A new methodology for measuring human security is presented. The three stages of the methodology are: i) threat assessment, ii) data collection and organization, and iii) data visualization and analysis, using Geographic Information Systems. Results from a Cambodia case study are highlighted. The United Nations Development Program’s notion of human security, which gives equal weight to economic, health, food, political, personal, and environmental factors, is used. Country-specific threats in each category are determined, and local, spatially referenced data are collected. In this paper, poverty, dengue fever, and tuberculosis are used as examples of the analytic process. Regions of Cambodia exposed to all three of these threats (“hot spots”) are located, and spatial correlation between poverty, dengue fever, and tuberculosis is calculated. The methodology i) advances a broad concept of human security, ii) will potentially assist policy and decision makers, and iii) identifies research questions that cannot be resolved using single-sector analysis.

INTRODUCTION

Human Security is the protection of the vital core (1) of all human lives from critical and pervasive economic, environmental, health, food, political and personal threats.

This definition articulates a general conceptualization of human security. By itself, however, it does little to indicate what the threats are, who they are affecting, and where they are of concern. Without this qualifying information, critics rightly point out that the broad concept of human security has little theoretical grounding or policy relevance (2–4).

With this in mind, we have developed a combination of grounded empirical and qualitative research and a Geographic Information System (GIS) approach that facilitates the collection, organization, and spatial analysis of human security information.

This methodology takes a subnational approach to data collection and analysis. The method isolates “hot spots” of aggregated insecurity and determines spatial correlations between rarely compared security threats.

This methodology also engages the paradox of measuring human security (5): that the broader the conceptualization used, the greater the difficulty of establishing a consistent metric. It does so by addressing the problem of the aggregation of differing data types. By building the methodology around the spatial reference of data, a common denominator is created—space—allowing for direct aggregation and analysis without creating a subjective nominal scale.

Also critical is the methodology’s focus on identifying local hot spots rather than creating a national index. Although many global indices point policymakers to underdeveloped or insecure countries (6), none isolate specific regional vulnerability within these countries. This coarse resolution arguably contributes to poor, nationally ubiquitous development policy and a lack of meaningful correlation analysis between harms.

MATERIALS AND METHODS

The following section briefly outlines the three stages of the human security mapping methodology: threat assessment, data collection and organization, and data visualization and analysis.

Stage 1: Threat Assessment

By shifting the focus of vulnerability from the state to the individual, human security attempts to incorporate what are traditionally considered development concerns into the realm of security studies—focusing on threats such as natural disasters, communicable diseases, dire poverty, human trafficking, or land mines rather than nuclear or interstate war (Fig. 1). This shift in focus, however, presents a potentially unmanageable mandate. Critics have pointed out that if all potential harms are included, the concept is elusive and analytically indeterminate (7, 8). Although this may be true if attempting to measure all possible harms in all places in the world, by controlling the location of the study, the list of relevant harms is limited significantly and the use of a GIS makes the spatially referenced data amenable to analysis.

The first stage of the methodology, therefore, seeks to determine from grounded empirical and qualitative research what specific threats affect a particular country or region. This can be achieved in a number of ways. Ideally, regional experts in each of the six categories of security would be interviewed and asked whether there are any issues that would qualify as human security threats in their region—threats that present a critical and pervasive vulnerability to the vital core. By way of illustration, for the environment, this could be an extreme flood, or for personal threat, this could be a high risk from land mines. There are no limits to the number of threats in any category, as the only criterion is that they surpass the threshold of human security.

The most important point about this stage of the methodology is that it has reduced a seemingly endless list of threats (anything that can seriously harm an individual) down to only those that in practice affect a particular country or region. By shifting scales from the national to a local focus, human security becomes a manageable concept, going from hundreds of threats down to a handful.
Stage 2: Data Collection and Organization

Now that the human security threats affecting a country have been determined and classified, data detailing them must be collected. These data can be both quantitative and qualitative, but all must have a spatial dimension. Ideally, the data sets collected will detail the indicator that best represents each specific threat. The indicators are chosen and the data collected using local researchers, the nongovernmental organization community, government ministries, and international organizations. There will of course be some overlap with the experts consulted in stage 1. A key to this stage is data availability. It is argued that the challenge is best addressed by looking at the subnational level, by using disciplinary experts, and by focusing only on relevant threats, namely, those that surpass the human security threshold.

The concept of subsidiarity (9) is particularly important to the feasibility of the data collection process. Although information on all threats will not be available for all areas, the data are likely to cluster in the scale and regions in which they are relevant. For instance, if a flood affects only region X of a country, there will not necessarily be relevant hydrologic data for region Y.

Once data sets detailing each threat are collected, they are organized in a GIS by their spatial reference. What is important is that there is a link between specific threat severity and location or space (10).

At this point, we can now determine the level of threat for any point in our study region for any of the initial threats (Table 1).

Stage 3: Data Visualization and Analysis

The final stage of the methodology is to map and analyze the spatially referenced threat data. For each of the determined threats, we now have data sets detailing the location and severity of the threat within the country (Fig. 2). As all information is linked to a spatial reference (province, city, coordinate, and so on), each threat can be mapped using a GIS. This process involves three steps: base map creation, hot spot analysis, and functional analysis.

**Base Maps.** Base maps are created in the GIS by linking threat data sets to digital boundary maps using their like spatial reference (11). Once this is done, each threat can be mapped. These base maps are called layers and will be the foundation for the subsequent spatial analysis.

**Hot Spots.** Hot spots are regions of aggregated human insecurities. They are places that experience multiple “high”-level human security threats. Although a country as a whole may experience many different threats, these threats are often regionally dispersed—different areas affected by different harms to different degrees of severity. In some locations, however, these threats overlap. Presumably, a person in a region suffering from five high-level threats will be less secure than someone in a region with only two threats (13).

### Table 1. An example of the stage 2 data set. Note that the spatial reference (province in this hypothetical case) does not have to be the same for all threat data sets. In the final table, however, all will get disaggregated down to match the set with the finest resolution.

<table>
<thead>
<tr>
<th>Province name</th>
<th>Economic Threat A</th>
<th>Economic Threat B</th>
<th>Economic Threat C</th>
<th>Health Threat A</th>
<th>Health Threat B</th>
<th>Health Threat C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</table>

### Figure 2. Diagram of spatial joining process. Although at this point each data set represents the total range of severity for each threat, this methodology is designed to isolate where each threat is most severe. This is done by first classifying the data on the basis of their natural breaks (12). This process produces a map for each threat showing where the threat severity is “high,” “medium,” or “low.”

Hot spots are found by first separating only the regions with “high” levels of insecurity in each of our threat severity maps. All these maps can then be overlaid (14) to show the regions subject to multiple high levels of human insecurity—how many “high” rankings a spatial unit has received.

In Table 2, it is clear that province 5, with six high security threats, is less secure than, say, province 2, with only one high security threat.

### Table 2. Example of stage 3.

<table>
<thead>
<tr>
<th>Province name</th>
<th>Health Threat A</th>
<th>Health Threat B</th>
<th>Health Threat C</th>
<th>Economic Threat A</th>
<th>Economic Threat B</th>
<th>Economic Threat C</th>
<th>Hot spot count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
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</tr>
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<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
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Human security hot spot analysis is useful for a number of reasons. First, conceptually, hot spots demonstrate the necessity of using a broad conception of human security. They clearly show that people remain insecure while not at war and that within their border they are suffering from a much wider range of possible threats than the traditional human security paradigm suggests.

Second, aggregating varying data sets spatially facilitates a degree of interdisciplinary analysis that is rarely achieved. By way of illustration, although many people know where floods are harming people and many people know where poverty is worst, few people know both. Also, difficulties of data aggregation and cross-discipline communication often hinder well-meaning broad analysis. By limiting subjective decisions on the relative severity of various threats to the early discipline-specific first stage (threats assessment), the analysis limits subjective data aggregation.

Third, hot spot analysis has practical utility for development and humanitarian relief efforts. The logistical benefits of knowing exactly what harms are affecting which region of a country
are clearly evident. In addition, having all the information in a GIS system allows for easy access to large data sets that generally do not get shared, let alone used widely within the development community.

Spatial Correlations. Finally, this methodology facilitates functional analysis through spatial correlation. First, the national probability of a high threat is calculated for each of the indicators. Then a series of spatial correlations is calculated by posing simple logic questions using the GIS: if high poverty and high disease threats, then human security is low. Using the base maps created in stage 2, we can now create new maps showing only those regions where specific combinations of high-level threats overlap, for example, all regions with a high level of poverty threat and a high level of health threat. By conducting a series of these binary questions, spatial correlations that would be very difficult, if not impossible, to see by manually comparing the very complex data sets can be revealed. We can also determine the probability of threat A being present in regions of threat B and vice versa (15).

Another feature of this methodology is that in order to put this information into regional and local context and to facilitate development operations, new data can be added to any of the maps created. This can include political boundaries, such as states or provinces; infrastructure, such as roads, airports, or cities; or topographical features, such as terrain type, elevation, or land use.

RESULTS

Figure 3 is an example of part of the methodology described here as it was implemented through a trial in Cambodia (16). It outlines the threat assessment, data collection, and spatial analysis stages for two of the six human security subsystems—economic security and health security (17). The process is divided into seven stages, briefly outlined as follows:

I. Human security is first conceptually divided into 6 subsystems following the United Nations Development Program’s (UNDP) categorization (18).

II. The relevant Cambodian threats for each of the threat subsystems were determined. Sixty interviews were conducted in Phnom Penh with experts spanning the six human security categories. They were asked what, if any, concern within their area of expertise would qualify as a threat to human security. For example, for economic security, poverty was the threat. For health security, HIV/AIDS, malaria, dengue fever, and tuberculosis were threats. In order to simplify the demonstration of the methodology, from this point on we will follow poverty, dengue fever, and tuberculosis from data collection to final correlation mapping. Again, in the full Cambodia study, 13 threats were identified and measured (19).

III. Indicators that best represented each of these threats were then determined by consulting disciplinary experts, and the spatial data necessary to measure them were collected.

IV. For poverty, the indicator chosen by the Cambodian experts was the percentage of population below the poverty line, calculated as the monetary equivalent of calorie intake collected at the commune level. For tuberculosis, the indicator was number of cases per 100 000 collected at the commune level. For dengue fever, the indicator was the number of cases per 100 000 collected at the provincial level. These data were then joined to the spatial databases of the boundary GIS files, enabling them to be mapped.

V. The data sets were classified by their natural breaks in order to define high-, medium-, and low-threat areas. High-threat areas were isolated and mapped on their own. This is important, as human security involves a threshold of severity. Human security is threatened when the worst of all the possible threats are at their highest levels in a particular location.

VI. All three high-threat maps can now be overlaid to find hot spots of aggregated insecurity. In Figure 3, the scale of this hot spot map is zero to three high threats in any one commune.

VII. Finally, spatial functional analysis can be conducted between pairs of human security threats. Taking the three examples from Figure 3, the national probability of being exposed to a high poverty, tuberculosis, and dengue fever threat was calculated. For example, out of a possible 1626 communes, 451 have a high poverty threat (more than 65% of the population below the poverty line), meaning that, all else being equal, there is a 27% probability of a commune having a high poverty threat.

Next, the GIS was queried for all communes with a high threat from poverty and tuberculosis or poverty and dengue fever. Table 3 shows the probability of being at a high poverty risk in areas of high dengue and TB and also, inversely, the probability of being at high dengue and tuberculosis risk in areas of high poverty. When these results are compared with the national probability of a high threat, the presence of possible correlations can be inferred.

In both the district- and the commune-level spatial analysis, there is a significantly higher probability of being at high poverty threat if also at high dengue fever or tuberculosis threat (analysis A). It would appear, however, that this correlation does not hold in the reverse direction, as analyses B and C do not show a significantly higher chance of being at high dengue fever or tuberculosis threat if at high poverty threat.

Table 3. Results of Spatial Analysis (20).

<table>
<thead>
<tr>
<th></th>
<th>District-level analysis</th>
<th>Commune-level analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. Poverty</td>
<td></td>
</tr>
<tr>
<td>National probability of being at high poverty risk</td>
<td>25%</td>
<td>27%</td>
</tr>
<tr>
<td>Probability if at high dengue risk</td>
<td>32%</td>
<td>39%</td>
</tr>
<tr>
<td>Probability if at high tuberculosis risk</td>
<td>46%</td>
<td>44%</td>
</tr>
<tr>
<td>B. Dengue fever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National probability of being at high dengue risk</td>
<td>27%</td>
<td>21%</td>
</tr>
<tr>
<td>Probability if at high poverty risk</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>C. Tuberculosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National probability of being at high tuberculosis risk</td>
<td>33%</td>
<td>33%</td>
</tr>
<tr>
<td>Probability if at high poverty risk</td>
<td>35%</td>
<td>35%</td>
</tr>
</tbody>
</table>

|                  |                        |                        |
| National probability of being at high tuberculosis risk | 33% | 33% |
| Probability if at high poverty risk | 35% | 35% |
DISCUSSION

The threat determination and data collection stages have shown that data are available to document a wider range of indicators at a finer resolution than has been suggested in some of the academic literature (21–23). Also, given a degree of institutional collaboration, meaningful collection and organization of broad ranging indicators are possible. Support for a broader definition of human security and the possibility of its rigorous analysis is thereby provided.

For development practitioners in Cambodia, this methodology has pointed clearly to regions that are subjected to the aggregated impact of multiple human insecurities. In the example given here, there are regions that suffer from poverty, tuberculosis, and dengue fever but also regions that suffer from two or all three of these threats simultaneously. Regions with three human insecurities are clearly less secure than those with two, one, or no high-level human security threats. Policymakers and decision makers should find this added spatial resolution of assistance.

The functional analysis has pointed to the possibility of a meaningful causal study. Although the results for Cambodia have indicated several relations, this will need to be tested with a meaningful causal study. However, as the hot spot analysis includes only the worst of the threats at their highest level, we feel that there is enough independence in each indicator to warrant separate categorization. However, in subsequent work, we have statistically analyzed the relations between the threats. As this work requires much more detailed data rather than generalities regarding threat “degree,” we keep the data sets in their cardinal format and build exploratory multivariate regression models. Results will be forthcoming in 2004.


An important question that could be addressed using this type of spatial analysis is, Under what conditions (i.e. poverty) is there likely to be violent outbursts? This could be done by using the methodology on historical data, an exercise that would add substantially to the credibility of the correlation.

This study was conducted from November 2002 to January 2003 based at the Cambodian Development Research Institute in Phnom Penh.

In the full study, data detailing 13 threats were collected and analyzed. For the details of this analysis and its conclusions, see T. Owen and P. Le Billion, Security mapping: measuring human security in Cambodia. Liu Institute for Global Issues Report (forthcoming).

CONCLUSION

In order to understand human security within complex systems, interdisciplinary collaboration and methods are imperative. Data from the natural and social sciences must be compiled and aggregated in a way that does not compromise the meaning of the measurement methods or the integrity of the science used. The outlined methodology uses individual insecurity as the referent object and space as the common denominator to aggregate and analyze a broad range of never previously aggregated impact of multiple human insecurities. In so doing, it is shown that looking at the location of people’s greatest vulnerability is a useful way of identifying research questions around human security threats that are impossible to resolve using single-sector analysis.

It is anticipated that, with further research, this methodology will help establish the utility of a broad concept of human security, assist actors and policymakers in regions of high vulnerability, and contribute to multisector analysis of complex systems.

References and Notes

6. For example, the Human Development Index and the Human Poverty Index.
9. The notion that problems be addressed at the relevant or most appropriate scale, commonly used in relation to central governmental administration operations that are subsidiary to essential local functions. This is particularly important in this methodology, as data for different threats must be represented using different scales and data types. This is the benefit of using spatial data and also the reason why we need to break data into classes before aggregating together.
10. This is ideally a standardized GIS code linked to a particular boundary. This is often not available, however, and the data will often need to be recoded (a feasible but timely process).
11. The databases are connected using the “join” function in ArcGIS.
12. There are many other ways that data can be classified. For a detailed description, see T. Slocum, Thematic Cartography and Visualization (Prentice Hall, Upper Saddle River, NJ, 1999). We chose natural breaks because we are looking only for the range in the data where a threat is most present. This was most meaningful to us. It is also conceptually elegant. As our primary collaborators are development workers and policymakers, there is no need to overcomplicate what is a simple stage of our methodology. In further work, where we study the statistical relations between threat data, we do not use natural breaks.
13. It is of course possible that an indicator for one system will also be relevant to another. This will result in a degree of spatial statistical independence between variables. However, as the hot spot analysis includes only the worst of the threats at their highest level, we feel that there is enough independence in each indicator to warrant separate categorization. However, in subsequent work, we have statistically analyzed the relations between the threats. As this work requires much more detailed data rather than generalities regarding threat “degree,” we keep the data sets in their cardinal format and build exploratory multivariate regression models. Results will be forthcoming in 2004.
15. An important question that could be addressed using this type of spatial analysis is, Under what conditions (i.e. poverty) is there likely to be violent outbursts? This could be done by using the methodology on historical data, an exercise that would add substantially to the credibility of the correlation.
16. This study was conducted from November 2002 to January 2003 based at the Cambodian Development Research Institute in Phnom Penh.
17. In the full study, data detailing 13 threats were collected and analyzed. For the details of this analysis and its conclusions, see T. Owen and P. Le Billion, Security mapping: measuring human security in Cambodia. Liu Institute for Global Issues Report (forthcoming).
20. Although the data collected was of varying spatial references (village, commune, regional district, and province), as it is all in one GIS database, the correlation analysis can be done at any one of the resolutions used. In order to capture inaccuracies due to either aggregation or disaggregation, all analysis was done at both the commune and the district level.
21. For extensive discussion on the problems of data collection, see P. Collier and A. Hoefler. Data issues in the study of conflict (paper for the Uppsala Conference on Conflict Data, June 2001). (http://www.per.uu.se/ident.html)