Supplementary Information for "A Bespoke Approach to Quantifying the Impacts of Disasters, Using Stakeholder-relevant Metrics"

Chenbo Wang[a]*, Fabrizio Nocera[a], Gemma Cremen[a], Carmine Galasso[a], Vibek Manandhar[b], Prayash Malla[b]

[a]Department of Civil, Environmental and Geomatic Engineering, University College London, United Kingdom
[b]National Society for Earthquake Technology - Nepal, Nepal

*Corresponding author: Chenbo Wang; `chenbo.wang@ucl.ac.uk`

1 Completing the testbed questionnaires

The testbed questionnaires were completed in three in-person workshops held by National Society of Earthquake Technology - Nepal (NSET) on 22 July 2023, 27 July 2023, and 28 August 2023, (26, 23, and 1 residents and 6, 0, and 34 other stakeholders per round respectively; see Figure S1). Each workshop began with an introduction to the background of the study. Transportation reimbursement and lunch boxes were provided to the stakeholders as compensation, in line with the ethics guidelines of University College London and NSET.

Figure S1. Workshops held by NSET in Kathmandu, Nepal (July - August 2023), in which recruited stakeholders completed the structured questionnaires.

2 *RankDIMs* and *CompareDIMs* web applications

2.1 Data

The required input data for both web applications are:

1. One or more *tibbles*. Each tibble contains questionnaire responses to all questions provided by all participants in a specific stakeholder group (or category). Each row contains responses for individual participants and each column contains all responses to a given question. Each cell contains either text (e.g., for question A2 (in part A of the 'other stakeholders' questionnaire) that request details on stakeholder roles within the company or organisation they represent), one number (for single-answer quantitative questions; see Figure S2), or a list of both numbers and/or text (for multiple-answer questions; see Figure S3). The responses for multiple-answer questions must be organised in the same order as shown in Figures S3 and S4;

2. Four string vectors that contain information on codes (question numbering) for each questionnaire question. Three of these vectors contain the codes of questions related to DIMs of each spatial scale

(e.g., "B6.1", "B7.1", "B8.1", "B10.1", "B12.1", etc., for household-level DIMs). The fourth vector contains codes of questions on disaster impacts across all spatial scales (e.g., "B31", see Figure S4). Each vector must be accompanied by another one that contains the descriptions of the corresponding disaster impacts (e.g., "access to green infrastructure is lost").

B5-2. Green infrastructure in your region is damaged.

Your answer:_____

Figure S2. An example of a single-answer question. Red text indicates the order in which the data should be provided within the corresponding cells of the tibble.

B8-2. Access to green infrastructure is lost across your neighbourhood.

For two weeks	For six months	Third entry
First entry	Second entry	Fourth entry

Figure S3. An example of a multiple-answer question. Red text indicates the order in which the data should be provided within the corresponding cells of the tibble.

B38. Permanent displacement occurs.

You	Your neighbourhood	Your region
First entry	Second entry	Third entry

Figure S4. An example of a question that involves all spatial scales.

2.2 Graphical user interfaces

Figures S5 and S6 provide the graphical user interfaces (GUIs) of the ***RankDIMs*** and ***CompareDIMs*** web applications. The various temporal instances and spatial scales considered in the applications are as described in Section 2. The applications currently account for the two stakeholder categories considered in the case study (i.e., residents and other stakeholders); future versions will capture all six representative stakeholder groups outlined in Section 2.

The input panel of the ***RankDIMs*** GUI asks users to select the temporal instance of interest, the weights assigned to each stakeholder category (w_j), the number of DIMs to consider ($n_{cus} = n_{sub}$), and a specified disaster impact to provide the ranking and S_{DIM_i} value for, across all spatial scales.

The ***CompareDIMs*** GUI contains three panels. The left panel requests information for comparing S_{DIM_i} values related to a specific disaster impact across different spatial scales, for a prescribed temporal instance, and set of stakeholder categories ("resident", "other stakeholders" or "both"). The middle panel is used to input information for comparing S_{DIM_i} values related to a specific disaster impact across different temporal instances, for a prescribed spatial resolution, and set of stakeholder categories ("resident", "other

3

stakeholders" or "both"). The right panel requests information to compare the S_{DIM_i} values obtained by each stakeholder category for a given DIM. The current version of the application requires inputs to be provided for all three panels before the calculations can be run. This issue is intended to be rectified in future versions of the application, which will also allow for more general comparisons across different disaster impacts.

RankDIMs

Provides rankings, S_{DIM_i} values and importance ratios I_{pos} and I_{tot} for a customisable number ($n_{cus} = n_{sub}$) of DIMs at all spatial scales and a prescribed temporal resolution

Prescribed temporal instance

two weeks ▾

Weight assigned to residents (w_1)

0.5

Weight assigned to other stakeholders (w_2)

0.5

The number of DIMs to consider ($n_{cus} = n_{sub}$)

25

Specify a disaster impact to provide ranking information and S_{DIM_i} values for, across all spatial scales

Access to drinking water is lost ▾

Generate new results

Figure S5. The GUI of *RankDIMs*.

CompareDIMs

Performs Welch's Analysis of Variance, Welch's two-sample t-test, and power analyses on the S_{DIM_i} values across different spatial scales, temporal instances, and stakeholder categories

Spatial comparison

Compare S_{DIM_i} values across different spatial scales, considering a specific disaster impact, a prescribed temporal instance, and a set of stakeholder categories

Disaster impact of interest

Access to community assets is lost ▼

Prescribed temporal instance

two weeks ▼

Stakeholder category

Both ▼

Temporal comparison

Compare S_{DIM_i} values across different temporal instances, considering a specific disaster impact, a prescribed spatial scale, and a set of stakeholder categories

Disaster impact of interest

Access to drinking water is lost ▼

Prescribed spatial scale

Household ▼

Stakeholder category

Resident ▼

Stakeholder category comparison

Compare S_{DIM_i} values across different stakeholder categories for a specific DIM

Disaster impact of interest

Access to required healthcare is lost ▼

Prescribed spatial scale

Household ▼

Prescribed temporal instance

two weeks ▼

Generate new results

Figure S6. The GUI of *CompareDIMs*.

RankDIMs outputs visualisations of rankings (similar to Figures 8 to 12 in Section 3.3 of the main text), importance ratios (I_{pos} and I_{tot}; see Figure S7), as well as separate ranking and S_{DIM_i} information for the disaster impact specified as part of the input (see Figure S8). The outputs of *CompareDIMs* are text descriptions of the results of its statistical tests described in Section 2.3.2 of the main text (e.g., Figures S9, S10, and S11).

The positive importance ratio (I_{pos}) and total importance ratio (I_{tot}) captured by the list of top $n_{cus} = n_{sub}$ DIMs at different spatial scales:

space	positive.importance.ratio	total.importance.ratio
household	0.92	0.65
neighbourhood	0.77	0.54
region	0.71	0.53

Figure S7. Example outputs of *RankDIMs*. The positive importance ratio (I_{pos}) and total importance ratio (I_{tot}) captured by the list of top $n_{cus} = n_{sub}$ DIMs at household, neighbourhood, and region level.

The selected disaster impact is ranked #2 at the household level, with an average weighted importance score of 3.681, #1 at the neighbourhood level, with an average weighted importance score of 3.698, and #1 at the region level, with an average weighted importance score of 3.698.

Figure S8. Example outputs of *RankDIMs*. Rankings and S_{DIM_i} values for the disaster impact associated with a prescribed temporal instance specified as part of the input, at household, neighbourhood, and region level.

Spatial comparison (Welch's Analysis of Variance and two-sample t-test and power analyses)

Result_ANOVA

The differences in importance scores for access to community assets is lost at the household, neighbourhood, and region level two weeks after the event are found to be NOT statistically significant with p-value= 0.5594, and importance scores being 3.12, 3.24, and 3.32, respectively.

Result_t_test

The differences in importance scores for access to community assets is lost at the household and neighbourhood levels two weeks after the event are found to be NOT statistically significant with p-value = 0.5093, statistical power = 0.1006, and importance scores being 3.12 and 3.24, respectively. To have a power of 0.80, the required sample sizes for household- and neighbourhood-level responses are 896 and 896, respectively.

The differences in importance scores for access to community assets is lost at the household and region levels two weeks after the event are found to be NOT statistically significant with p-value = 0.2832, statistical power = 0.1876, and importance scores being 3.12 and 3.32, respectively. To have a power of 0.80, the required sample sizes for household- and region-level responses are 338 and 338, respectively.

The differences in importance scores for access to community assets is lost at the region and neighbourhood levels two weeks after the event are found to be NOT statistically significant with p-value = 0.6549, statistical power = 0.07287, and importance scores being 3.32 and 3.24, respectively. To have a power of 0.80, the required sample sizes for region- and neighbourhood-level responses are 1954 and 1954, respectively.

Figure S9. Example outputs of *CompareDIMs*. Results for the comparison of S_{DIM_i} values obtained across different spatial scales, considering a specific disaster impact, a prescribed temporal instance, and a set of stakeholder categories, specified by inputs in the 'Spatial comparison' panel.

Temporal comparison (Welch's two-sample t-test and power analyses)

Result

The differences in importance scores for access to drinking water is lost at the household level at two weeks and six months after the event are found to be NOT statistically significant with p-value = 0.4366, statistical power = 0.1207, and importance scores being 3.49 and 3.656, respectively. To have a power of 0.80, the required sample sizes for responses associated with two weeks and six months after the event are 631 and 412, respectively.

Figure S10. Example outputs of **_CompareDIMs_**. Results for the comparison of S_{DIM_i} values obtained across different temporal instances, considering a specific disaster impact, a prescribed spatial scale, and a set of stakeholder categories, specified by inputs in the 'Temporal comparison' panel.

Stakeholder category comparison (Welch's two-sample t-test and power analyses)

Result

The differences in importance scores associated with residents and other stakeholders, respectively, for access to required healthcare is lost at the household level two weeks after the event are found to be NOT statistically significant with p-value = 0.2459, statistical power = 0.2115, and importance scores being 3.18 and 3.436, respectively. To have a power of 0.80, the required sample sizes for responses of residents and other stakeholders are 289 and 226, respectively.

Figure S11. Example outputs of **_CompareDIMs_**. Results for the comparison of S_{DIM_i} values obtained by each stakeholder category for a given DIM, as specified by inputs in the 'Stakeholder category comparison' panel

To access the source codes for the web applications, please go to `https://github.com/wangcb98/DIMs/tree/main/web_applications`.

3   Questionnaires

To access the questionnaires developed for the Kathmandu testbed application, please go to `https://github.com/wangcb98/DIMs/tree/main/questionnaires_KTM`.