Water Associated Disease Index

The Water Associated Disease Index (WADI) project is a global initiative to measure, map, and mitigate the vulnerability of individuals and communities to infectious water-related diseases in the face of global environmental change.

RATIONALE

There is a clear need for measures to combat the high burden of illness associated with water-associated diseases. A large burden of this illness is borne by groups with high vulnerability and little ability to invest in resilience building activities. In response, a global vulnerability mapping initiative is being led by the United Nations University Institute for Water, Environment, and Health (UNU-INWEH). The **goal** is to develop an interactive tool with global coverage and accessibility that provides locally relevant visual representation of current and projected environmental disease indicators and disease incidence. This is critical for the purpose of targeted research and intervention, policy and capacity development, and informed resource allocation. This will also facilitate evaluations of how communities are able to withstand, adapt to or recover from specific water-associated disease.

The project applies a systematic ecosystem approach as an alternative to monodisciplinary models. This type of framework considers the inextricable links between people, the environment and health (Fig. 1).

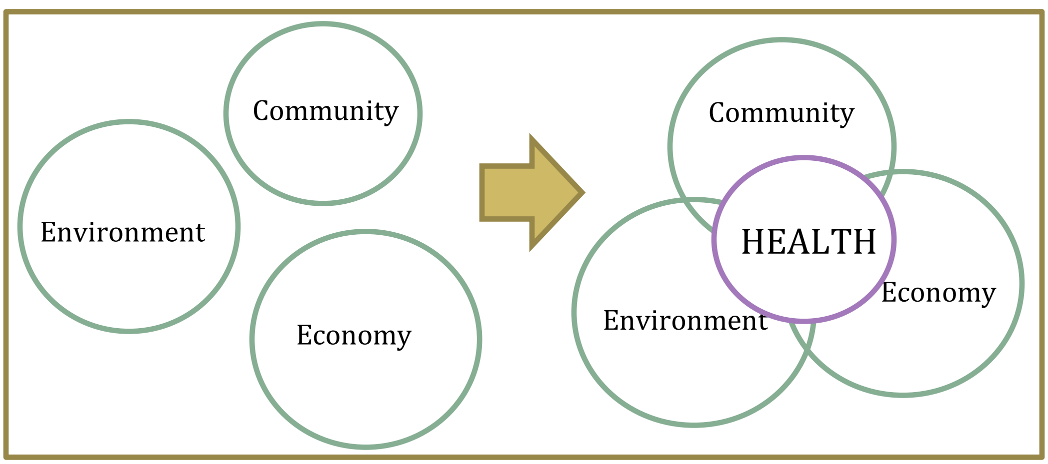


Figure 1: The ecosystem approach (after Lebel, 2003[1])

1. Lebel J. In focus: health - an ecosystem approach. Ottawa: International Development Research Centre; 2003.

PROJECT OBJECTIVES:

- To identify cross-disciplinary factors and associations (physical, social, economic, cultural, political) impacting exposure, susceptibility and adaptive capacity to select water-related infectious diseases
- To describe and map the current global burden of illness associated with select water-related infectious diseases
- To map the location of populations currently identified as vulnerable to different water-related infectious diseases
- To identify areas that may become increasingly vulnerable to different water-related infectious diseases as a result of anticipated global environmental change
- To develop a capacity-building strategy through dissemination of the suite of tools to a range of end-users at the water-health nexus

Vunlerability	• The condition of a system to be adversely affected by a hazard such as a waterborne pathogen
Exposure	• Presence of disease and likelihood of transmission
Suceptibility	• Sensitivity to hazards (based on social, economic, environmental, political conditions)
Resilience	• The ability of a system to withstand, adapt, and recover from a hazard

METHODOLOGY

Indicators are used to simplify and distil complex real-world information into a format that is relevant and useful for decision-making. The WADI integrates disparate information types from the physical and social environment into an index to identify and visualize areas of vulnerability to individual water related diseases. The index is comprised of sub-indicators of exposure and susceptibility, which represent different dimensions of vulnerability. The level of exposure represents presence of a water-associated pathogen and likelihood of transmission within the environment. The indicator of susceptibility represents the extent to which the human population (individual and collective) is sensitive to a specific water-associated infection due to existing conditions such as physiological, social, cultural, economic factors. The components of these indicators are developed based on a review of the literature and selection of factors which have been demonstrated to mediate relationships between human health, the environment and a specific water-related disease. A statistical validation and sensitivity analysis procedure is applied to determine a weighting scheme for contributing indicators, and to demonstrate the reliability of the vulnerability assessment output.

DATA SOURCES

A conceptual framework is developed for each application of the WADI to simplify the complex relationships between environmental, social and biological factors. This is used for selection of trans-disciplinary datasets for each indicator. The WADI methodology can be employed in data-poor regions, by utilizing accessible global or regional datasets, such as climate and land use image surfaces. Low-cost or freely available data on social determinants can be obtained from statistics routinely collected by national agencies. Index development is data driven and requires exploring the most relevant, accurate, and up-to-date datasets for the highest quality information to populate the indicator components. The resolution and level of applicability of the overall vulnerability index is defined by the extent of data being employed.

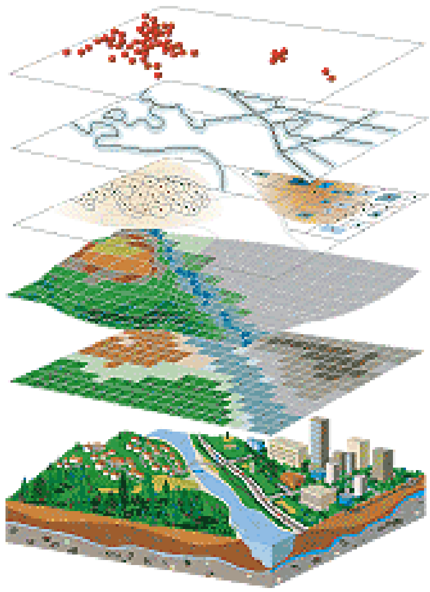


Figure 2: Different data types are integrated in a GIS (ESRI)

ANALYSIS AND OUTPUT

Datasets are imported into a GIS (geographical information system) and converted to a consistent raster format. Software including open source applications like GRASS GIS, as well as proprietary ArcGIS (ESRI) can be used for WADI construction. Raster processing in a GIS is used to integrate the WADI components into indicators of exposure and susceptibility based on a weighting scheme determined through sensitivity analysis. This is employed to determine the contribution of each indicator to overall vulnerability, using disease trend data as a proxy for vulnerability. This output is used to create an overall index of vulnerability (Fig. 3). Weighting schemes for index development are context-specific, and will change with each application of the WADI to a different disease. Following integration of the indicators into an overall index, the outputs are visualized in a GIS in map format, and can be disseminated for end-users. Visualization of the index is a key step, as this facilitates greater understanding of the differential regions of high or low vulnerability. Areas of low vulnerability are interesting because they indicate resilience to a water-related disease hazard, and can be used to build adaptive capacity in other vulnerable regions.

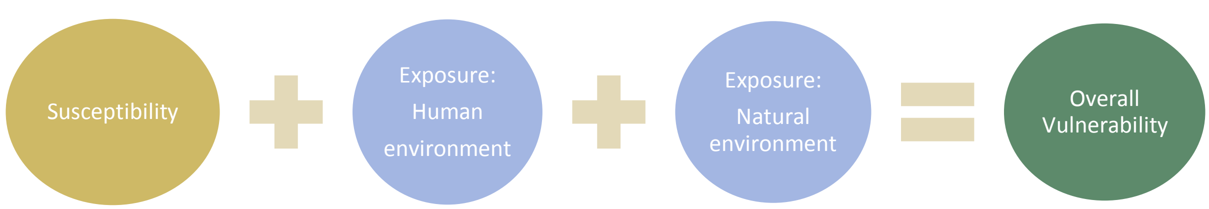


Figure 3: Raster processing is used to integrate indicators in a GIS

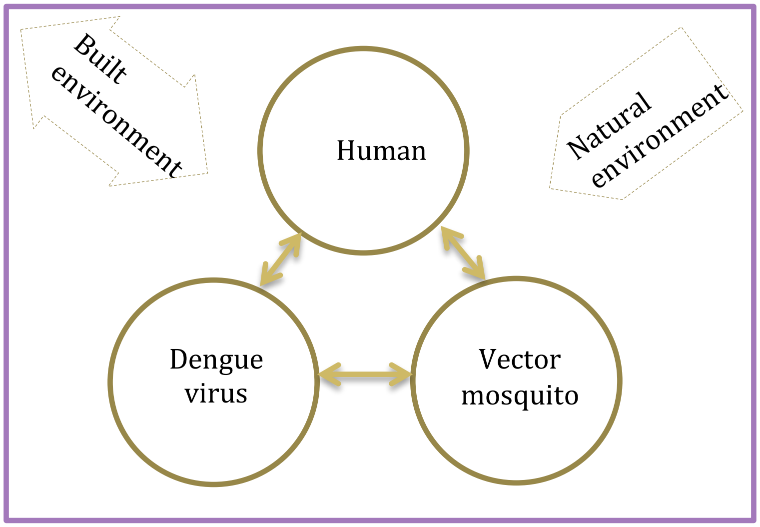


Figure 4: Conceptual diagram describing linkages between system components

Dengue is a water-associated disease that represents a serious health risk for up to 2.5 billion people worldwide. This mosquito-borne viral infection is endemic in more than 100 countries, with the majority of cases occurring in Southeast Asia, the Americas and western Pacific region. A vaccine has yet to be produced in order to combat this illness so the emphasis is on measures to control vector populations. In countries like Malaysia, these can be better targeted through the application of the WADI methodology to identify areas of vulnerability.

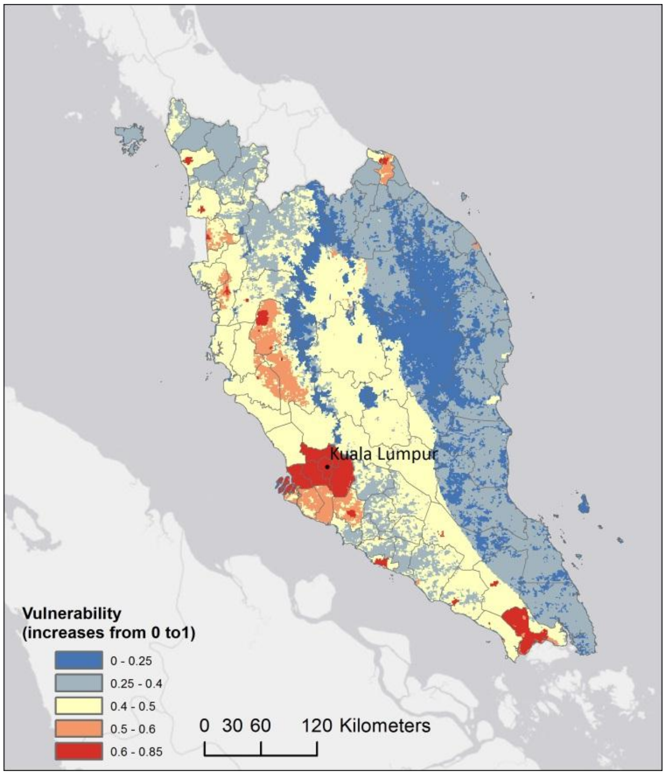
For this proof of concept study, a simplified conceptual diagram describing linkages between humans and the environment in the context of dengue fever is illustrated in Figure 4. This was used to select socioeconomic and environmental datasets for the region of Peninsular Malaysia, such as temperature, population density, and sanitation type. These were obtained and imported into a GIS to construct the index.

ANALYSIS

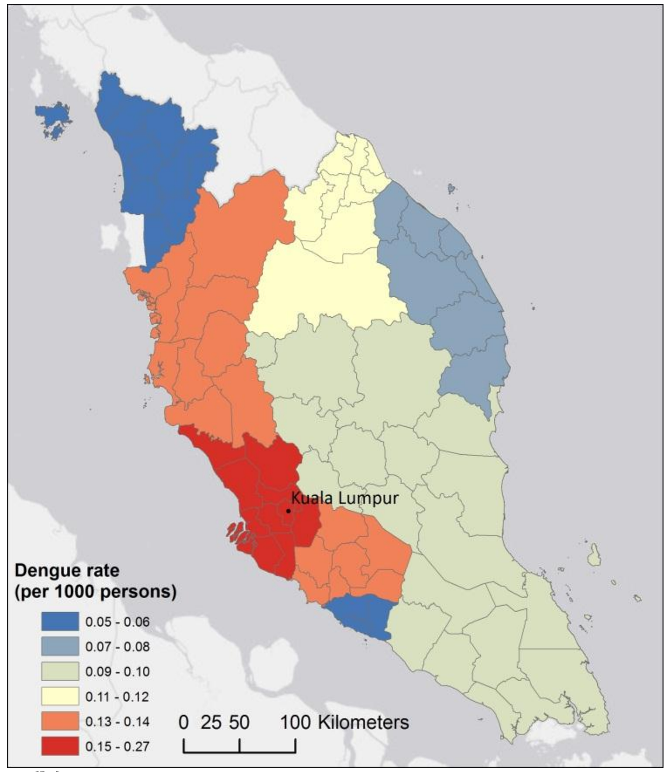
The scope of the WADI proof of concept study in Malaysia is at the national level, using state and district scale datasets dating from 2000 or later, and monthly global climatologies. In this study, indicators of exposure and susceptibility are weighted based on their contribution to overall vulnerability, with a higher weight for exposure based on a sensitivity analysis. The raster images are then processed to create the overall vulnerability index, and mapped to produce a visual output of the results. This approach could allow the methodology to be used to create analogous maps for global comparisons, as well as being useful at the country level for informing policy tools.

OUTPUT

Overall vulnerability visualization



(a)



(b)

Figure 5a: WADI output for December (left) with vulnerability increasing from 0 towards 1
Figure 5b: Dengue rate at state-level in February (2000-2010 average)

Key findings

In the context of WADI, the combination of high exposure and high susceptibility presents the strongest conditions for disease transmission, if the regional environmental conditions such as temperature range can support vector populations. In Figure 5a an example of a WADI vulnerability output is illustrated in map format for the month of December. Integrating climate patterns adds a temporal dimension to the vulnerability assessment, which enhances understanding of how the system changes over time. In this example, the effect of the monsoon season on the East Coast of Malaysia reduces exposure to the mosquito vector, as extremely heavy rains wash away vector breeding sites. Furthermore, urban centres show increased vulnerability due to factors in the built and social environment. A comparison to 10 year average dengue rates for February is shown in Figure 5b. A lag of two months is used due to the delayed effects of climate trends on vector populations. This application of the integrated WADI approach to Malaysia demonstrates that susceptibility and exposure should be considered together rather than separately to more effectively determine vulnerability in the region.

Statistical validation using 10 year average dengue rates at a state level is applied in this proof of concept to demonstrate the validity of the approach. A simple test of correlation was used to show how dengue trends are related to the vulnerability index at a state-level in Malaysia, and during all months of the year. The resulting Pearson's Correlation coefficient value of 0.83 indicates a strong relationship, especially in the context of a complex water-associated disease system. This straightforward validation approach can be used by decision-makers to evaluate the effectiveness of the WADI in a particular region or disease context.

Given the validation illustrated above, the WADI can next be applied to global environmental change projections to increase understanding of vulnerability to water-associated disease under changing social and biophysical conditions.

Contact information:

Dr. Corinne Schuster-Wallace
Corinne.SchusterWallace@unu.edu
Project Officer, Water-Health Nexus
United Nations University – Institute for Water, Environment and Health
175 Longwood Road South, Suite 204, Hamilton Ontario L8P 0A1 CANADA
Website: www.inweh.unu.edu