E-RA (Earthquake Rapid Assessment), application-based rapid assessment tools

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Abstract. Earthquake rapid assessment after an earthquake is critical to gather the data for public damaged houses. In the past, many methods were used for assessing damaged houses, while most used manual methods by writing or filling out a print-out form. This type of method took up a lot of time to collect the data from every assessor and assessed as having many shortcomings. It caused the National Agency for Disaster Countermeasure (BNPB) to develop an application-based data collecting tool called "InaRISK" as an improvement to the existing rapid assessment method. Even though this application has made some breakthroughs; there are still some drawbacks, especially in using the application without an internet connection that affected to the data validation. So, the Andalas University Team decided to develop an improvement to InaRISK called "E-RA (Earthquake Rapid Assessment)" that can used without an internet connection and is more accessible. This paper discusses the development of a rapid assessment application called E-RA for collecting damaged houses data after an earthquake.

1 Introduction

Indonesia is a country located between four confluences of tectonic plates, namely Eurasian, Pacific, Indo-Australian, and Philippine Sea Plates [1]. These four tectonic plate activities are concentrated in the plate boundaries and have the highest activity when two or more plates collide at the meeting points [2,3]. Therefore, the islands of Indonesia are very susceptible to natural disasters, especially earthquakes [4]. 71,628 earthquake events have been recorded that can be analyzed during the period of 11 years of earthquake observation (2009-2019) in the territory of Indonesia [5].

After the earthquake, the need for damaged houses data is critical to support the rehabilitation and reconstruction activities. The data collecting method is based on rapid assessment methods such as FEMA 154, FEMA 310, or the Quick Visual Assessment" method from the National Agency for Disaster Countermeasures (BNPB) regulation number of 2017 [6,7]. However this method has proven to take up a lot of time in its process, and the data obtained and calculated by the surveyors/ assessors are very diverse, which makes it difficult for the government or related institutions to establish valid data. It caused the National Agency for Disaster Countermeasure (BNPB) to develop an application-based data collecting tool called "InaRISK" as an improvement to the existing rapid assessment method, but there are still some drawbacks, especially in using the application without an internet connection which can affect the data validation.

For the reason above, the Andalas University Team decided to develop an improvement to InaRISK called "E-RA (Earthquake Rapid Assessment)" that can be used without an internet connection and is more accessible.

2 E-RA

The E-RA (Earthquake Rapid Assessment) is the development of an IT-based rapid assessment method for damaged houses due to earthquakes. This rapid assessment method is a new development in collecting damaged houses data for emergency handling in a short time, at an economical cost, flexible, and low risk.

The E-RA application was developed by considering some weaknesses which is based on the previous rapid assessment application, named InaRISK. Even so, the use or goals of the two applications are very different but on the same basis, namely rapid assessment of damaged houses due to earthquakes. The E-RA application has several advantages that differ from the previous method, as follows:

- Using kobotoolbox as a media in taking and organizing data offline (offline).
- Data collected in real-time accelerates data collection on the database.

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- The e-forms on E-RA are arranged in a systematic and simple manner so that they are easier to use for users who are intended for the wider community.
- The results of calculating the weight of the damage to the house can be seen only on the website admin E-RA application, thus closing the possibility of field data falsification to obtain certain results. The application design for E-RA can be seen in Fig. 1.

Fig. 1. E-RA application icon design.

3 The basis of E-RA

3.1 Damage calculation

The E-RA application uses a form from the National Agency for Disaster Countermeasure (BNPB) as a reference for assessing damage to each element of the building structure which is reviewed through direct observation in the field. There are seven sections in the form must be filled in before the application calculates the weight of the damage. This calculation method is based on the “Quick Visual Assessment” method from the National Agency for Disaster Countermeasure (BNPB) regulation number of 2017 [7] and the method from the Ministry of Public Works and Public Housing of the Republic of Indonesia “Quick Assessment for Non-Engineered Structures” [8].

3.1.1 Homeowner general information

This section of the form contains information that can be used to ascertain the homeowners who were damaged after the earthquake. This contains the homeowner's name, single identity number, family card, phone number, address, and a photo of the house to make it easier to find a house in the field.

3.1.2 Visual condition of foundation/sloof

This section of the form contains a visual damage assessment which is divided into cracks on the concrete surface, destruction of the concrete, and settlement of the foundation. This is filled in by selecting the percentage of damage from 0%, 1-30%, 31-50%, or 51%-100% and is equipped with a photo of the situation in the field.

3.1.3 Visual condition of beams/columns

This part of the form is filled in with the visual condition of the post-earthquake beams/ columns which are divided into hairline cracks on the concrete surface, very obvious cracks in the concrete, and destruction of concrete with buckling reinforcement. This part of the form is filled in by selecting the percentage of damage from 0%, 1-30%, 31-50%, or 51%-100% which is visually assessed and accompanied by a photo in the field.

3.1.4 Visual condition of the roof truss

This part of the form is filled in by taking a field photo of the condition of the roof truss of the house after the earthquake. Then the form is also filled in by determining the percentage of damage in the condition of the batten partially/completely destroyed and the trusses partially/completely collapsed. Damage percentage is divided into no damage (0%), 1-30%, 31-50%, or 51%-100%.

3.1.5 Visual condition of the roof covering

In this form, you will be asked to take a photo of the roof covering according to field conditions as data to validate the damage. The surveyor/assessor is asked to determine the percentage of damage to the roof covering on the part of the roof covering partially/completely falling. Damage percentage can be selected between no damage (0%), 1-50%, or 51%-100%.

3.1.6 Wall visual condition

Wall damage on the form is filled out by taking photos of the field conditions. The form is filled with an assessment of the visual condition of the wall which is divided into the percentage of plaster chipped off, the percentage of wall cracks (translucent/not), and the percentage of fallen walls. The percentage of damage for each of these parts can be chosen from no damage (0%), 1-30%, 31-50%, or 51-100%.

3.1.7 Floor visual condition

The form requires a photo of the visual condition of the floor in the field to calculate the weight of the damage to the floor. The damage assessment is divided into the percentage of hairline damage and the percentage of floor split/destroyed on the floor. The percentage of damage to these parts can be selected from no damage (0%), 1-30%, 31-50%, or 51-100%.

Each selected damage percentage in all parts of the form has a different damage weight. Damage weight is calculated according to calculations on the form from BNPB (Fig. 2). The picture shows the part of the building that was visually observed with the type of damage it experienced, then the number of components replaced on the E-RA form into a percentage of damage, as follows:

- For the number of components 0 = percentage of damage 0%

- For the number of components 1 = percentage of damage 1-30%
- For the number of components 2 = percentage of damage 31-50%
- For the number of components> 3 = percentage of damage 51-100%

Damage			
Building Element	Damage Type	Component Quantity	Damage weight (%)
Foundation/Sloof	☐ Cracks is visible on the concrete surface (1 - 2mm)	1;2; ≥ 3	3;4;5
	☐ Concrete destruction with visible reinforcement	1;2; ≥ 3	5;8;11
	☐ Stagnation and/or destruction of foundation	1;2; ≥ 3	11;14;15
Column/Beam	☐ Cracks is visible on the concrete surface (0,2 - 1 mm)	1;2; ≥ 3	7;9;11
	☐ Visible cracks (1 - 2mm)	1;2; ≥ 3	7;9;11
	☐ Destruction of concrete, buckled reinforcement or deformation of column	1;2; ≥ 3	12;26;35
Roof frame/ Roof truss	☐ Roof batten is partially or fully destroyed	1;2; ≥ 3	3;5;11
	☐ Roof truss is partially or fully collapse	1;2; ≥ 3	11;14;15
Roof cover	☐ Fall partially or fully	1; ≥ 2	5;10
Wall	☐ Stucco delaminates or fall over	1;2; ≥ 3	3;4;5
	☐ Cracks is visible ,through the rocks	1;2; ≥ 3	5;8;11
	☐ The wall is partially or fully fall over	1;2; ≥ 3	11;14;15
Floor	☐ Small crack that spreads partially or fully	1; ≥ 3	2;3
	☐ Large crack/split/destroyed partially or fully	1;2; ≥ 3	8;9;10

Fig. 2. The damage type based on the number of component (percentage of damage).

The highest damage weight in each part of the visual condition on the form will be accumulated to determine the type of damage experienced by the house. The type of damage that occurs according to the accumulated weight of the damage is divided into three types that is:

- For total damage of 1-30% = Minor damage
- For total damage of 31-50% = Moderate damage
- For total damage of 51-100% = Severe damage

So, the damaged houses assessment, the weight of the damage is obtained which determines the type of damage occurs. That is the assessment workflow that forms the basis for a damaged houses assessment which will be calculated automatically by the application and the calculation results can only be accessed by the admin on the E-RA website to reduce the efforts to falsify damage calculations which results in increasing the validity of the data obtained in assisting damaged houses during the post-disaster rehabilitation and reconstruction process.

3.2 The making of E-RA

The stages in making the rapid assessment application are divided into 2 parts, stages of making the data collecting application and stages of making a website for data display and calculation.

3.2.1 Stages of making the data collecting app

Making the application begins with designing the form that will be used to collect data according to the basis of the E-RA application. Form creation is assisted by using an additional application, namely the KoboToolbox application. The KoboToolbox application provides tools that are used to quickly collect and sort data even without an internet connection. After the E-RA form has been created based on the E-RA application basis, kobotoolbox will issue a QRcode which can be scanned for other users who will access the E-RA form.

3.2.2 Stages of making a website for data display and calculation

Making the website use framework bootstrap for Frontend, Node Js as runtime, and Express as backend. The website uses Google Maps to support the vision (visual) of the damaged house's location, so the website is subscribed to Google Cloud and API Custom Google Maps.

For data display and calculation, the website uses API that has been provided, so the website can display locations on maps, pictures of the state of the house that is filled out on the forms, and statistical visualization of data. The website also uses the framework jQuery to display data in tabular data tables to make it easier to create data filtering features, search data, and produce data in Excel form (exporting).

4 Stages of using E-RA application

The E-RA application has two parts, an application on Android or iOS that can be accessed by surveyors or assessors and a website that can only be accessed by the admin.

4.1 The E-RA application

The E-RA application is accessible on Android or iOS and can be accessed by surveyors and assessors to collect the post-earthquake damaged houses data. The following are the stages of use for the E-RA application:

The E-RA application can be installed on each user's mobile phone either Android or iOS to make it more accessible (Fig. 3).

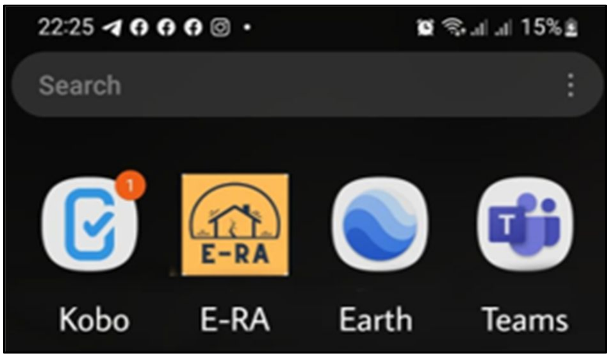

Fig. 3. E-RA application icon (E-RA 2023).

After clicking on the E-RA application a home screen (Fig. 4). In this view there is a "fill blank form" section to fill in a new form from the E-RA application, "Edit Saved Form" to change the contents of the previously filled form before sending it to the database, "Send Finalized Form" to send/synchronize data a form with a database, "View Sent Form" to see the contents of the forms we have sent, "Get Blank Form" to get a new form if we update the form we are using by scanning the QR code, and "Delete Saved

Form" to delete the form stored on the user's mobile phone.

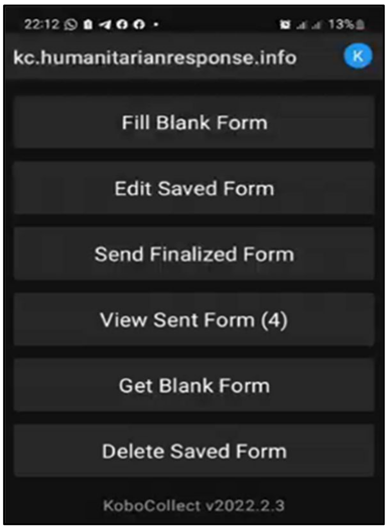

Fig. 4. E-RA home screen (E-RA 2023).

To fill in the form, we will start by clicking "Fill Blank Form" and selecting the E-RA form. Then, when filling out the initial form, you will be asked to determine the coordinates of the damaged house by clicking "Start Geopoint" (Fig. 5).

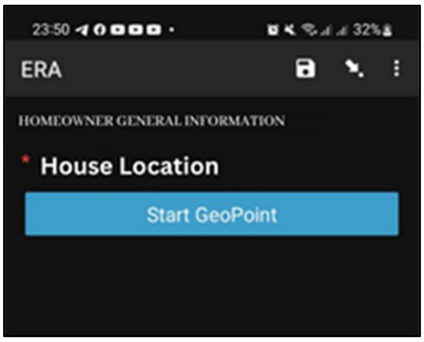

Fig. 5. The geopoint section on the E-RA (E-RA 2023).

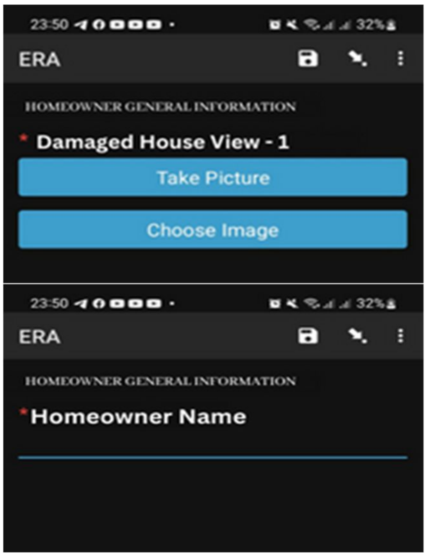

Fig. 6. The homeowner general information section on the E-RA form (E-RA 2023).

After the coordinates of the house are obtained, the next form will display a section to take a photo of the house and type in the space provided for the house ownership data such as homeowner name, single identity number, family card, etc. (Fig. 6).

Then in the visual damage condition assessment section on the form, the user will be asked to choose the percentage of damage that occurred to the house and present a photo of the field condition of the damage that occurred on the form (Fig. 7).

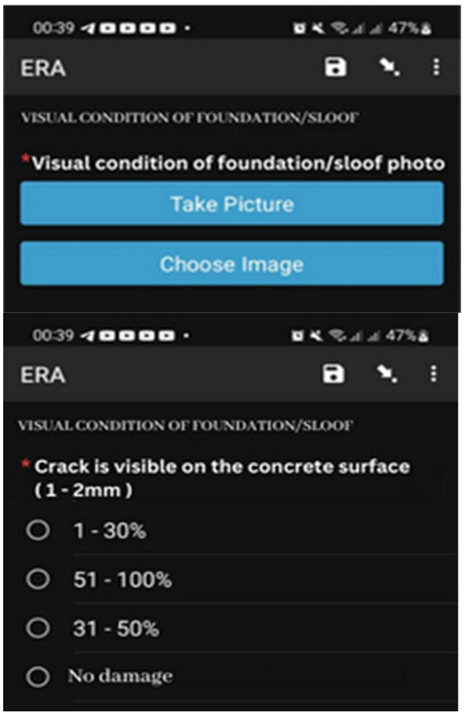

Fig. 7. The visual condition data of the damaged houses on the E-RA form (E-RA 2023).

After completing all parts of the form, the form display will state that the user is at the end of filling out the form. Users will be asked to name the form and save the form before proceeding to the initial appearance of the form (Fig. 8).

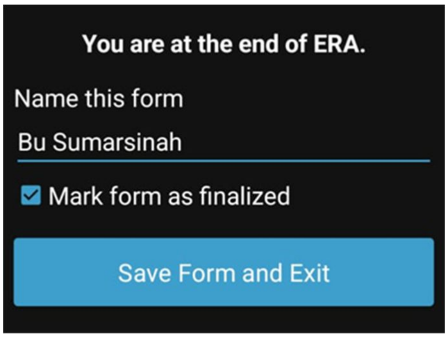

Fig. 8. Final section of the E-RA Form (E-RA 2023).

When the user selects "Save Form and Exit", the user will be taken back to the initial display of the form (Fig. 3), The user can only fill out the form without being able to see the calculation results which will be carried out on a website that can only be accessed by the admin to reduce data fraud. The data form that has been sent along with the results of calculating the weight of the damage in determining the type of damage to the house will be accessible only by the admin team from E-RA on the E-RA website.

4.2 The E-RA admin website

The E-RA admin website is only accessible by the admin or authorized personnel when used to collect damaged houses data. The following are the stages of use for the E-RA application:

The E-RA website can be accessed on the URL https://www.earthquakera.com/ using an Android/ iOS smartphone or using a laptop/computer browser. When you open the URL in the browser, a login display of the E-RA website will appear on the screen (Fig. 9).

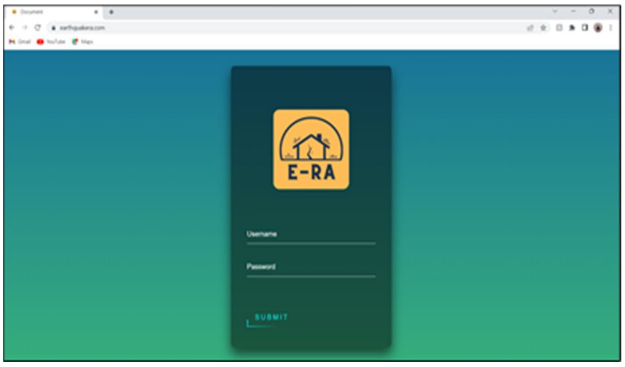

Fig. 9. E-RA website login display (E-RA 2023).

After entering the admin username and password, it will proceed to the home screen on the E-RA website which displays Google Maps along with a marker for the location of the damage to the house with the type of damage. In addition to location markers, this home view also contains general information on damaged homeowners on the screen's upper right side and a recap of damage data on houses which are depicted in the form of a pie chart on the screen's bottom-left side (Fig. 10).

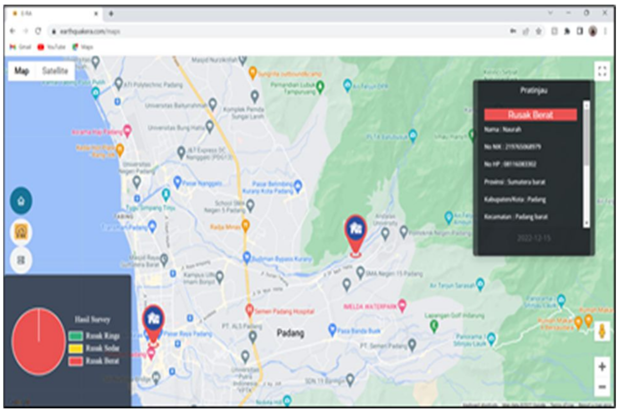

Fig. 10. Home display of E-RA website (E-RA 2023).

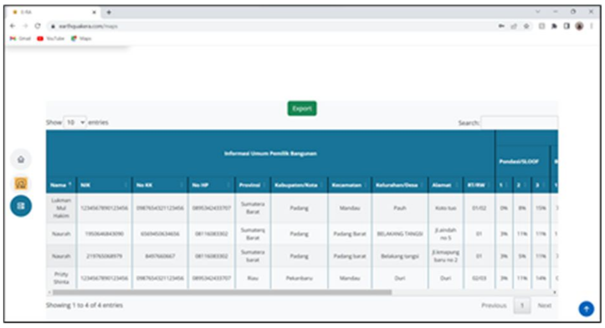

Fig. 11. Database display of E-RA website (E-RA 2023).

On the left side of the website, there are options for home and database in the form of round choices. Click the "Database" section at the bottom. Then the database display will appear (Fig. 11).

The database can be exported into the form of an Excel table which can be done by clicking the "export" button.

5 E-RA application trial and validation

Before Earthquake Rapid Assessment (E-RA) application can be used by the community on a large scale. Trials are needed to find out whether the E-RA application is in accordance with the basis and purpose of its formation. So the application trial activities were carried out for validation in the West Pasaman area. The trial was carried out by giving the application to people whose houses were damaged to carry out independent data collection under the control of an admin. The trial was carried out by Mr. Mardan using an admin's cellphone as a test. Using the cellphone Mr. Mardan filled out the form using the photos of his and the house's damaged percentage (Fig. 12).

After the form is sent to the database, the admin then checks the website to see the results of calculating the weight of the damage suffered by Mr. Mardan's house. From the data obtained, the application calculates that the house has suffered heavy damage and pinpoints the location of Mr. Mardan's house on the website map (Fig. 13).

Fig. 12. Mr. Mardan's damaged house in Kajai, West Pasaman.

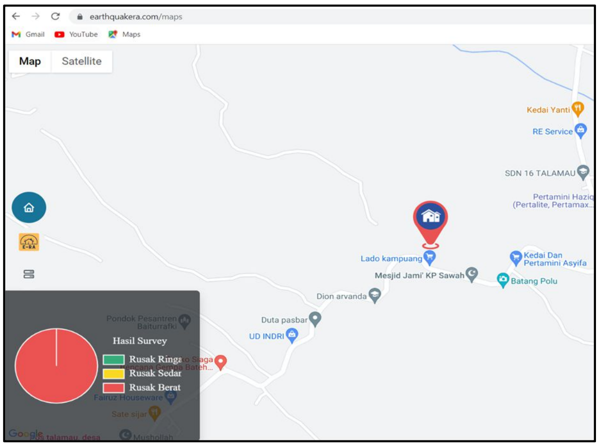

Fig. 13. Mr. Mardan's damaged house location on E-RA website.

On the website database, it can be seen the weight of the damage suffered by Mr. Mardan's house in each visual condition assessment, as shown in Table 1 and Fig. 14.

Table 1. Results of public buildings observation and the repair recommendation.

Visual Condition		
Elements	**Percentage**	**Calculation**
Foundation/ sloof	1.3%	Severe damage
	2.5%	
	3.11%	
Column/ beam	1.11%	
	2.11%	
	3.26%	
Roof truss	1.5%	
	2.14%	
Roof	1.5%	
Wall	1.5%	
	2.11%	
	3.15%	
Floor	1.3%	
	2.9%	

VISUAL CONDITION															CALCU LATION
FOUNDATION/ SLOOF			COLUMN/ BEAM			ROOF TRUSS		ROOF	WALL			FLOOR			
1	2	3	1	2	3	1	2	1	1	2	3	1	2		
3%	5%	11%	11%	11%	26%	5%	14%	5%	5%	11%	15%	3%	9%		SEVERE DAMAGE

Fig. 14. Mr. Mardan's house damage weight on E-RA website.

Based on Table 1 and Fig. 14, if the calculation is done according to the basis of the E-RA application, namely taking the largest damage weight in each part of the visual condition assessment of the house damage, then the weight of the damage that occurs to Mr. Mardan's house is 11% for the foundation/ sloof section, 26% for beams and columns, 14% for roof trusses, 5% for roof cladding, 15% for walls and 9% for floors. So the weight of the total damage experienced by the house was 80% which stated that Mr. Mardan's house was damaged with the type of heavy damage.

This proves a validation of the E-RA application and website to be in line with the E-RA basis of its formation, so the application can be used for further rapid assessment.

6 Conclusion

In conclusion, the E-RA (Earthquake Rapid Assessment) is a tool that was developed by the Andalas University Team to become a breakthrough in the rapid assessment community with its time-saving and practical use. The application also corrected some drawbacks that arose while using the past rapid assessment method such as the use of no internet connection area and the data fraud that disrupts the validity of data. It is hoped that in the near future E-RA application as a rapid assessment method can facilitate the rehabilitation and reconstruction of post-earthquake activities with its usefulness.

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