input type="radio" name="observer" value="observer"> Observer
23                 <input type="radio" name="defector" value="defector"> Defector
24             </span>
25             <input type="text" name="username" id="username" placeholder="username">
26             <input type="text" name="password" id="password" placeholder="password">
27             <input type="text" name="repassword" id="repassword" placeholder="confirm password">
28             <input type="button" name="login-submit" id="login-submit" value="Register">
29         </div>
30     </div>
31     <div class="footer-info">
32         <p>Created by <a href="#"> Chathura Silva </a></p>
33     </div>
34 </div>
35 <script src="https://ajax.googleapis.com/ajax/libs/jquery/3.3.1/jquery.min.js"></script>
36 </body>
37 </html>

```

- Map Screen:

```

2 <!-- MAP PAGE -->
3 <!DOCTYPE html>
4 <html>
5 <head>
6
7 <title>Sustainable App - Landslide Sri Lanka</title>
8 <meta charset="utf-8" />
9 <meta name="viewport" content="width=device-width, initial-scale=1.0">
10 <link rel="shortcut icon" type="image/x-icon" href="docs/images/favicon.ico" />
11 <link rel="stylesheet" href="https://use.fontawesome.com/releases/v5.7.2/css/all.css"
12 integrity="sha384-fnmOCqbTlWIlj8LyTjo7mOUStjsKC4pOpQbqyi7RrhN7udi9RwhKk9HpvLbHG9Sr" crossorigin="anonymous">
13 <style type="text/css">
14 @import url('https://fonts.googleapis.com/css?family=Josefin+Slab');
15 @import url('https://fonts.googleapis.com/css?family=Open+Sans');
16 @import url('https://fonts.googleapis.com/css?family=Lato');
17 </style>
18 <link rel="stylesheet" href="style.css" type="text/css">
19 </head>
20 <body>
21 <!-- <div class="cover">
22 <div class="wrapper"> -->
23 <div class="menu-wrap">
24 <div class="menu-bar"></div>
25 <div class="menu-bar"></div>
26 <div class="menu-bar"></div>
27 </div>
28 <!-- starts here main content -->
29 <div class="menu" >
30 <div>
31 <div class="close-btn"><i class="far fa-times-circle"></i></div>
32 <div class="profile">
33 <div class="prof-info">
34 <div class="noti-name">JohnS</div>
35 <div class="noti-status">
36 <i class="fas fa-circle-notch"></i>
37 <p>Observer</p>
38 </div>
39 <div class="zone-prof">
40 <span>Location:</span>
41 <span class="zone-type">Kegalle</span>
42 </div>
43 </div>
44 <i class="far fa-bell"></i>
45 </div>
46
47 <div class="menu-items">
48 <h4 class="menu-h4-1">create</h4>
49 <div class="menu-items-1">
50 <span class="markers-span">Markers</span>
51 <div class="markers">Type-A</div>
52 <div class="markers">Type-A</div>
53 <div class="markers">Type-A</div>
54 </div>
55 <h4>location:</h4>
56 <div class="content-set-wrap">
57 <input type="text" name="set-name-set" id="username-set" >
58 <p class="set-name-set">Kegalle</p>
59 <button>edit</button>
60 </div>
61 </div>
62
63 <div>
64 <div class="set-cnt-items">
65 <h4>change user type:</h4>
66 <div class="content-set-wrap">
67 <p class="set-name-set">Objector</p>
68 <button>Change</button>
69 </div>
70 </div>
71 </div>
72 </div>
73 </div>
74 </div>
75 </div>
76 </div>
77 </div>
78 </div>
79 </div>
80 </div>
81 </div>
82 </div>
83 </div>
84 </div>
85 </div>
86 </div>
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101 </div>
102 </div>
103 </div>
104 </div>
105 </div>
106 </div>
107 </div>
108 </div>
109 </div>
110 </div>
111 </div>
112 </div>
113 </div>
114 </div>
115 </div>
116 </div>
117 </div>
118 </div>
119 </div>

```

```

120 <h4>Add Donation:</h4>
121 <div class="content-set-wrap">
122   <p class="set-name-set">VISA ***</p>
123   <button>Add/Change</button>
124 </div>
125 <div class="content-set-wrap title-set-ovr">
126   <h4>Keep me public: </h4>
127   <label class="switch">
128     <input type="checkbox" checked>
129     <span class="slider round"></span>
130   </label>
131 </div>
132 <div class="content-set-wrap logout-btn">
133   <button>logout</button>
134 </div>
135 </div>
136 <div class="content-set-wrap info-settings">
137   <button>Info</button>
138 </div>
139 <div class="wrap-info-details">
140   <div class="set-close info-close-btn">
141     <i class="far fa-times-circle"></i>
142   </div>
143   <h3>App Information</h3>
144   <span>
145     Users live in or outside danger zones.
146   </span>
147   <div>
148     <div class="info-span-1"></div>
149     <div class="info-span-2">Defector User</div>
150   </div>
151   <div>
152     <div class="info-span-1"></div>
153     <div class="info-span-2">Observer User</div>
154   </div>
155   <span>
156     Markers indicate any location where there's a potential hazard is
157     identified. It can be categorized to Hazards made by Humans, happened or happening
158     due to Weather or happens or happening naturally.
159   </span>
160   <div>
161     <div class="info-span-1"></div>
162     <div class="info-span-2">Human made Markers</div>
163   </div>
164   <div>
165     <div class="info-span-1"></div>
166     <div class="info-span-2">Weather created Markers</div>
167   </div>
168   <div>
169     <div class="info-span-1"></div>
170     <div class="info-span-2">Environment created Markers</div>
171   </div>
172   <span>
173     Zones are the area or location which is created as a campaign for the victims. It
174     can be created by users or governmental and non NGO organizations.
175   </span>

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176 <div>
177   <div class="info-span-1"></div>
178   <div class="info-span-2">Rescue zones created by Users</div>
179 </div>
180 <div>
181   <div class="info-span-1"></div>
182   <div class="info-span-2">Rescue zones created by Governmental or NGOs. Also
183     known as disaster management centers.
184   </div>
185 </div>
186 <span>
187   These are larger areas of a disaster predictment.
188 </span>
189 <div>
190   <div class="info-span-1"></div>
191   <div class="info-span-2">Disaster Zone. An area which likely to be
192     impacted by a landslide.
193   </div>
194 </div>
195 <div>
196   <div class="info-span-1"></div>
197   <div class="info-span-2">Danger zone. An area which is already impacted by a landslide.</div>
198 </div>
199 </div>
200 </div>
201 <!-- Markers -->
202 <div class="markers-wrap mrk-edit">
203   <h3>Markers</h3>
204   <div class="set-close">
205     <i class="far fa-times-circle"></i>
206   </div>
207   <div class="gallery-wrap">
208     <div class="camera-btn alt="camera button">
209       <i class="fas fa-camera"></i>
210     </div>
211     <div class="gal-img">
212       
213       
214       
215     </div>
216     <div class="gal-btns">
217       <i class="fas fa-square"></i>
218       <i class="fas fa-square"></i>
219       <i class="fas fa-square"></i>
220     </div>
221   </div>
222   <div class="marker-type">
223     <select name="marker-type" id="marker-type">
224       <option value="select the marker">select the marker</option>
225       <option value="human-made">Human-Made</option>
226       <option value="water-based">Water-Based</option>
227       <option value="environment-based">Environment-Based</option>
228     </select>
229   </div>
230   <div class="des-details">
231     <textarea name="descri-marker" id="descri-marker">EDIT</textarea>
232   </div>
233   <div class="marker-btn">
234     <button>confirm</button>
235   </div>
236 </div>

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237 <!-- Markers View -->
238 <div class="markers-wrap mrk-view" id="markerViewID01">
239   <h3>Markers</h3>
240   <div class="set-close">
241     <i class="far fa-times-circle"></i>
242   </div>
243   <div class="gallery-wrap">
244     <div class="camera-btn" alt="camera button">
245       <i class="fas fa-camera"></i>
246     </div>
247     <div class="gal-img">
248       
249       
250       
251     </div>
252     <div class="gal-btms">
253       <i class="fas fa-square"></i>
254       <i class="fas fa-square"></i>
255       <i class="fas fa-square"></i>
256     </div>
257     <div class="edit-mrk-view">edit</div>
258   </div>
259   <div class="marker-type">
260     <div>
261       Human Causes
262     </div>
263   </div>
264   <div class="des-details">
265     <div name="descri-marker" id="descri-marker">This area faces deforestation.
266     Around 15,000 Square Meters of area is affected.</div>
267   </div>
268   <div class="mrk-view-loc">
269     <span>Location:</span>
270     <span>Nivithigala,Ratnapura</span>
271   </div>
272
273   <div class="social-content-markers">
274     <div class="approve-v">
275       <div class="approve-v2">
276         <label>Approve: </label>
277         <button><i class="fas fa-check"></i></button>
278         <button><i class="fas fa-times"></i></button>
279       </div>
280       <div class="approve-rate">
281         <span><i class="fas fa-check"></i></span>
282         <span>40%</span>
283         <span><i class="fas fa-times"></i></span>
284         <span>60%</span>
285       </div>
286     </div>
287     <div class="create-v">
288       <div class="social-media">
289         <label for="share">Share:</label>
290         <span><i class="fab fa-facebook-square"></i></span>
291         <span><i class="fab fa-twitter-square"></i></span>
292         <span><i class="fab fa-instagram"></i></span>
293       </div>
294       <div class="create-by">
295         <span>Created by:</span>
296         <span>JohnS</span>
297       </div>
298     </div>
299     <div class="comments-box">
300       <div>User comments:</div>
301       <div class="comments-add">
302         <textarea name="comments-by" placeholder="Write your comment" id="comments-by">
303       </textarea>
304     </div>
305     <div class="view-comments">view comments</div>
306     <div class="add-comments">add</div>
307   </div>
308 </div>

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309 </div>
310 <!-- Second marker for Steer Slope -->
311 <div class="markers-wrap mrk-view" id="markerViewID02">
312 <h3>Markers</h3>
313 <div class="set-close">
314 <i class="fas fa-times-circle"></i>
315 </div>
316 <div class="gallery-wrap">
317 <div class="camera-btn" alt="camera button">
318 <i class="fas fa-camera"></i>
319 </div>
320 <div class="gal-img">
321 
322 
323 
324 </div>
325 <div class="gal-btns">
326 <i class="fas fa-square"></i>
327 <i class="fas fa-square"></i>
328 <i class="fas fa-square"></i>
329 </div>
330 <div class="edit-mrk-view">edit</div>
331 </div>
332 <div class="marker-type">
333 <div>
334 Human Causes
335 </div>
336 </div>
337 <div class="des-details">
338 <div name="descri-marker" id="descri-marker">
339 This place has a construction site and it is digging a slope. </div>
340 </div>
341 <div class="mrk-view-loc">
342 <span>Location:</span>
343 <span>Karawita,Ratnapura</span>
344 </div>
345 <div class="social-content-markers">
346 <div class="approve-v">
347 <div class="approve-v2">
348 <label>Approve: </label>
349 <button><i class="fas fa-check"></i></button>
350 <button><i class="fas fa-times"></i></button>
351 </div>
352 <div class="approve-rate">
353 <span><i class="fas fa-check"></i></span>
354 <span>40%</span>
355 <span><i class="fas fa-times"></i></span>
356 <span>60%</span>
357 </div>
358 </div>
359 <div class="create-v">
360 <div class="social-media">
361 <label for="share">Share:</label>
362 <span><i class="fab fa-facebook-square"></i></span>
363 <span><i class="fab fa-twitter-square"></i></span>
364 <span><i class="fab fa-instagram"></i></span>
365 </div>
366 <div class="create-by">
367 <span>Created by:</span>
368 <span>JohnS</span>
369 </div>
370 </div>
371 <div class="comments-box">
372 <div>User comments:</div>
373 <div class="comments-add">
374 <textarea name="comments-by" placeholder="Write your comment" id="comments-by">
375 </textarea>
376 </div>
377 <div class="view-comments">view comments</div>
378 <div class="add-comments">add</div>
379 </div>
380 </div>
381 </div>
382 </div>
383
384

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385
386
387 <!-- show comments on click -->
388 <div class="comment-view-wrap">
389   <div class="close-btn">
390     <i class="far fa-times-circle"></i>
391   </div>
392   <h3>User Comments:</h3>
393   <div class="comments-view">
394     <div class="comments-seq">
395       <p>Your Comment will be shown here</p>
396       <span>Date: Time: JohnS</span>
397     </div>
398     <div class="comments-seq">
399       <p>Your Comment will be shown here</p>
400       <span>Date: Time: JohnS</span>
401     </div>
402     <div class="comments-seq">
403       <p>Your Comment will be shown here</p>
404       <span>Date: Time: JohnS</span>
405     </div>
406     <div class="comments-seq">
407       <p>Your Comment will be shown here</p>
408       <span>Date: Time: JohnS</span>
409     </div>
410     <div class="comments-seq">
411       <p>Your Comment will be shown here</p>
412       <span>Date: Time: JohnS</span>
413     </div>
414     <div class="comments-seq">
415       <p>Your Comment will be shown here</p>
416       <span>Date: Time: JohnS</span>
417     </div>
418     <div class="comments-seq">
419       <p>Your Comment will be shown here</p>
420       <span>Date: Time: JohnS</span>
421     </div>
422     <div class="comments-seq">
423       <p>Your Comment will be shown here</p>
424       <span>Date: Time: JohnS</span>
425     </div>
426     <div class="comments-seq">
427       <p>Your Comment will be shown here</p>
428       <span>Date: Time: JohnS</span>
429     </div>
430     <div class="comments-seq">
431       <p>Your Comment will be shown here</p>
432       <span>Date: Time: JohnS</span>
433     </div>
434     <div class="comments-seq">
435       <p>Your Comment will be shown here</p>
436       <span>Date: Time: JohnS</span>
437     </div>
438     <div class="comments-seq">
439       <p>Your Comment will be shown here</p>
440       <span>Date: Time: JohnS</span>
441     </div>
442   </div>
443 <!-- ZONES ADD SCREEN -->
444 <div class="zones-wrap-add add-zone-event">
445   <div class="set-close">
446     <i class="far fa-times-circle"></i>
447   </div>
448   <h3>add zones</h3>
449   <div class="member-wrap">
450     <input type="text" class="zone-title" placeholder="Enter Title">
451     <input type="text" class="add-location-zone" placeholder="Add location">
452     <div class="members-wrap">
453       <div>Add members:</div>
454       <input type="text" class="search-members">
455       <div class="members-display">
456         <div class="member-names">firstN</div>
457       </div>
458       <div class="members-display">
459         <div class="member-names">firstN</div>
460       </div>
461       <div class="members-display">

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461 <div class="members-display">
462   <div class="member-names">firstN</div>
463 </div>
464
465 <select name="zone-types" id="zone-types" class="zone-types">
466   <option value="Donations">Donations</option>
467   <option value="Materials-giving">Material Giving</option>
468   <option value="Laour-groups">Labour Groups</option>
469   <option value="dmc">Disaster Management Centres</option>
470 </select>
471 <div class="description-zone">
472   <textarea name="description-zone-text" id="zone-des-txt"></textarea>
473 </div>
474 <div class="register-provincial">
475   <p>Event / Zone Registration</p>
476   <input type="text" class="external-contact" placeholder="Enter Registration Number">
477   <input type="text" class="external-contact" placeholder="Registered Person Name">
478   <span class="register-provincial-tooltip">
479     <ul>
480       <li>Every Rescue zone should be registered with Provincial Council of the District.</li>
481       <li>Verification and the Name of the person registered should be submitted.</li>
482       <li>Verification will take 2-3 Working Days.</li>
483     </ul>
484   </span>
485 </div>
486 <input type="text" class="external-link-zone" placeholder="paste any external links">
487 <div class="activity-btn-group">
488   <button class="activity-add-btn activity-add-me">
489     Add Activities
490   </button>
491   <button class="activity-add-btn zone-gal-me">
492     Add Gallery
493   </button>
494 </div>
495 <input type="text" class="external-contact" placeholder="add contact method">
496 <div class="members-buttons">
497   <button class="zone-btn-confirm">confirm</button>
498   <button class="zone-btn-draft">draft</button>
499 </div>
500 </div>
501
502 <div class="comment-view-wrap activity-group">
503   <div class="close-btn activity-group">
504     <i class="far fa-times-circle"></i>
505   </div>
506   <h3><span>Zone:</span> - Activities:</h3>
507   <div class="comments-view activity-group">
508     <input type="text" name="activity-name" id="activity-name" placeholder="Activity Name">
509     <textarea name="activity-des" id="activity-des" placeholder="Create a description"></textarea>
510     <button class="add-activity-btn">Add Activity</button>
511   </div>
512 </div>
513
514 <div class="description-zone">
515   <textarea name="description-zone-text" id="zone-des-txt"></textarea>
516 </div>
517 <input type="text" class="external-link-zone" placeholder="paste any external links">
518 <button class="activity-add-btn">
519   Add Activities
520 </button>
521 <input type="text" class="external-contact" placeholder="add contact method">
522 <div class="members-buttons">
523   <button class="zone-btn-confirm">confirm</button>
524   <button class="zone-btn-draft">draft</button>
525 </div>
526 </div>

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600     <span class="location-zone-view">Karawita Central School</span>
601 </div>
602 <div>Type:
603     <span class="type-zone-view">Disaster Management Center
604     </span>
605 </div>
606 </div>
607 <div class="gallery-wrap">
608     <div class="gal-img">
609         
610         
611         
612     </div>
613     <div class="gal-btns">
614         <i class="fas fa-square"></i>
615         <i class="fas fa-square"></i>
616         <i class="fas fa-square"></i>
617     </div>
618 </div>
619 <div class="zone-view-cnt">
620     <div class="descrip-zones-view">
621         The Disaster Management Center has been established under the National Council for Disaster Management.
622         In a case of emergency, victims can locate to the school temporarily. Basic needs are provided by DMC.
623         Any donations to this center is greatly appreciated.
624     </div>
625     <div class="contact-links-zones">call: <span>0022334433</span></div>
626     <div class="external-link-zone">Website: <a href="www.dmc.lk">DMC website</a></div>
627     <div class="activity-view-zone">
628         <div>Activities:</div>
629         <div class="activity-zone-display">
630             <div class="type-zone-view">Materials giving</div>
631             <div class="date-view">10-12-19, 20:30 Hr</div>
632             <div class="location-view-zone-ac">Karawita Central School</div>
633             <div class="btn-add-me-activity activity-adding-me">add me</div>
634             <div class="btn-add-me-activity members-show-me">Members</div>
635         </div>
636     </div>
637 </div>
638 <div class="activity-social-view">
639     <div class="social-media">
640         <label for="share">Share:</label>
641         <span><i class="fab fa-facebook-square"></i></span>
642         <span><i class="fab fa-twitter-square"></i></span>
643         <span><i class="fab fa-instagram"></i></span>
644     </div>
645 </div>
646 </div>
647 <div class="members-activity-view">
648     <div class="close-btn-members-list">
649         <i class="far fa-times-circle"></i>
650     </div>
651     <div>Activity Name: <span>Materials giving</span></div>
652     <div>Location: <span>Sabaragamuwa, Colombo</span></div>
653     <div class="member-list-activity">
654         <ul>
655             <li>JohnS</li>
656             <li>HarryP</li>
657             <li>RonW</li>
658         </ul>
659     </div>
660 </div>
661 <div class="zones-wrap-add view-zones" id="zoneViewID02">
662     <div class="set-close">
663         <i class="far fa-times-circle"></i>
664     </div>
665     <h3>custom zones</h3>
666     <div class="member-wrap">
667         <div>Location:
668             <span class="location-zone-view">Singer Plus Building, Niwithigala</span>

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669 </div>
670 <div>Type:
671   <span class="type-zone-view">Resource Gathering Center
672 </span>
673 </div>
674 </div>
675 <div class="gallery-wrap">
676   <div class="gal-img">
677     
678     
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680   </div>
681   <div class="gal-btns">
682     <i class="fas fa-square"></i>
683     <i class="fas fa-square"></i>
684     <i class="fas fa-square"></i>
685   </div>
686 </div>
687 <div class="zone-view-cnt">
688   <div class="descrip-zones-view">
689     We have a shortage of medical related items such as pain killers, bandages. Any other items are happily accepted.
690   </div>
691   <div class="contact-links-zones">call: <span>0022334433</span></div>
692   <div class="activity-view-zone">
693     <div>Activities:</div>
694     <div class="activity-zone-display">
695       <div class="type-zone-view">Materials giving</div>
696       <div class="date-view">10-12-19, 20:30 Hrc</div>
697       <div class="location-view-zone-ac">Singer Plus, Niwithigala</div>
698       <div class="btn-add-me-activity activity-adding-me">add me</div>
699       <div class="btn-add-me-activity members-show-me">Members</div>
700     </div>
701   </div>
702 </div>
703 <div class="activity-social-view">
704   <div class="social-media">
705     <label for="share">Share:</label>
706     <span><i class="fab fa-facebook-square"></i></span>
707     <span><i class="fab fa-twitter-square"></i></span>
708     <span><i class="fab fa-instagram"></i></span>
709   </div>
710 </div>
711 </div>
712 <div class="members-activity-view">
713   <div class="close-btn-members-list">
714     <i class="far fa-times-circle"></i>
715   </div>
716   <div>Activity Name: <span>Materials giving</span></div>
717   <div>Location: <span>Sabaragamuwa, Colombo</span></div>
718   <div class="member-list-activity">
719     <ul>
720       <li>JohnS</li>
721       <li>HarryP</li>
722       <li>RonW</li>
723     </ul>
724   </div>
725 </div>
726
727 <!-- map should stay here -->
728 <div id='map'></div>
729 <!-- </div></div> -->
730
731 <!-- Reports -->
732 <div id="report-view">
733   <h3>Reports</h3>
734   <div class="set-close">
735     <i class="far fa-times-circle"></i>
736   </div>
737   <input type="text" placeholder="Search Location" />
738
739   <div class="div-flex">
740     <input type="checkbox" value="Markers" name="Markers">
741     <span>Precipitation</span>
742   </div>
743   <div class="div-flex">
744     <input type="checkbox" value="Markers" name="Markers">
745     <span>Markers</span>
746   </div>
747   <div class="div-flex">
748     <input type="checkbox" value="Markers" name="Markers">

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749 |         <span>Harzard Zone</span>
750 |     </div>
751 |     <div class="div-flex">
752 |         <button>Line</button>
753 |         <button>Bar</button>
754 |         <button>Area</button>
755 |     </div>
756 |     <div class="marker-btn">
757 |         <button>confirm</button>
758 |     </div>
759 |
760 | </div>
761 |
762 |
763 |     <script src="https://ajax.googleapis.com/ajax/libs/jquery/3.3.1/jquery.min.js"></script>
764 |     <script src="custom.js">
765 |     </script>
766 |     <script src="https://maps.googleapis.com/maps/api/js?key=AIzaSyDk6SF85G8c_jp648MVSS0xJTt99fS14Uo&callback=initMap"
767 |         async defer>
768 |     </script>
769 |
770 | </body>
771 | </html>
```


- JavaScript Coding:

```

3 // jQuery codes
4 $(document).ready(function(){
5 // BUTTONS TOGGLE
6 $(".menu-wrap").click(function() {
7 $(".menu").toggle("slide");
8 $(".menu-wrap").hide();
9 });
10 $(".close-btn").click(function() {
11 $(".menu").toggle("slide");
12 $(".menu-wrap").show();
13 });
14 $(".menu-h4-1").click(function() {
15 $(".menu-items-1").toggle("slide");
16 });
17 $(".menu-h4-2").click(function() {
18 $(".menu-items-2").toggle("slide");
19 });
20 $(".markers-span").click(function() {
21 $(".markers").toggle("slide");
22 });
23 $(".zones-span").click(function() {
24 $(".zones-1").toggle("slide");
25 });
26 $(".f-markers-span").click(function() {
27 $(".f-markers").toggle("slide");
28 });
29 $(".f-zones-span").click(function() {
30 $(".f-zones").toggle("slide");
31 });
32 $("#search-f").val("");
33 $("#descri-marker").val("");
34 $("#comments-by").val("");
35 // Settings buttons
36 $(".settings-btn h4").click(function() {
37 $(".settings-wrap").show();
38 });
39 $(".set-close").click(function() {
40 $(".settings-wrap").hide();
41 });
42 $(".content-set-wrap.info-settings button").click(function() {
43 $(".wrap-info-details").show();
44 });
45 $(".set-close.info-close-btn").click(function() {
46 $(".wrap-info-details").hide();
47 });
48 // Markers buttons
49 $(".markers").click(function() {
50 $(".markers-wrap.mrk-edit").show();
51 });
52 $(".f-markers").click(function() {
53 $(".markers-wrap.mrk-view").show();

```

```

54 });
55 $(".markers-wrap .set-close").click(function() {
56 $(".markers-wrap").hide();
57 });
58 // View Comments
59 $(".view-comments").click(function() {
60 $(".comment-view-wrap").show();
61 });
62 $(".comment-view-wrap .close-btn").click(function() {
63 $(".comment-view-wrap").hide();
64 });
65 // Adding Zone
66 $(".zones-1").click(function() {
67 $(".zones-wrap-add.add-zone-event").show();
68 });
69 $(".zones-wrap-add.add-zone-event .set-close").click(function() {
70 $(".zones-wrap-add.add-zone-event").hide();
71 });
72 // Adding Activity
73 $(".zones-wrap-add.add-zone-event .set-close").click(function() {
74 $(".comment-view-wrap.activity-group").hide();
75 });
76 $(".activity-add-btn.activity-add-me").click(function() {
77 $(".comment-view-wrap.activity-group").show();
78 });
79 // Adding Gallery
80 $(".activity-add-btn.zone-gal-me").click(function() {
81 $(".comment-view-wrap.gallery-group").show();
82 });
83 $(".comment-view-wrap.gallery-group .set-close").click(function() {
84 $(".comment-view-wrap.gallery-group").hide();
85 });
86 // View Zones
87 $(".f-zones").click(
88 function() {
89 $(".zones-wrap-add.view-zones").show();
90 }
91 );
92 $(".zones-wrap-add .set-close").click(function() {
93 $(".zones-wrap-add.view-zones").hide();
94 });
95 // View activity members
96 $(".close-btn-members-list").click(function() {
97 $(".members-activity-view").hide();
98 });
99 $(".btn-add-me-activity.members-show-me").click(function() {
100 $(".members-activity-view").show();
101 });
102 });

```

```

104 var map;
105
106 // Map Initialization
107 function initMap() {
108   map = new google.maps.Map(document.getElementById('map'), {
109     center: {lat: 6.705574, lng: 80.384735},
110     zoom: 11,
111     fullscreenControl: false,
112     mapTypeControl: false,
113     scaleControl: false,
114     streetViewControl: false,
115     zoomControl: false
116   });
117
118   var marker01 = new google.maps.Marker({
119     position: {lat: 6.591922, lng: 80.417245},
120     icon: 'http://kukomosdesign.com/AUT-map-2/e-m.png',
121     map: map,
122     title: 'unplanned construction'
123   });
124
125   var marker02 = new google.maps.Marker({
126     position: {lat: 6.652178, lng: 80.417355},
127     icon: 'http://kukomosdesign.com/AUT-map-2/h-m.png',
128     map: map,
129     title: 'Deforestation'
130   });
131
132   var marker02v = new google.maps.Marker({
133     position: {lat: 6.692178, lng: 80.419475},
134     icon: 'http://kukomosdesign.com/AUT-map-2/h-m-black.png',
135     map: map,
136     title: 'unvalidated Marker example'
137   });
138
139
140   var zone01 = new google.maps.Marker({
141     position: {lat: 6.584679, lng: 80.416998},
142     icon: 'http://kukomosdesign.com/AUT-map-2/d-z.png',
143     map: map,
144     title: 'Rescue Center for resource gathering'
145   });
146
147   var zone02 = new google.maps.Marker({
148     position: {lat: 6.5959109, lng: 80.4577939},
149     icon: 'http://kukomosdesign.com/AUT-map-2/r-z.png',
150     map: map,
151     title: 'Potential Displacement Center for Victims'
152   });
153

```

- CSS Coding:

```

2  .leaflet-control-zoom.leaflet-bar.leaflet-control {
3  display: none;
4  }
5  @import url('https://fonts.googleapis.com/css?family=Josefin+Slab');
6  @import url('https://fonts.googleapis.com/css?family=Open+Sans');
7  @import url('https://fonts.googleapis.com/css?family=Lato');
8  /* css starts from here */
9  html,
10 body {
11 height: 100%;
12 }
13 body {
14 padding: 0;
15 margin: 0;
16 }
17 #map {
18 height: 700px;
19 width: 320px;
20 }
21 h3 {
22 text-align: center;
23 font-weight: 100;
24 margin-bottom: 3px;
25 padding: 0;
26 }
27 h4 {
28 text-transform: uppercase;
29 text-align: left;
30 background: black;
31 padding: 5px 10px;
32 margin: 0;
33 }
34 html {
35 height: 100%;
36 }
37 body {
38 padding: 0;
39 margin: 0;
40 font-size: 16px;
41 font-family: 'Lato', sans-serif;
42 /* font-family: 'Josefin Slab', serif;
43 font-family: 'Open Sans', sans-serif;*/
44 height: 100%;
45 }
46 ul {
47 margin: 0;
48 }
49 .wrapper,
50 #map {
51 width: 100%;
52 height: 100%;
53 top: 0;
54 left: 0;
55 position: relative !important;
56 }
57 #map {
58 position: absolute !important;
59 z-index: 10;
60 }
61 .cover {
62 width: 320px;
63 position: relative;
64 border: 1px solid #000;
65 height: 105%;
66 margin: 20px auto 20px;
67 }
68 a,
69 a:visited,
70 a:active {
71 color: #0cb3b3;
72 text-decoration: none;
73 }
74 input {
75 width: 100%;
76 font-family: 'Josefin Slab', serif;
77 font-size: 1.2em;
78 box-sizing: border-box;
79 padding: 5px 10px;
80 margin-bottom: 15px;
81 height: 2.5em;
82 }
83 input[type="button"] {
84 background: #0cb3b3;
85 border: 0;
86 color: #fff;
87 font-weight: 700;
88 }
89 input[type="text"] {
90 border: 1px solid #068c8c;
91 }
92 .wrapper {
93 width: 100%;
94 height: 100%;
95 box-sizing: border-box;
96 overflow-y: hidden;
97 }
98 .input-wrap {
99 margin: 0 10px;
100 }

```

```

101 img.logo {
102 display: block;
103 margin: 10px auto 20px;
104 }
105 .footer-info {
106 position: absolute;
107 bottom: 0;
108 padding: 5px;
109 left: 0;
110 right: 0;
111 background: #071212;
112 z-index: 200;
113 }
114 .footer-info p {
115 margin: 0;
116 width: 100%;
117 text-align: right;
118 color: white;
119 padding-top: 3px;
120 }
121 .menu-wrap {
122 position: absolute;
123 left: 20px;
124 top: 18px;
125 z-index: 60;
126 cursor: pointer;
127 }
128 .menu-bar {
129 width: 51px;
130 border-radius: 15px;
131 margin-bottom: 8px;
132 height: 6px;
133 background: #096262;
134 }
135 .menu {
136 width: 80%;
137 height: 100%;
138 position: absolute;
139 background: #062027;;
140 top: 0;
141 left: 0;
142 overflow-x: hidden;
143 z-index: 100;
144 color: #fff;
145 display: none;
146 }
147 .menu-items-1{
148 display: none;
149 cursor: pointer;
150 margin-bottom: 15px;
151
152 .menu-items-2 {
153 display: none;
154 cursor: pointer;
155 }
156 .menu h4 {
157 cursor: pointer;
158 }
159 .menu-items-1 .markers,
160 .menu-items-1 .zones-1,
161 .menu-items-2 .f-markers,
162 .menu-items-2 .f-zones {
163 display: none;
164 }
165 #search-f {
166 font-size: 18px;
167 height: 27px;
168 line-height: 27px;
169 padding-top: 8px;
170 padding-left: 3px;
171 }
172 .markers,
173 .zones-1,
174 .f-zones,
175 .f-markers {
176 padding: 3px 25px;
177 }
178 .markers::before,
179 .zones-1::before,
180 .f-zones::before,
181 .f-markers::before {
182 content: "- ";
183 }
184 .close-btn {
185 position: absolute;
186 font-size: 25px;
187 top: 0;
188 right: 5px;
189 font-weight: initial;
190 font-family: arial;
191 cursor: pointer;
192 z-index: 10;
193 margin-top: 2px;
194 }
195 .profile {
196 display: -webkit-flex;
197 display: -moz-flex;
198 display: -ms-flex;
199 display: -o-flex;
200 display: flex;
201 position: relative;
202 width: 100%;
203 background: #071212;
204 }
205 .prof-img {
206 width: 80px;
207 height: 80px;
208 background: white;
209 border-radius: 80px;
210 margin: 10px;
211 }
212 .pic {
213 width: 40%;
214 }
215 .prof-info {
216 width: 60%;
217 display: -webkit-flex;
218 display: -moz-flex;
219 display: -ms-flex;
220 display: -o-flex;
221 display: flex;
222 flex-direction: column;
223 justify-content: end;
224 padding-bottom: 15px;
225 padding-left: 16px;
226 font-size: 19px;
227 }
228
229 .noti-status {
230 display: flex;
231 font-size: 14px;
232 }
233 .noti-status p {
234 margin: 0;
235 display: -webkit-flex;
236 display: -moz-flex;
237 display: -ms-flex;
238 display: -o-flex;
239 display: flex;
240 line-height: 23px;
241 padding-left: 5px;
242 }
243 .zone-prof {
244 padding-top: 5px;
245 border-top: 1px solid #fff;
246 margin-top: 5px;
247 margin-right: 5px;
248 }
249 .zone-prof span {
250 font-size: 15px;
251 }
252 .noti-status i {
253 position: relative;
254 top: 3px;

```



```

152 .menu-items-2 {
153   display: none;
154   cursor: pointer;
155 }
156 .menu h4 {
157   cursor: pointer;
158 }
159 .menu-items-1 .markers,
160 .menu-items-1 .zones-1,
161 .menu-items-2 .f-markers,
162 .menu-items-2 .f-zones {
163   display: none;
164 }
165 #search-f {
166   font-size: 18px;
167   height: 27px;
168   line-height: 27px;
169   padding-top: 8px;
170   padding-left: 3px;
171 }
172 .markers,
173 .zones-1,
174 .f-zones,
175 .f-markers {
176   padding: 3px 25px;
177 }
178 .markers::before,
179 .zones-1::before,
180 .f-zones::before,
181 .f-markers::before {
182   content: "- ";
183 }
184 .close-btn {
185   position: absolute;
186   font-size: 25px;
187   top: 0;
188   right: 5px;
189   font-weight: initial;
190   font-family: arial;
191   cursor: pointer;
192   z-index: 10;
193   margin-top: 2px;
194 }
195 .profile {
196   display: -webkit-flex;
197   display: -moz-flex;
198   display: -ms-flex;
199   display: -o-flex;
200   display: flex;
201   position: relative;
202   width: 100%;
203   background: #071212;
204 }
205 .prof-img {
206   width: 80px;
207   height: 80px;
208   background: white;
209   border-radius: 80px;
210   margin: 10px;
211 }
212 .pic {
213   width: 40%;
214 }
215 .prof-info {
216   width: 60%;
217   display: -webkit-flex;
218   display: -moz-flex;
219   display: -ms-flex;
220   display: -o-flex;
221   display: flex;
222   flex-direction: column;
223   justify-content: end;
224   padding-bottom: 15px;
225   padding-left: 16px;
226   font-size: 19px;
227 }
228 }
229 .noti-status {
230   display: flex;
231   font-size: 14px;
232 }
233 .noti-status p {
234   margin: 0;
235   display: -webkit-flex;
236   display: -moz-flex;
237   display: -ms-flex;
238   display: -o-flex;
239   display: flex;
240   line-height: 23px;
241   padding-left: 5px;
242 }
243 .zone-prof {
244   padding-top: 5px;
245   border-top: 1px solid #fff;
246   margin-top: 5px;
247   margin-right: 5px;
248 }
249 .zone-prof span {
250   font-size: 15px;
251 }
252 .noti-status i {
253   position: relative;
254   top: 3px;
255 }
256 .zone-type {
257   color: #fff;
258   margin-top: 6px;
259   position: relative;
260   top: 0;
261   background: #ecb826;
262   padding: 2px;
263 }
264 .far.fa-bell {
265   position: absolute;
266   right: 0;
267   bottom: 0;
268   margin: 5px;
269   color: #4ce34c;
270   font-size: 20px;
271   cursor: pointer;
272 }
273 .settings-btn {
274   position: relative;
275   bottom: 0;
276   right: 0;
277 }
278 /* menu items */
279 .menu-items div span {
280   display: block;
281   padding: 10px;
282   font-size: 18px;
283 }
284 /* login */
285 .memory-input {
286   display: -webkit-flex;
287   display: -moz-flex;
288   display: -ms-flex;
289   display: -o-flex;
290   display: flex;
291 }
292 .memory-input p {
293   width: 60%;
294   text-align: right;
295 }
296 .memory-input input {
297   width: 10%;
298 }
299 .input-wrap > a {
300   text-align: center;
301   display: block;
302 }
303 input[type="button"] {
304   margin-bottom: 5px;

```

```

305 cursor: pointer;
306 }
307 .settings-btn h4 {
308 background: #1a2f33;
309 }
310 /* settings */
311 .user-input {
312 display: -webkit-flex;
313 display: -moz-flex;
314 display: -ms-flex;
315 display: -o-flex;
316 display: flex;
317 line-height: 55px;
318 width: 80%;
319 margin: auto;
320 }
321 .user-input input {
322 width: 18%;
323 }
324 .settings-wrap {
325 position: absolute;
326 top: 0;
327 left: 0;
328 width: 100%;
329 z-index: 111;
330 display: none;
331 background: #fff;
332 height: 100%;
333 }
334 .set-close {
335 position: absolute;
336 right: 0;
337 top: 0;
338 z-index: 114;
339 color: #fff;
340 font-size: 1.8em;
341 margin: 4px 3px auto;
342 cursor: pointer;
343 }
344 .settings-wrap h3,
345 .markers-wrap h3,
346 .zones-wrap-add h3 {
347 color: #fff;
348 text-transform: uppercase;
349 background: #1a2f33;
350 height: 52px;
351 margin: 0;
352 line-height: 53px;
353 }
354 }
355 .set-cnt-items h4 {
356 font-size: 18px;
357 background: initial;
358 text-transform: capitalize;
359 margin: 5px auto;
360 }
361 .content-set-wrap {
362 margin: 5px 25px;
363 font-size: 18px;
364 display: -webkit-flex;
365 display: -moz-flex;
366 display: -ms-flex;
367 display: -o-flex;
368 display: flex;
369 align-items: center;
370 height: 22px;
371 justify-content: center;
372 }
373 .content-set-wrap input {
374 height: 24px;
375 margin: 0;
376 padding: 0;
377 padding-top: 6px;
378 font-size: 18px;
379 padding-left: 5px;
380 display: none;
381 }
382 .content-set-wrap p,
383 .content-set-wrap input {
384 width: 60%;
385 background: #dedede;
386 padding-left: 5px;
387 padding-top: 3px;
388 }
389 .content-set-wrap button {
390 height: 25px;
391 text-transform: uppercase;
392 margin-left: 10px;
393 cursor: pointer;
394 border: 0;
395 width: 108px;
396 background: #1a2f33;
397 color: #fff;
398 }
399 .setting-content {
400 border-bottom: 1px solid #cad3d5;
401 padding-bottom: 10px;
402 }
403 /* overflow issues */
404 .input-wrap.register {
405 overflow-y: auto;
406 }
407 .input-wrap.register {
408 overflow-y: auto;
409 max-height: 350px;
410 padding-right: 10px;
411 }
412 .wrapper.main-screen {
413 display: -webkit-flex;
414 display: -moz-flex;
415 display: -ms-flex;
416 display: -o-flex;
417 display: flex;
418 align-items: center;
419 align-content: center;
420 opacity: 0;
421 }
422 /* Switch */
423 .switch {
424 position: relative;
425 display: inline-block;
426 width: 60px;
427 height: 20px;
428 }
429 .switch input {
430 opacity: 0;
431 width: 0;
432 height: 0;
433 }
434 .slider {
435 position: absolute;
436 cursor: pointer;
437 top: 0;
438 left: 0;
439 right: 0;
440 bottom: 0;
441 background-color: #ccc;
442 -webkit-transition: .4s;
443 transition: .4s;
444 }
445 .slider:before {
446 position: absolute;
447 content: "";
448 height: 14px;
449 width: 14px;
450 left: 4px;
451 bottom: 3px;
452 background-color: white;

```

```

452 -webkit-transition: .4s;
453 transition: .4s;
454 }
455 input:checked + .slider {
456 background-color: #2196F3;
457 }
458 input:focus + .slider {
459 box-shadow: 0 0 1px #2196F3;
460 }
461 input:checked + .slider:before {
462 -webkit-transform: translateX(38px);
463 -ms-transform: translateX(38px);
464 transform: translateX(38px);
465 }
466 /* Rounded sliders */
467 .slider.round {
468 border-radius: 34px;
469 }
470 .slider.round:before {
471 border-radius: 50%;
472 }
473 /* ----- */
474 .content-set-wrap.title-set-ovr {
475 display: -webkit-flex;
476 display: -moz-flex;
477 display: -ms-flex;
478 display: -o-flex;
479 display: flex;
480 align-items: initial;
481 align-content: flex-end;
482 justify-content: left;
483 margin-left: 0;
484 margin-top: 25px;
485 }
486 .content-set-wrap.title-set-ovr h4 {
487 margin: 0;
488 padding: 0 10px;
489 }
490 .logout-btn {
491 margin: auto;
492 margin-top: 25px;
493 }
494 /* Markers */
495 .markers-wrap {
496 display: none;
497 position: absolute;
498 top: 0;
499 left: 0;
500 z-index: 111;
501 background: #fff;
502 width: 100%;
503 height: 100%;
504 }
505 .gal-img {
506 position: relative;
507 overflow: hidden;
508 height: 100%;
509 }
510 .gallery-wrap {
511 position: relative;
512 height: 180px;
513 margin-bottom: 10px;
514 }
515 .camera-btn {
516 position: absolute;
517 z-index: 1;
518 margin: 5px;
519 color: #fff;
520 border: 1px solid #fff;
521 cursor: pointer;
522 }
523 .camera-btn i {
524 padding: 3px;
525 font-size: 25px;
526 }
527 .img-gal {
528 position: absolute;
529 width: 100%;
530 height: auto;
531 }
532 .gal-btns {
533 position: absolute;
534 bottom: 0;
535 right: 0;
536 margin-right: 5px;
537 font-size: 13px;
538 color: #fff;
539 cursor: pointer;
540 }
541 .marker-type,
542 .des-details,
543 .marker-btn {
544 width: 100%;
545 padding: 0 10px;
546 box-sizing: border-box;
547 margin-bottom: 10px;
548 }
549 .marker-btn button,
550 .contact-links button,
551 .members-buttons button,
552 .activity-add-btn,
553 .add-activity-btn,
554 .comment-view-wrap.gallery-group div button {
555 width: 100%;
556 font-size: 17px;
557 background: #1a2f33;
558 border: 0;
559 color: #fff;
560 text-transform: capitalize;
561 padding: 3px 0;
562 cursor: pointer;
563 }
564 .marker-type select,
565 .marker-type option,
566 .des-details textarea,
567 .member-wrap input[type="text"] {
568 font-size: 17px;
569 text-transform: capitalize;
570 width: 100%;
571 font-family: 'Josefin Slab', serif;
572 }
573 .member-wrap .search-members {
574 margin-top: 0;
575 }
576 .members-display {
577 display: inline-block;
578 width: 95px;
579 }
580 .members-display div {
581 display: inline-block;
582 width: 100%;
583 max-width: 66px;
584 background: #f3f3f3;
585 }

```



```

586 .members-display::after {
587   content: "X";
588   background: #989393;
589   color: #fff;
590   padding: 2px;
591   font-size: 8px;
592   position: relative;
593   top: -6px;
594   left: -3px;
595   cursor: pointer;
596 }
597 .member-wrap #zone-types {
598   width: 100%;
599   margin-top: 10px;
600   font-size: 17px;
601   margin-bottom: 4px;
602   height: 25px;
603 }
604 .member-wrap textarea {
605   width: 100%;
606   height: 120px;
607   resize: none;
608   max-width: 320px;
609   margin-bottom: 4px;
610   font-family: 'Josefin Slab', serif;
611 }
612 .members-buttons {
613   display: -webkit-flex;
614   display: -moz-flex;
615   display: -ms-flex;
616   display: -o-flex;
617   display: flex;
618 }
619 .members-buttons button {
620   width: 48%;
621   margin: 5px 1%;
622 }
623 .des-details {
624   position: relative;
625   margin-bottom: 4px;
626 }
627 .des-details textarea {
628   width: 100%;
629   height: 120px;
630   resize: none;
631   max-width: 292px;
632   font-family: 'Josefin Slab', serif;
633 }
634 .member-wrap .activity-add-btn {
635   margin-top: 10px;
636 }
637 .activity-btn-group {
638   display: -webkit-flex;
639   display: -moz-flex;
640   display: -ms-flex;
641   display: -o-flex;
642   display: flex;
643 }
644 .activity-btn-group button,
645 .comment-view-wrap.gallery-group div button {
646   width: 48%;
647   margin: 0 1%;
648 }
649 /* markers edit screen */
650 .edit-mrk-view {
651   position: absolute;
652   left: 0;
653   bottom: 0;
654   padding: 8px;
655   color: #fff;
656   text-transform: uppercase;
657   background: #1a2f33;
658   margin: 3px;
659   border: 1px solid aliceblue;
660   font-size: 12px;
661   cursor: pointer;
662 }
663 .mrk-view-loc {
664   position: relative;
665   text-align: right;
666   padding: 0 10px;
667   margin-bottom: 4px;
668   font-size: 14px;
669   margin-top: 12px;
670   color: #a82020;
671 }
672 .approve-v {
673   display: -webkit-flex;
674   display: -moz-flex;
675   display: -ms-flex;
676   display: -o-flex;
677   display: flex;
678   padding: 0 10px;
679   align-content: center;
680   align-items: center;
681   text-align: center;
682   border: 1px solid gray;
683   padding: 6px 0;
684   margin-bottom: 7px;
685 }
686 .approve-v2 button {
687   cursor: pointer;
688 }
689 .fas.fa-check {
690   color: tomato;
691 }
692 .fas.fa-times {
693   color: green;
694 }
695 .approve-rate {
696   width: 45%;
697 }
698 .approve-v2 {
699   width: 55%;
700 }
701 .social-content-markers {
702   padding: 0 10px;
703   box-sizing: border-box;
704 }
705 .create-v {
706   display: -webkit-flex;
707   display: -moz-flex;
708   display: -ms-flex;
709   display: -o-flex;
710   display: flex;
711 }
712 .create-by,
713 .social-media {
714   width: 50%;
715   margin-bottom: 9px;
716   align-content: center;
717   align-items: center;
718   box-sizing: border-box;
719   padding-left: 9px;
720 }

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```

721 .social-media i {
722   display: ;
723   font-size: 18px;
724   cursor: pointer;
725   color: #0cb3b3;
726   padding-left: 2px;
727 }
728 .comments-add textarea {
729   width: 100%;
730   resize: none;
731   font-family: 'Josefin Slab', serif;
732 }
733 .view-comments {
734   width: 60%;
735   display: inline-block;
736   text-align: center;
737   background: #328393;
738   color: #fff;
739   text-transform: uppercase;
740   padding: 3px;
741   max-width: 150px;
742   cursor: pointer;
743 }
744 .add-comments {
745   width: 40%;
746   display: inline-block;
747   text-align: center;
748   background: #1a2f33;
749   color: #fff;
750   text-transform: uppercase;
751   padding: 3px;
752   margin-left: 10px;
753   max-width: 120px;
754   cursor: pointer;
755 }
756 .comments-box {
757   position: relative;
758 }
759 .mrk-view-loc span {
760   padding-right: 5px;
761 }
762 .add-comments,
763 .view-comments {
764   font-size: 12px;
765   text-transform: capitalize;
766   height: 20px;
767   line-height: 20px;
768   margin-top: 2px;
769 }
770 .comment-view-wrap {
771   position: absolute;
772   top: 0;
773   left: 0;
774   width: 100%;
775   z-index: 1211;
776   border: 2px solid #0f7a87;
777   box-sizing: border-box;
778   height: 100%;
779   background: #fff;
780   display: none;
781 }
782 }
783 .comments-view {
784   position: relative;
785   top: 2%;
786   height: 88%;
787   background: #eaeaea;
788   padding: 10px;
789   box-sizing: border-box;
790   overflow: auto;
791 }
792 .comments-seq {
793   position: relative;
794   border: 1px solid #ccc8c8;
795   margin-bottom: 5px;
796   padding: 4px;
797 }
798 .comments-seq p {
799   margin: 0;
800   margin-top: 10px;
801   position: relative;
802   margin-top: 0;
803   padding-top: 0;
804   margin: 5px 0;
805 }
806 .comments-seq span {
807   text-align: right;
808   width: 100%;
809   display: block;
810 }
811 /* adding zones */
812 .zones-wrap-add {
813   position: absolute;
814   top: 0;
815   width: 100%;
816   background: #fff;
817   height: 100%;
818   z-index: 111;
819   display: none;
820 }
821 .zones-wrap-add input,
822 .zones-wrap-add textarea {
823   margin-top: 10px;
824   font-size: 17px;
825   font-family: 'Josefin Slab', serif;
826   height: 35px;
827   margin-bottom: 3px;
828 }
829 .member-wrap {
830   padding: 0 10px;
831   position: relative;
832 }
833 #activity-des {
834   width: 100%;
835   max-width: 296px;
836   box-sizing: border-box;
837   padding: 5px 10px;
838   height: 105px;
839   resize: none;
840 }
841 .comments-view.activity-group {
842   top: 0;
843 }
844 #zone-des-txt {
845   height: 90px;
846 }
847 .add-activity-btn {
848   margin-top: 10px;
849 }
850 .zones-wrap-add.view-zones {
851   display: none;
852 }
853 .zones-wrap-add.view-zones .member-wrap div {
854   margin-top: 10px;
855   font-weight: 900;
856 }
857 .location-zone-view,
858 .type-zone-view {
859   font-weight: initial;
860 }
861 .zones-wrap-add.view-zones .gallery-wrap {
862   margin-top: 10px;
863 }
864 /* View Zones */
865 .zone-view-cnt {
866   padding: 0 10px;
867   margin-bottom: 5px;
868 }
869 .descrip-zones-view {
870   margin-bottom: 7px;
871   text-align: left;
872 }

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873 .register-provincial {
874   position: relative;
875   background: #d2d2d2;
876   padding-bottom: 10px;
877   padding: 10px;
878 }
879 .register-provincial-tooltip {
880   display: none;
881   position: absolute;
882   left: 28px;
883   top: 0;
884   background: #e9e9e9;
885   padding: 6px;
886   border: 1px solid grey;
887   font-size: 11px;
888   width: 284px;
889 }
890
891 .register-provincial-tooltip ul {
892   padding: 1px 15px;
893 }
894 .register-provincial-tooltip ul li {
895   padding-bottom: 5px;
896 }
897 .register-provincial p {
898   margin: 5px;
899 }
900 .contact-links-zones {
901   text-transform: capitalize;
902   padding-bottom: 5px;
903 }
904 .activity-view-zone {
905   margin-top: 8px;
906 }
907 .type-zone-view {
908   font-weight: 900;
909 }
910 .date-view {
911   font-size: 11px;
912   padding-top: 5px;
913 }
914 .btn-add-me-activity {
915   background: #071212;
916   padding: 3px;
917   max-width: 100px;
918   text-align: center;
919   color: #fff;
920   text-transform: capitalize;
921   margin: 3px 0;
922   cursor: pointer;
923 }
924 /* zone gallery added later */
925 .comment-view-wrap.gallery-group {
926   display: none;
927   border: none;
928 }
929 .close-btn.gallery-group-close {
930   color: #fff;
931   z-index: 111;
932 }
933 .close-btn.activity-group {
934   color: #fff;
935 }
936 .comment-view-wrap.gallery-group div {
937   /*display: -webkit-flex;
938   display: -moz-flex;
939   display: -ms-flex;
940   display: -o-flex;
941   display: flex;*/
942 }
943 .comment-view-wrap.gallery-group div button {
944   margin-top: 10px;
945   margin-bottom: 10px;
946 }
947 .activity-zone-display {
948   background: #e9e9e9;
949   padding: 2px 0;
950   margin-top: 3px;
951 }
952 .members-activity-view {
953   background: #f9f9f9;
954   position: absolute;
955   width: 100%;
956   height: 100%;
957   top: 0;
958   z-index: 111;
959   padding: 0 10px;
960   box-sizing: border-box;
961   display: none;
962 }
963 .members-activity-view div {
964   margin-top: 10px;
965   margin-bottom: 10px;
966   font-weight: 900;
967 }
968 .members-activity-view div span,
969 .members-activity-view div ul li {
970   font-weight: initial;
971 }
972 .close-btn-members-list {
973   position: absolute;
974   right: 5px;
975   top: 0;
976   font-size: 25px;
977   margin: 0 !important;
978   cursor: pointer;
979 }
980 .content-set-wrap.info-settings button {
981   background: white;
982   color: #000;
983   border: 1px solid gray;
984 }
985 .content-set-wrap.info-settings {
986   margin-top: 20px;
987 }
988 /* informatin page */
989 .set-close.info-close-btn {
990   font-size: 2em;
991 }
992 .wrap-info-details {
993   display: none;
994   position: absolute;
995   top: 0;
996   left: 0;
997   background: #fff;
998   font-size: 12px;
999   height: 100%;
1000   z-index: 115;
1001 }
1002 .wrap-info-details > span {
1003   font-size: 13px;
1004   text-align: left;
1005   width: 94%;
1006   display: block;
1007   padding-left: 8px;
1008   margin: 10px 0;
1009   margin-bottom: 12px;
1010   padding-right: 8px;
1011   border-top: 1px solid #e1e1e1;
1012   padding-bottom: 6px;
1013   padding-top: 4px;
1014 }
1015 .wrap-info-details img {
1016   width: 30px;
1017 }
1018 .wrap-info-details>div {
1019   display: -webkit-flex;
1020   display: -moz-flex;
1021   display: -ms-flex;
1022   display: -o-flex;
1023   display: flex;
1024   align-items: center;
1025 }
1026 .info-span-1 {
1027   width: 20%;
1028   margin-left: 10%;
1029 }
1030 /* Google Map CSS */
1031 div a {
1032   cursor: pointer;
1033 }
1034
1035 /* Chart Reporting */
1036 .settings-btn.report-item h4 {
1037   background: #464141;
1038 }
1039 #report-view {
1040   display: none;
1041   position: absolute;
1042   top: 0;
1043   left: 0;
1044   z-index: 111;
1045   background: #fff;
1046   width: 100%;
1047   height: 100%;
1048 }
1049 #report-view h3 {
1050   color: #fff;
1051   text-transform: uppercase;
1052   background: #1a2f33;
1053   height: 52px;
1054   margin: 0;
1055   line-height: 53px;
1056 }
1057 #report-view input[type="text"] {
1058   margin-top: 10px;
1059   width: 100%;
1060   max-width: 477px;
1061   margin: auto;
1062   margin-top: 10px;
1063   display: block;
1064   margin-bottom: 10px;
1065 }

```