Supplementary Material

Construction of an original evaluation matrix

Following Zou et al. (2006), we developed a Shannon entropy an evaluation matrix and finally weighed up indicators that were used for the overall livelihood vulnerability index.

Suppose there are m number of indicators (e.g., households who reported a chronic illness) in a specific major component (e.g., health) and n evaluating objects (households), then we can form an original indicators' value matrix as follows:

$$x = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix} \quad , \tag{1}$$

where x represents the major components. For example, in Table 1, x_1 is the major component "health" and it comprises four indicators (i.e., *m*=4) for all of the households (i.e., *n*=391). x_{11} represents "households who reported chronic illness" (the first of the four indicators listed under health) for household number 1. Therefore, the first column in the matrix represents all the major components of the livelihood vulnerability for household number 1.

Standardisation

We used a normlaization method to obtain the normlizing matrix R: the method of normalisation in this study takes the functional relationship between the predictor indicator and vulnerability. This is a dimensionnless processing technique that makes it possible to easily compare score values. In this process, we normalized the matrix computed above to obtain the following equation:

$$\boldsymbol{R} = (\boldsymbol{r_{ij}})_{\boldsymbol{m \times n}} \ (2)$$

where r_{ij} is the data of the evaluating object j of indicator i. In this case, the indicators have a positive functional relationship with vulnerability among these indicators, in which a higher value is generally understood to mean a greater amount of vulnerability. The normalising equation is:

$$r_{ij} = \begin{cases} \dfrac{x_{ij} - \min\limits_j(x_{ij})}{\max\limits_j(x_{ij}) - \min\limits_j(x_{ij})} & \max\limits_j(x_{ij}) \neq \min\limits_j(x_{ij}) \\ 1 & \max\limits_j(x_{ij}) = \min\limits_j(x_{ij}) \end{cases} , \qquad (3)$$

where $i = 1, 2, \ldots, m,$ and $j = 1, 2, \ldots, n.$

Thereby, the normalised matrix R is:

$$\begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{pmatrix} . \qquad (5)$$

Proportion of indicators in the matrix

For each r_{ij}, the proportion of the j^{th} indicator is:

$$f_{ij} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}} . \qquad (6)$$

If the value of each object is identical for a certain evaluating indicator, the share of the various evaluation objects in the index will be equal.

In that case, the proportion matrix F is:

$$F = \begin{pmatrix} f_{11} & f_{12} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ f_{m1} & f_{m2} & \cdots & f_{mn} \end{pmatrix} . \qquad (7)$$

Calculating the entropy value matrix S

According to the formula:

$$S_{ij} = \begin{cases} f_{ij} \ln(f_{ij}) & f_{ij} \neq 0 \\ 1 & f_{ij} = 0 \end{cases} \quad (8)$$

The results matrix S is:

$$S = \begin{pmatrix} S_{11} & S_{12} & \cdots & S_{1n} \\ S_{21} & S_{22} & \cdots & S_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ S_{m1} & S_{m2} & \cdots & S_{mn} \end{pmatrix} \quad (9)$$

where m is again the number of indicators and n is the number of evaluating objects. The entropy (H) of indicator i is defined as:

$$H_i = -\frac{1}{ln(n)} \sum_{j=1}^{n} S_{ij}, H = (H_1 H_2 \cdots H_m) \text{ where } i = 1,2,\ldots,m \quad (10)$$

Weighting entropy

The weight (w) of the entropy of the i^{th} indicator is defined as:

$$\sum_{i=1}^{m} w_i = \sum_{i=1}^{m} \frac{1-H_i}{m-\sum_{i=1}^{m} H_i} = 1 \quad (11)$$

in which $0 \leq w_i \leq 1, w_i = \frac{1-H_i}{m-\sum_{i=1}^{m} H_i}$.

Comprehensive index value

$$e_j = \sum_{i=1}^{m} (w_{ij} \times r_{ij}) \quad (12)$$

$$E = (e_1 e_2 \cdots e_n) = (w') \times R \quad (13)$$

Calculation of IPCC-based livelihood vulnerability (IPCC–LVI)

The major components were categorised into the dimensions of exposure, sensitivity, and adaptive capacity following the IPCC-based definition of vulnerability (Hahn et al., 2009). The comprehensive index vlaues computed in Eq.12 were summed up and made the dimesnions of the livelihood vulnerability as defined by IPCC.

The index for exposure (Exp) includes climate-related shocks and climate variability (one component); it was calculated as follows

$$Exp = CL \quad , \tag{14}$$

where CL represents the climate variability and shock experience(For instance CL was computed from the sum of values of rainfall, temperature, housheolds experice of shocks, access to warnign information and SPI).

The index of sensitivity (Sen) was calculated as follows:

$$Sen = Wa + H + F \quad , \tag{15}$$

where $Wa, H,$ and F are the major components of health, food, and water, respectively.

The adaptive capacity (AdaCap) index was calculated as follows:

$$AdaCap = SD + LS + SN \tag{16}$$

where SD, LS, and SN represent the socio-demographic, livelihood strategies, and social networks components, respectively.

Once the values of these three dimensions were calculated, the three contributing factors were combined using the following equation:

$$IPCC\!-\!LVI = AdaCap + Exp + Sen \tag{17}$$

where IPCC-LVI$_a$ is the LVI for community *a* expressed using the IPCC vulnerability framework. The minimum value was scaled to 0 (least vulnerable) and the maximum to 1 (most vulnerable).

Obstructing factors

We analysed the level at which each factors (indicators) obstructed adaptive capacity with the following formulae:

$$A_j = {I_j W_j}\Big/\left(\sum_{j=1}^{n} I_j W_j\right) \times 100\%, \tag{18}$$

$$I_j = 1 - X'_{ij}, \tag{19}$$

where I_j is the index deviation, which is the difference between index j and the optimal value; X'_{ij} is the standardised value of the indicator; W_j is the factor contribution, namely the weight of index j to adaptive capacity; and A_j is the degree of obstruction of factor j to adaptive capacity.