# Design and Implementation of Earthquake Early Warning Dissemination Mobile App for Uttarakhand (India)

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**Abstract**

Now days smart phones are very affordable, common to people and used in many applications. Thus, implementation of a dedicated mobile app for EEW systems is perhaps the best option that can save lot of money and time to achieve dissemination of earthquake early warning (EEW). This paper presents details of development of a smart phone app for android and iOS operating systems for EEW System currently operational in Uttarakhand, India. This app is freely available on Play Store and App Store with the name of "Uttarakhand Bhookamp Alert". This app uses Firebase Cloud Messaging (FCM) service for sending earthquake early warning to users. User needs to install the app in their smart phones for receiving early warnings. User's basic information along with FCM token is saved at the developed warning server in a database during the user registration process, which is being shared with the disaster response authority in case of earthquake to rescue the users if they are stuck. Our app also contains information about the steps needed to be followed on occurrence of an earthquake as well as how to make and find safe places in your house for hiding during occurrence of earthquake.

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## ABSTRACT

Now days smart phones are very affordable, common to people and used in many applications. Thus, implementation of a dedicated mobile app for EEW systems is perhaps the best option that can save lot of money and time to achieve dissemination of earthquake early warning (EEW). This paper presents details of development of a smart phone app for android and iOS operating systems for EEW System currently operational in Uttarakhand, India. This app is freely available on Play Store and App Store with the name of **"Uttarakhand Bhookamp Alert"**. This app uses Firebase Cloud Messaging (FCM) service for sending earthquake early warning to users. User needs to install the app in their smart phones for receiving early warnings. User's basic information along with FCM token is saved at the developed warning server in a database during the user registration process, which is being shared with the disaster response authority in case of earthquake to rescue the users if they are stuck. Our app also contains information about the steps needed to be followed on occurrence of an earthquake as well as how to make and find safe places in your house for hiding during occurrence of earthquake.



**Keywords: Warning Dissemination, Earthquake Early Warning, Smartphone App, India, Disaster risk reduction**

## 1 Introduction

Most of the Himalayan region is earthquake prone and faults in this region can generate large earthquakes (Sreejith et al., 2018).Accurate and efficient prediction of earthquakes is not possible at present (Kanamori, 2003), which creates an urge for Earthquake Early Warning (EEW) in this region to mitigate the impact of the major earthquake. EEW systems are being used by many countries like Japan (Brown et al., 2009; Horiuchi et al., 2005; Hoshiba et al., 2008; Kamigaichi et al., 2009; Y Nakamura, 2004; Yutaka Nakamura & Saita, 2007; Odaka et al., 2003; Saita & Nakamura, 2003), Taiwan (Chen et al., 2015; Hsiao et al., 2009; Wen et al., 2009; Wu & Teng, 2002; Wu & Zhao, 2006), Mexico (J. M. Espinosa-Aranda et al., 2012; J M Espinosa-Aranda et al., 2009; Juan Manuel Espinosa-Aranda et al., 2003), Turkey (Alcik et al., 2009; Erdik et al., 2003; Zschau et al., 2003), Romania (Böse et al., 2007; Ionescu et al., 2007; Wenzel et al., 1999) and these systems are tested and validated successfully (R. M. Allen et al., 2009; Brown et al., 2009; Cochran et al., 2018; Satriano et al., 2011). Many of these countries are issuing the earthquake early warning through smart phone apps such as EW App for PRESTo EEWS in Southern Italy (Colombelli et al., 2020) and SkyAlert, QuakeAlertUSA, MyShake public alert provider's apps (https://www.shakealert.org/implementation/lto/) for ShakeAlert EEW system for the West Coast of the United States. Some smart phone apps are being developed for acting as strong ground motion sensors for EEW system such as MyShake app (Richard M Allen et al., 2020; Kong et al., 2016).

Himalaya has seen 14 major earthquakes (M>=7.5) in last century and since then no major earthquake occurred till now in this region. It clearly indicates that Himalaya is storing the energy for a great earthquake. Further the ground motion of earthquakes originating in central Himalayas will be amplified on the adjoining plains due to the soft alluvium soil and will cause large scale destruction in high population density regions with the poorly constructed houses. As these plains are more than 100 km from the main central thrust (MCT) of Himalayas, an earthquake early warning system can give sufficient lead time to save large population from death and injuries with the help of proper training and awareness (Strauss & Allen, 2016). With this in view, Government of India granted a pilot project in 2013 for the development of an earthquake early warning system for northern India. Due to the importance of the project, in 2017, Uttarakhand State Disaster Management Authority (USDMA)took over this project, extended its coverage area and dissemination network. Currently this project has 167 strong ground motion sensor installations in Uttarakhand and a dedicated network of sirens in two major cities (Dehradun and Haldwani), which is shown in figure 1. These sensors are streaming real time ground motion data to central server, where real time data processing takes place. Dissemination of warning is carried out through dedicated sirens and mobile app. This paper presents the details of mobile app named "Uttarakhand Bhookamp Alert" developed for this project. This mobile app was launched for public on 4$^{th}$ August 2021.

## 2 Background and infrastructure

In central Himalayas, IIT Roorkee has installed a regional EEW system comprising of 82 Palert sensors in Garhwal region and 85 Palert+ sensors in Kumaon region of Uttarakhand. These 167 sensors are MEMS based low-cost strong ground motion sensors and transmit the real time ground motion data to the central server at EEW Lab, IIT

Roorkee. The central server performs the tasks of earthquake detection and size estimation from the acceleration data received from these sensors. At central server, Earthworm (developed by USGS) software has been installed along with some modules which receive and process this real time data for the detection and size estimation of the event. The central server uses standard STA-LTA algorithm (R. V. Allen, 1978, 1982) along with two more parameters Pa and Pv, to avoid false picking caused by background noise (Chen et al., 2015) for P-onset and Geiger's grid search method is being used for finding the location of the earthquake. It uses 3 seconds of data after P-onset for calculating the peak displacement (Pd) parameter, which is further used for the magnitude determination.

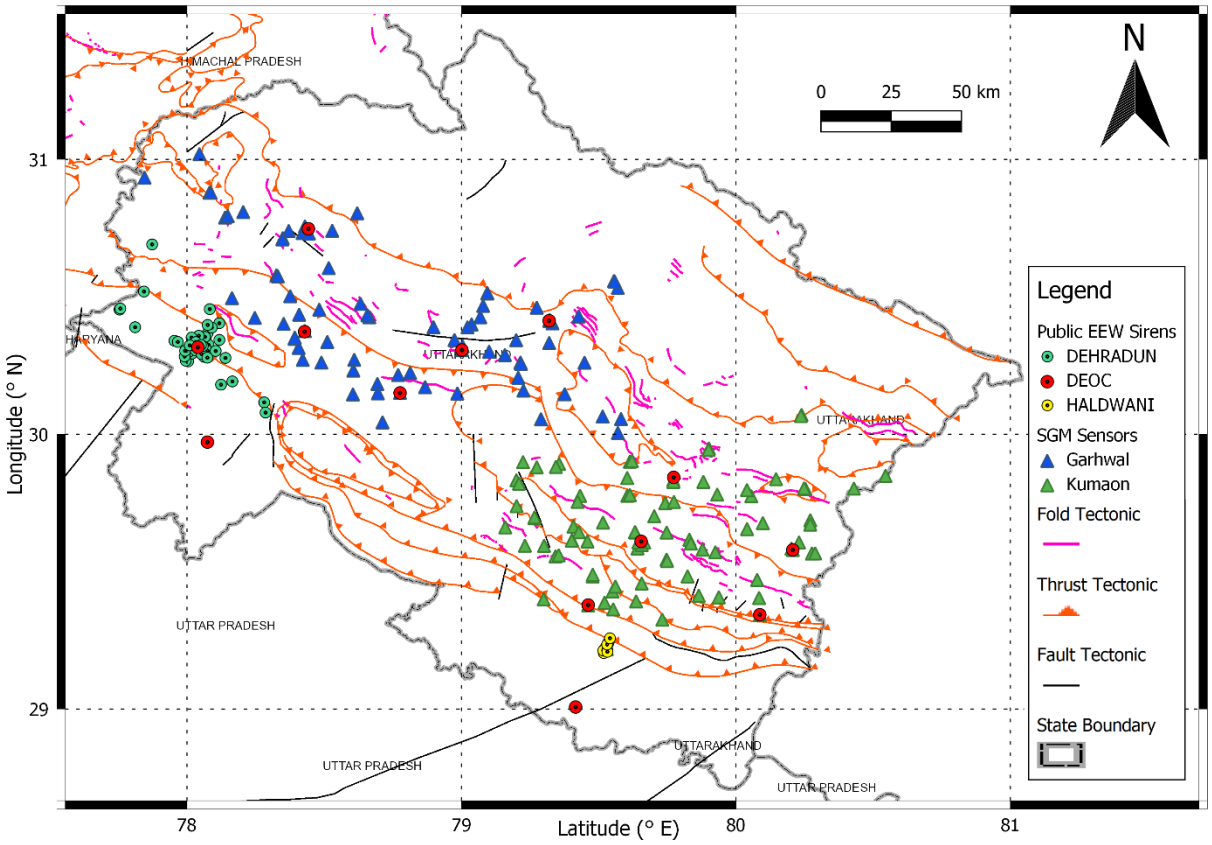


**Figure 1:** EEW Instrumentation in Uttarakhand

This EEW system is operational in Uttarakhand region and sirens have been installed for warning dissemination in public. Figure 2 gives architecture of complete EEW system. Currently the numbers of siren are very less to cover the state due to constraints in cost and time required for installations and maintenance of these sirens. For solving this problem, a smart phone app is developed, which could be easily distributed to mass from Play and App store and require less time or cost to maintain it. The app is developed using Flutter framework, which can build executable app for android and iOS simultaneously. Further, the earthquake detection information (epicenter, origin time, magnitude and number of stations triggered) is transmitted through a secured web API from central server to warning server. Warning server is responsible to disseminate the warning to the suitable audience based on the earthquake detection parameters. Currently, the warning is disseminated to public if calculated magnitude is greater than 5.0 and number of triggered stations is greater than 8. If magnitude is less than 5.0 and numbers of triggered

stations are greater than 5, then a simple notification about the earthquake is sent to public on smart phone app only and sirens are kept silent. Further, in all other cases the warning is disseminated to EEW lab team only through smart phone app and email.

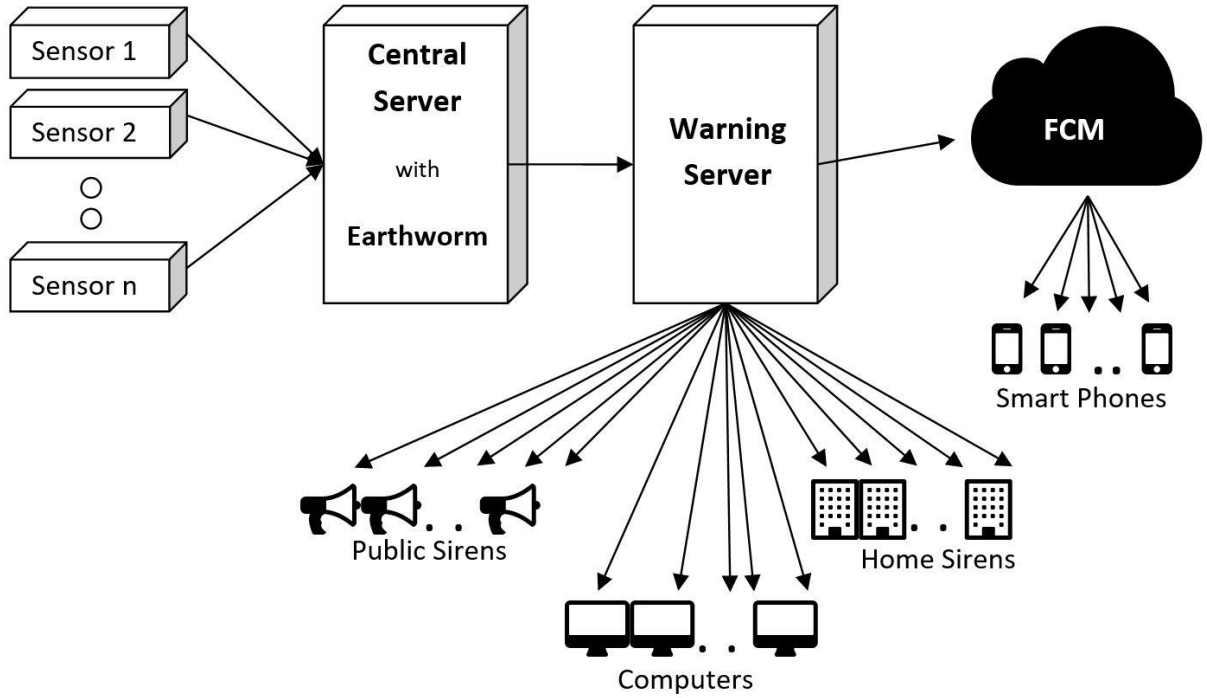


**Figure 2:** Architecture of the Complete EEW System for Northern India

## 3 Methodology and Warning Dissemination System

The developed app is made to receive the warning from the existing EEW system installed in Himalayan region and to alert people via audio-visual alerts. The developed app could be also integrated with other EEW system in future. The idea behind the development of this app is that, it should be an independent system and able to integrate with any other early warning system. For this, we have developed a warning server which includes a web-server, database management system, MQTT broker, dedicated web-portal and various custom written programs to make the whole process automated. We have used cloud-based services for this as maintenance of an in-house server costs a lot more than cloud based as well as it is difficult to manage 24x7. As the central server is situated at IIT Roorkee, so a secured web API is written on warning server for transmitting the earthquake information to the warning server. Whereas, warning server processes the incoming messages from the central server and depending on the earthquake parameters, it chooses the audience for transmitting information or alerting about the earthquake. Further for transmitting information to the sirens a MQTT broker is used, where each siren has a unique id stored into the database. This unique id facilitates us to perform various necessary tasks individually as well as various topics are being created for broad casting necessary messages and earthquake warnings. Sirens could be restarted from the servers or play a test sound for speaker check on daily basis as end users generally forget to check siren's speaker manually by pressing the test button. A program "Siren Manager" is written for checking and keeping the records of

the siren's health at a regular interval. These records help us in planning and decision making for the future. All activities with these sirens are being logged in the database with the help of Siren Manager. The Siren Manager automatically adds all new sirens installed in the field and user can view these sirens on a dynamic map with live status of the siren. Further, for presenting the logged siren data and checking the current status of complete warning server, a dedicated web-portal is developed named as "EWMS". In dashboard of the web-portal various graphs and number are shown to give a clear idea of the warning server. User can get more information from other tabs also. Figure 3 shows the architecture of the developed warning server.

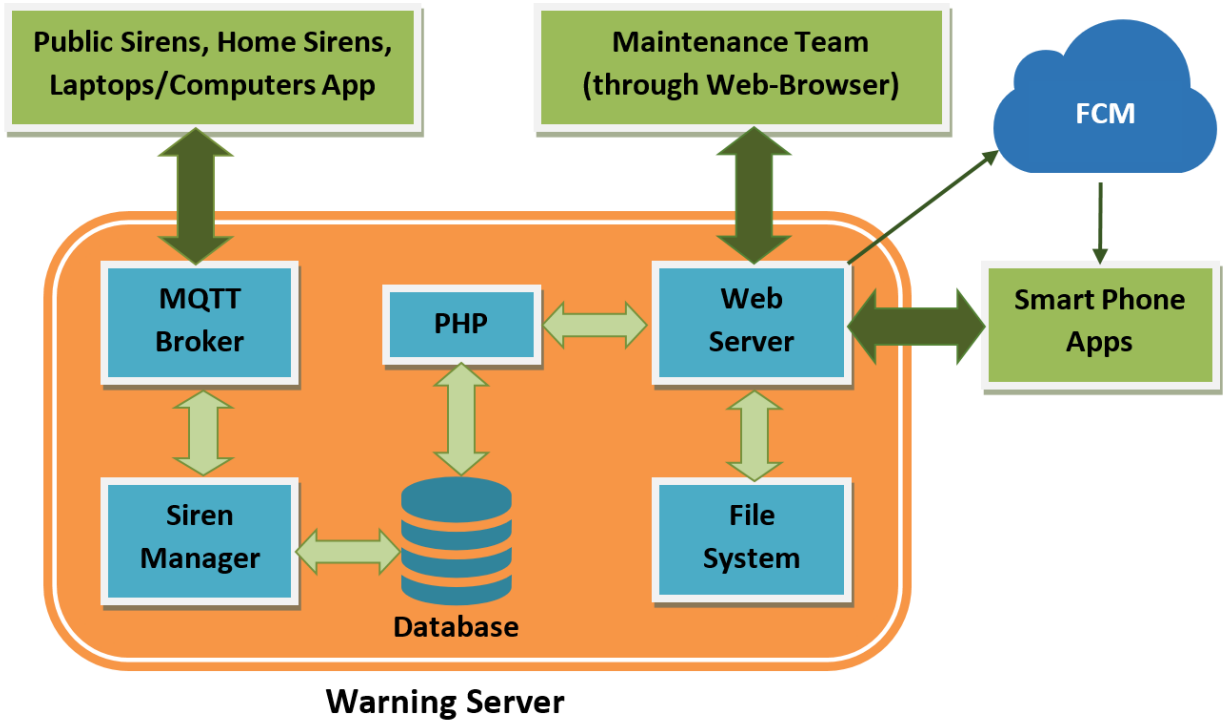


**Figure 3**: Architecture of the developed Warning Dissemination System

## 4 Uttarakhand Bhookamp Alert App: Methodologies and Graphical User Interface

Figure 4 shows the various screen shots of the developed app. In first screen user is asked for registration with some basic information such as name, mobile number, near and distant emergency contact numbers. After that user goes to home screen, which is shown in second screenshot, where instructions and video tutorial to safe guard themselves during the earthquake are given. User can also get information about the EEW system and how it works for better understanding about the developed EEW system through these videos. Videos and instructions are available in Hindi and English according to the user's app language. User can change the app language at any time by tapping the language icon on top-right and shown in third screenshot. Instructions for earthquake safety are given in graphical and textual format in instructions tab on home screen and shown in fourth screenshot. Further, the app also contains the details about past earthquake in this region, which is shown in fifth screenshot, so that user can easily take an idea about the seismicity of the region. The early notification to the earthquakes are given through notifications as shown in sixth screenshot, which is also the evidence of success of this application. The earthquake early warning to

users is sent with a loud human voice, if magnitude is greater than 5.0, so that users get alerted even the phone is kept in their pockets or bag. On tapping at the alert notification, users can get information about epicenter, magnitude and time left before the impending earthquake waves which is shown in seventh screenshot. We kept a pause of 1 minute, when the countdown timer stops, so that some wrong information by the user is not being sent to the server while safe guarding him. After this 1-minute pause time the next screen appears which is shown in eighth screenshot, where user is being asked for their condition. If user presses "I need Help" then this information is shared with disaster management authority and if user presses "I am Safe" then user is marked as safe. Seventh and eighth screenshots could be also seen during the demo of the app in normal mode for the awareness among the users.

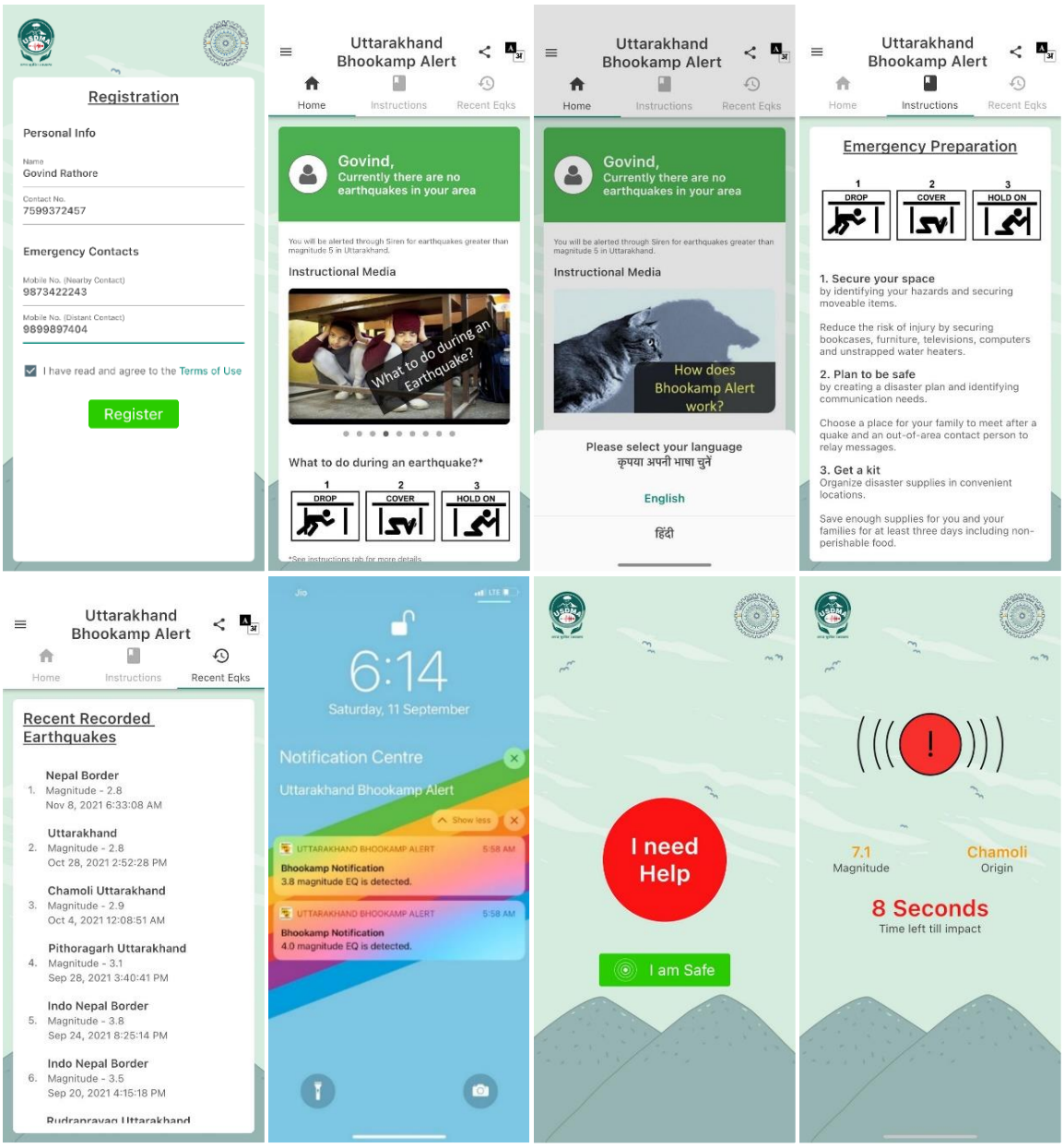


**Figure 4:** Screenshots of Uttarakhand Bhookamp Alert smartphone app

The developed app has three modes i.e., normal mode (for awareness), Information mode (for sending important information) and Alert mode (for alerting). The app is developed for two languages (Hindi and English) and app's language is asked before the registration process, which could be also changed in home screen later. User is also asked for granting notification and location permission to the app, user needs to grant both permission for the proper working of the app. Notification permission must be granted to receive the early warning of earthquakes, user can also grant the notification permission from the setting on later stage if he/she denied it during the installation process. Further, user is also need to accept terms & conditions to use this app, which gives information about the various conditions and limitations of the app in details. The block diagram of the app is shown Figure 5, which shows the working of each mode. Each mode is explained in details separately.

### 4.1 Normal Mode

In this mode the app can be used for awareness purpose and user is directed to home screen, where various video tutorials and textual information about what to do and what not to do during earthquakes are given. Users can select and play various videos according to their choices and requirement. Further, a catalog of past earthquakes in the region is also provided to user for understanding the seismicity of the region, which also encourages users to share this app to their relatives and friends using in app share button. User can share this app via various methods such as email, messaging apps etc. In normal mode user can also edit the basic information filled during the registration, which helps disaster response team to connect with user's relatives or friends during rescue operations. User can also set his/her preferred language as app's language in Normal mode. At last, normal mode also facilitate user to check demo of alert mode of the app, in which user is guided to get familiar about the app functioning during the earthquake. The screenshots ($7^{th}$ and $8^{th}$) of earthquake early warning demo can be seen in Figure 4.

### 4.2 Information Mode

This mode has been made for spreading the important information to users, mainly for the upcoming mock-drills. Further, real time detected non-damaging earthquake information is also sent to users in this mode, for creating user's confidence in this app. Further, this mode is also used to send regret message to users, if a false warning is issued to public due to any technical failure. Other information related to earthquakes such as government initiatives and app features are also being sent to the users to get them informed. Users are being informed by sending push notifications with brief information and by tapping on the notification the users will get detailed information through videos or textual content in user's preferred language.

### 4.3 Alert Mode

This mode only works when the earthquake early warning is received. An alert sound with human voice is played as warning sound to alert people even if the mobile phones are in their pockets. Further, this sound warning also alerts the nearby people. If user taps on the notification the app opens in alert mode and shows the earthquake information along with the time left for the impinging earthquake waves. On completion the time left, it pauses for 1 minute to

avoid accidental button tap for critical information sent to the server. After that user is asked for their condition or requirement of any help.

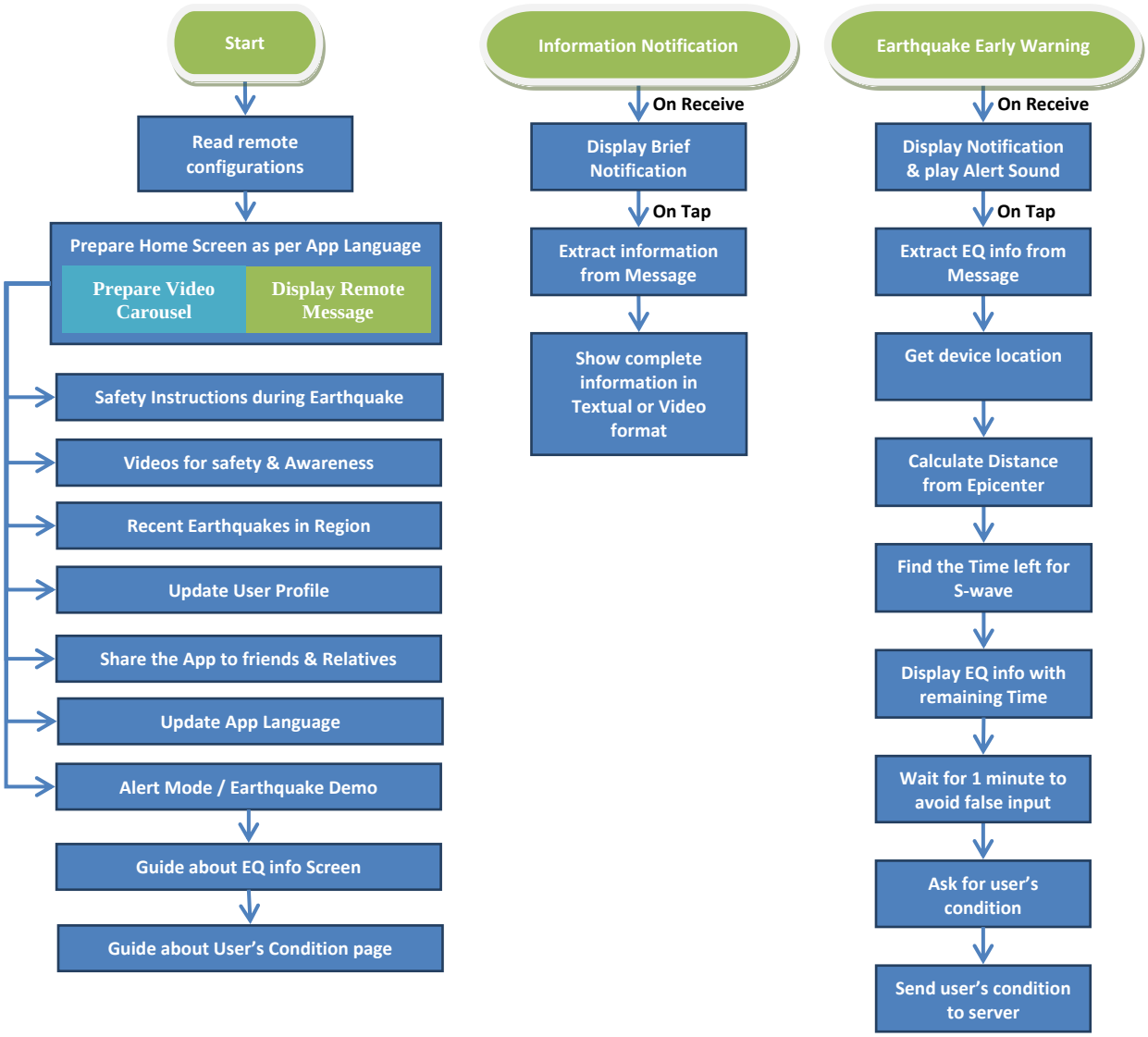


**Figure 5**: Flow Diagram of Developed Mobile App "Uttarakhand Bhookamp Alert"

## 5 Success Story & Mock-drills

On 11th September, 2021, an early notification of the earthquake has been successfully sent to the app users within few seconds after the earthquake originated. Sixth screenshot of figure 4 shows the screenshot of the notification received on mobile phone. As magnitude was less than 5.0, therefore only a notification was sent on mobile phone without sound alert and EEW public sirens were not activated as per the necessity as magnitude less than 5.0 is not a damaging earthquake. This type of early earthquake notification on smart phones will create confidence in users and also encourage people to install this app for their safety.

We have successfully conducted 3 mock-drills till now. These mock-drills are being conducted on 1st day of each month and will be continued. Monthly notifications are sent to users about the awareness and upcoming mock-drills, which encourage users to talk about the app. This awareness also increased the new installations. Further during mock-drill user also get the idea about the time required to escape from the building and other option for hiding themselves from falling objects, if they are unable to escape. Awareness of the app among public is also being spread by distributing pamphlets and sticking the sticker on common places. Our maintenance teams are also spreading the information about the app among people and make sure about some installations in some phones at each site during the maintenance in the field.

## 6 Summary and Conclusion

A bilingual smart phone app **"Uttarakhand Bhookamp Alert"** is developed for Android and iOS operating systems for earthquake early warning dissemination. User has option to choose his/her preferred language for operations or usage of the app. This app receives push notification of earthquake information from warning server to alert people based on user's location. This app has successfully given an earthquake early notification to users and has been successfully tested 3 times since launching. Mock-drills on first day of each month is helping to spread the awareness of this app and EEW system installed in the Uttarakhand. The app also has informative tutorials for do's and don'ts during the earthquakes as well as earthquake resistant building guidelines and mock drills in two languages (Hindi & English), so that users can easily understand about the earthquake early warning system and limitation of the app along with the do's and don'ts. Users also has option ask help through app, if he/she stuck somewhere during the earthquake. We are also able to spread the awareness about the app and EEW system with the help of USDMA, maintenance teams, classifieds, posters and pamphlets. Proper awareness would be helpful in saving lives and injuries during the earthquakes.

## Statements and Declarations

**Declaration of Competing Interests:** The authors acknowledge that there are no conflicts of interest recorded.


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