PAHO's GIS in Public Health Project: The Honduras Case

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Office of Deputy Director (DD)
Pan American Health Organization (PAHO)

International Geographic Information Systems (IGIS)
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Health Situation Analysis (ASIS), Assessment of coverage and access to Health Services in Honduras.

Objective: Assessment of Health Situation using Health Indicators.

Methods:

Thematic mapping and exploratory data analysis was applied to Morbidity Indicators. A method of construction of a compound index was applied using a selected set of indicators. A correlation analysis allows to identify the indicators for the model.

Results:

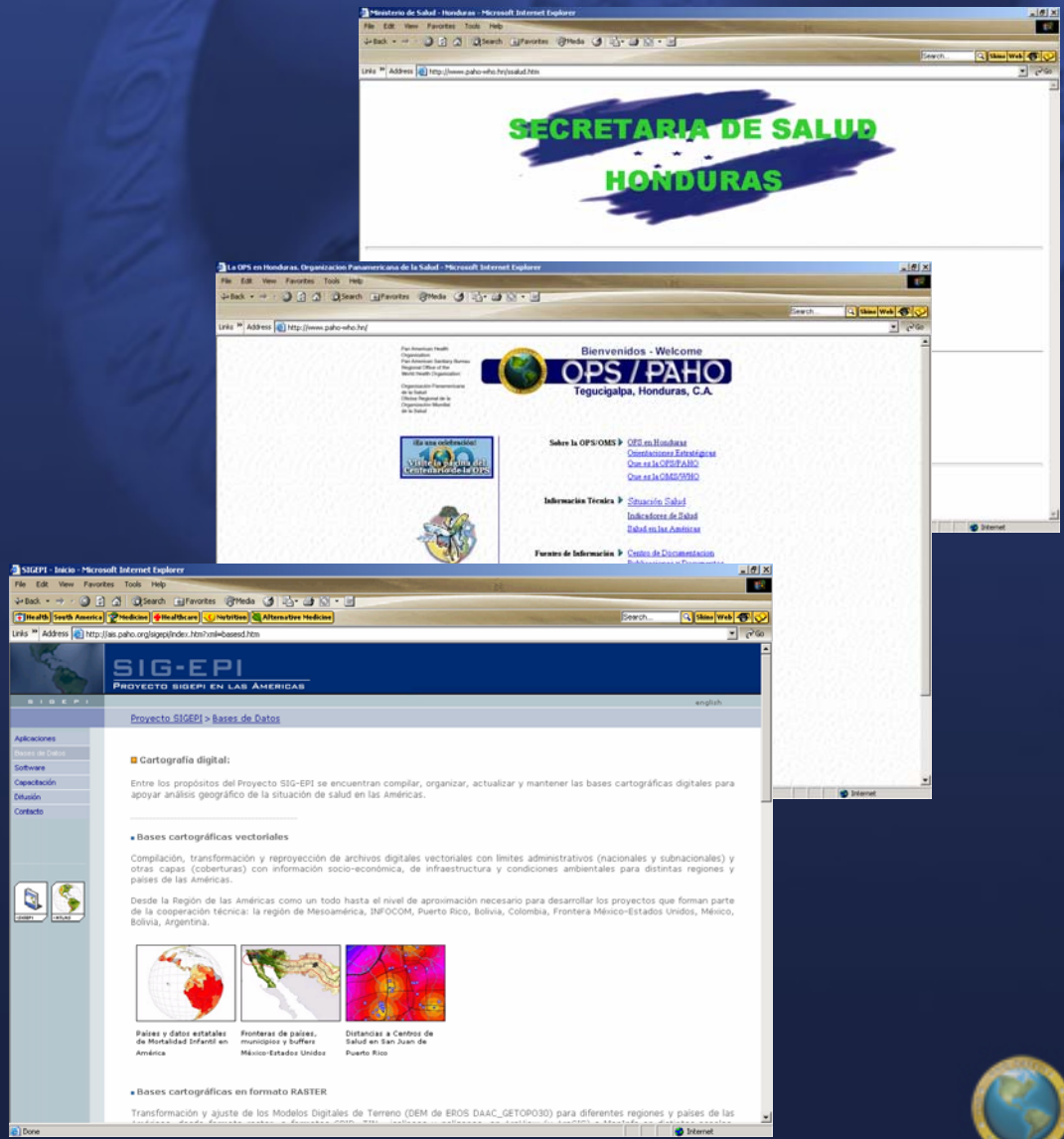
Was identified the critical municipalities by indicators and the morbidity index.
The results of this exploratory and health situation analysis is used to assess the regional coverage and access to first level health services in Honduras and correlating with geographic accessibility.

Background

- **Problem definition**
  - Take decisions about which Primary Health Care centers open or close
    - Health needs
    - Geographic availability and coverage
    - Accessibility and road infrastructure
  - Low Budget
    - Need to focus interventions
- **Decision to ask technical cooperation to PAHO**
  - Design a first proposal to develop the proof of concept for a GIS model
  - Mission to Honduras to:
    - discuss the proposal
    - identify different sources of digital geographic information
    - identify other collaborating groups

General Objective

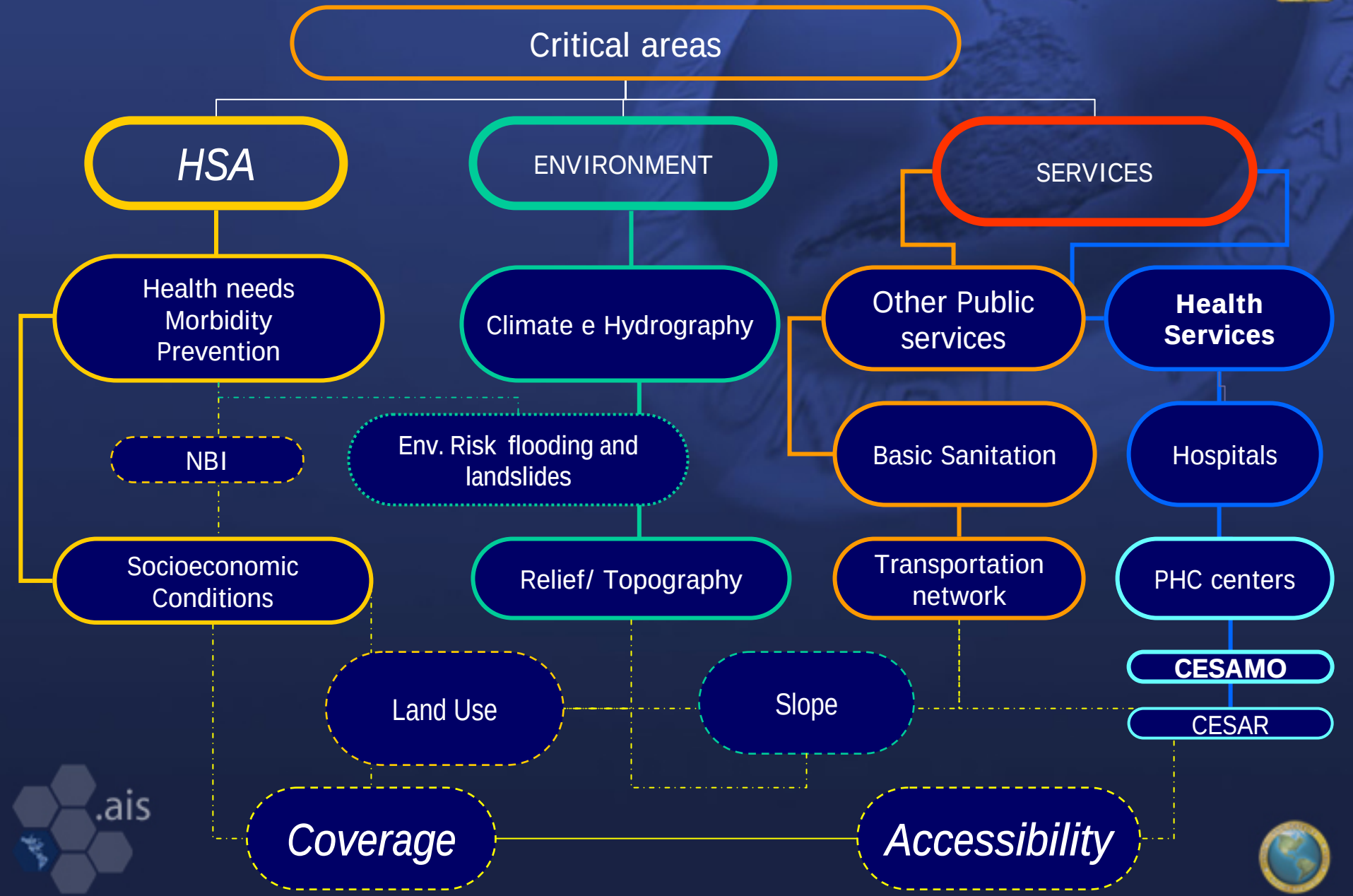
- To develop a GIS for the Health Situation Analysis (HSA) assessment, identify problems in the availability and regional coverage Primary Health Care and low accessibility areas in Honduras



Development of the GIS application

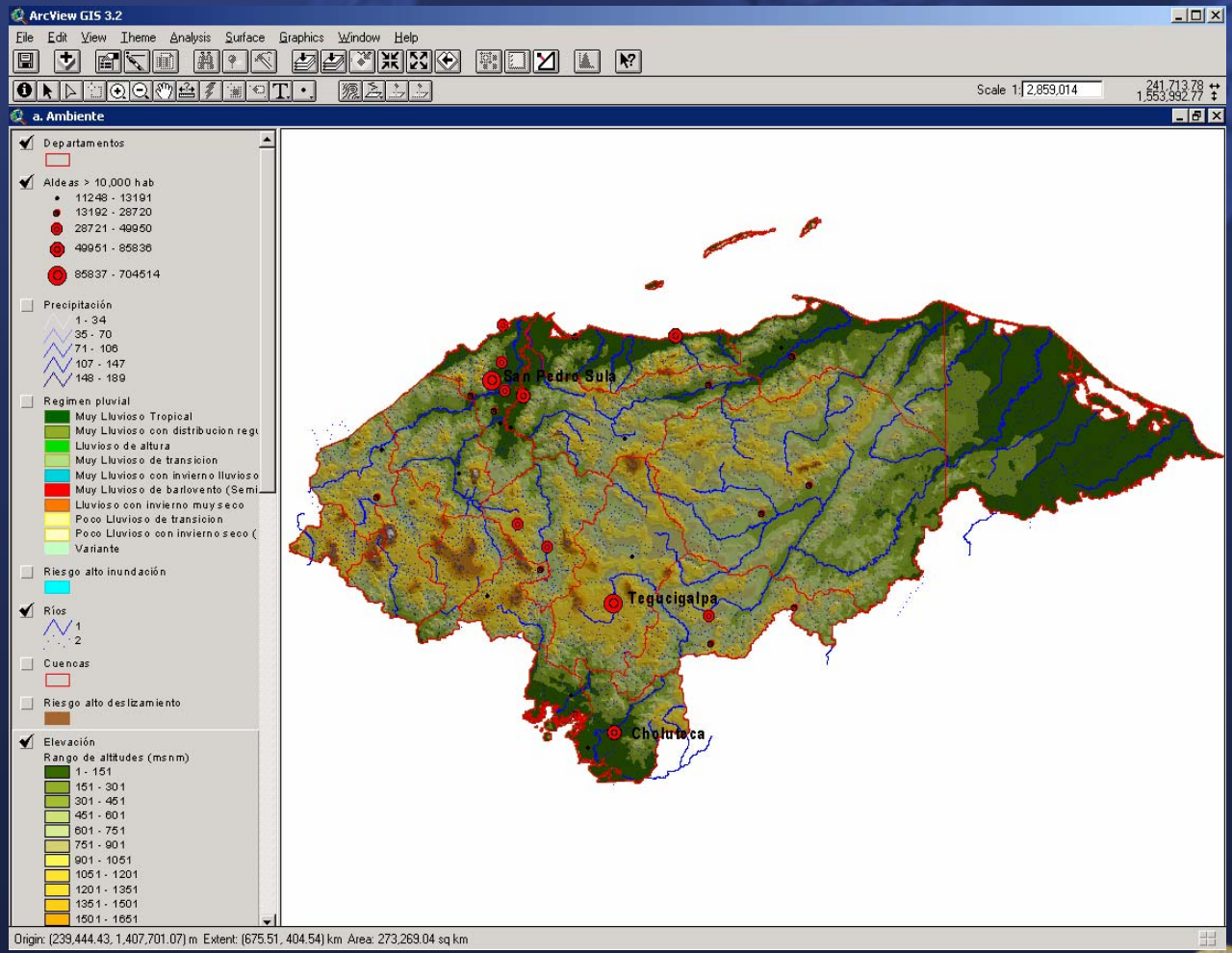
- Conceptual model development
- Identification of the operational design of the accessibility measures and factors that modify it
- Data preparation, geo-processing and projection (Geographic-UTM16)
- Application of public health methods to select GIS and spatial analysis techniques
- Identification of low accessibility and high health needs critical areas
- Definition of “What-if scenarios” (in process)

Conceptual model and operational design



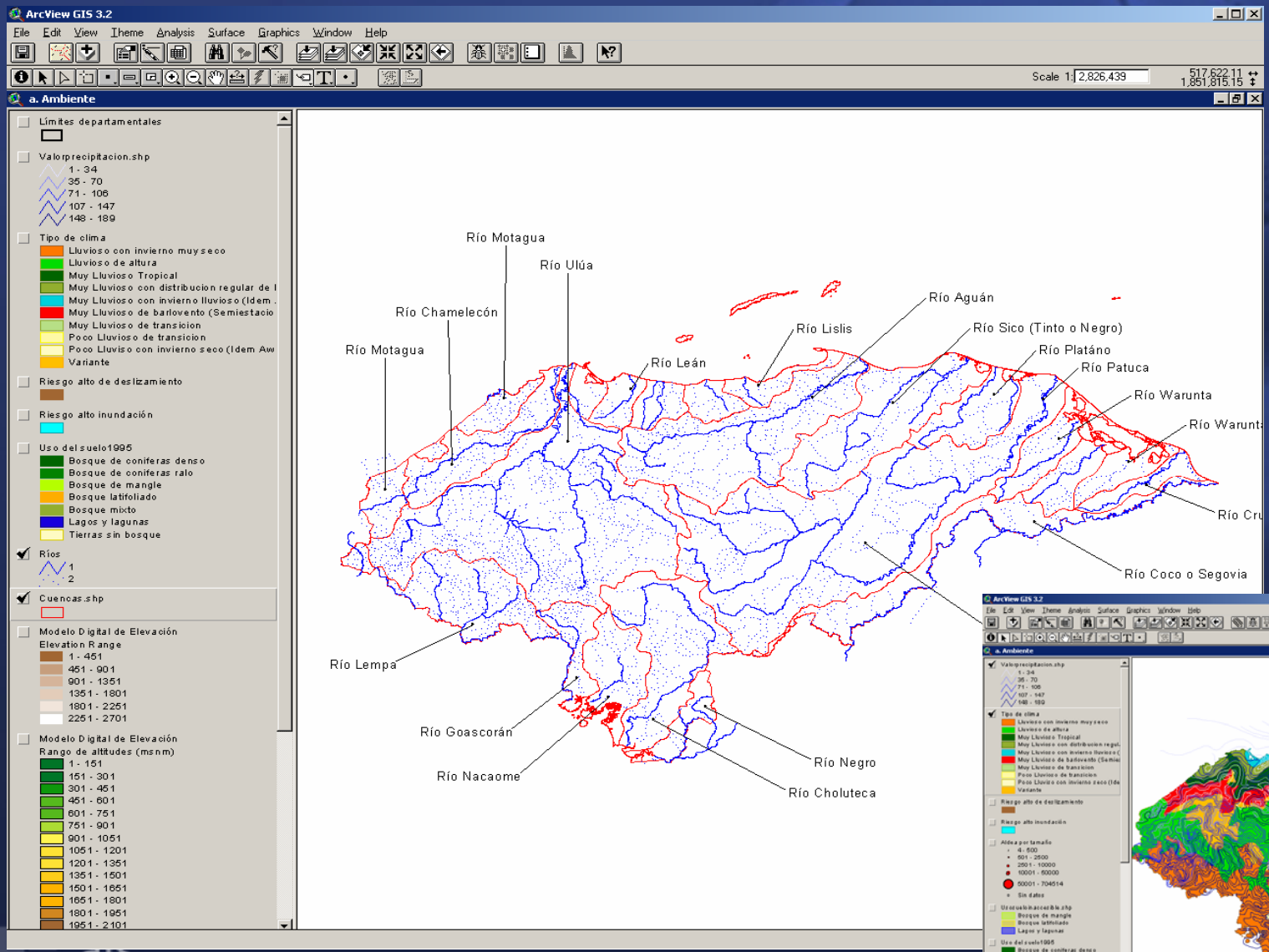
Data preparation: compilation, geo-processing and projection

- Standardize projections and Datum
- Geo-processing of administrative limits and localities
- Geo-coding health statistical data
- Management and overlapping of maps about natural features
- Transformation of DEM (Digital Elevation Model) to ArcView formats (GRID, TIN)



USGS/EROS DATA Center. http://edcdaac.usgs.gov/gtopo30/gtopo30.html

Environmental digital data



Climate

Hydrography

Public Health Methods for GIS and Spatial Analysis

Critical Areas

HSA

Pop. Distribution
Geo-referencing, Density, interpolation
Morbidity Std Index, 2001
Z score = IEM

NBI
Municipal Geo-coding

ENVIRONMENT

Environmental risks
Landslides and flooding areas
Query and spatial selections
Specific Tool

Relief / Topography
Slope, aspect,
Spatial Analyst (GRID, TIN),

Land Use
Spatial quieries

SERVICES

Roads
Classification
Distances
Slopes
Spatial Tools
(Assign slope values)

Health Services
Geo-codification

Hospitals
GRID Distances
Spider Diagrams
Catchment's area

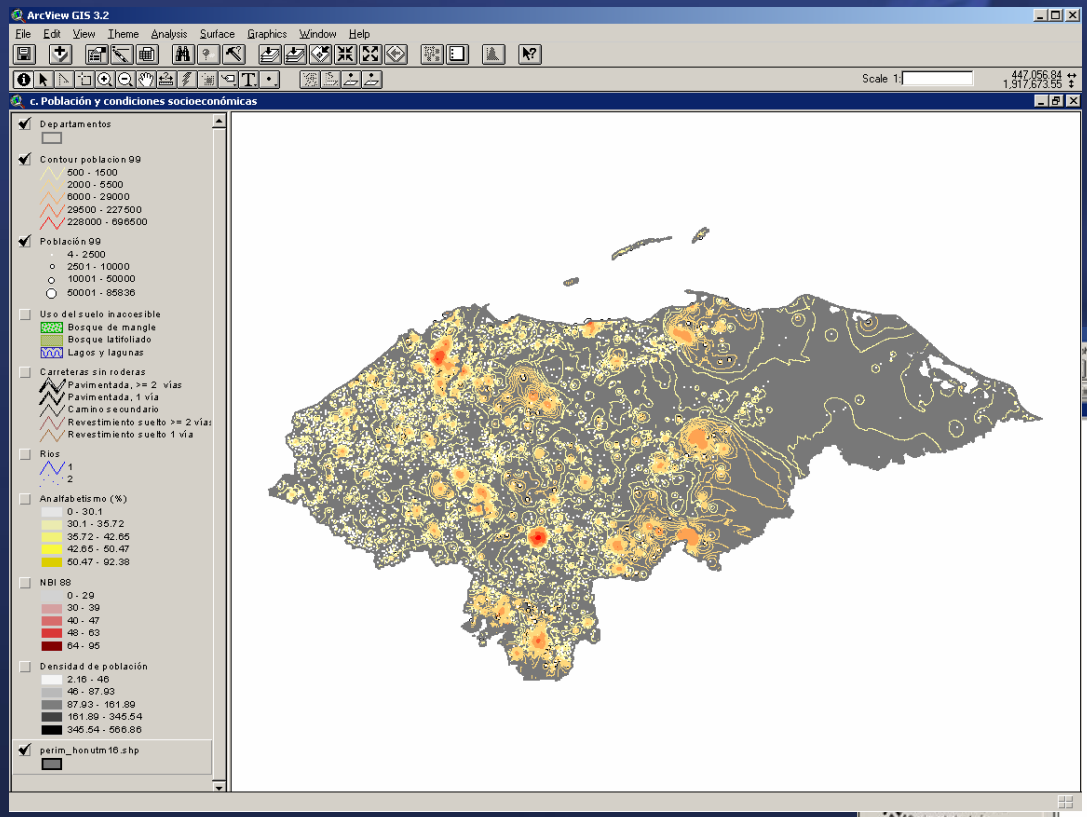
Cesamo
Geo-coding
Spider Diagrams
Distances
Catchment's area

Cesar

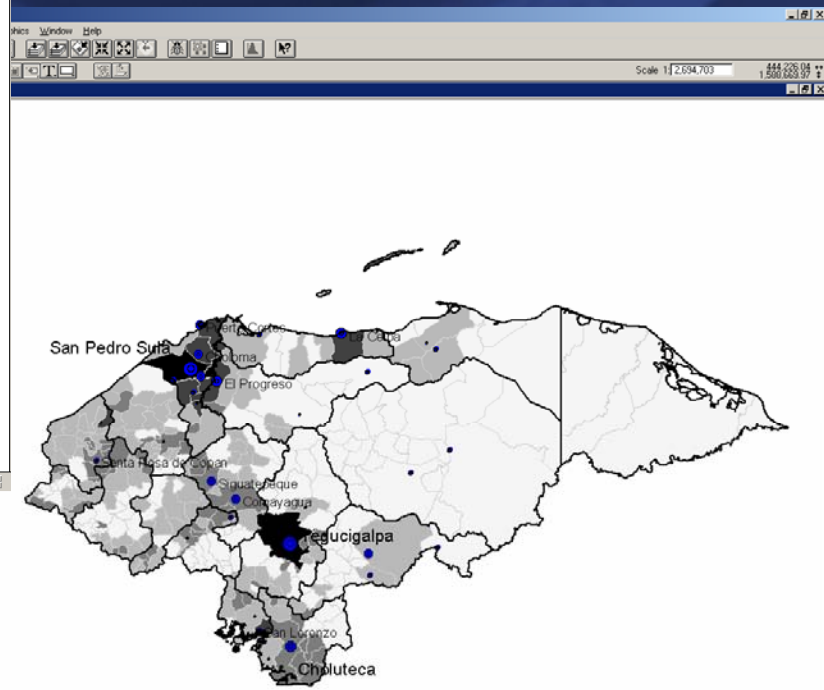
Thiessen Polygons, Buffers
Coverage

Zscore = ICA
Interpolation
Accessibility Index

Population Distribution



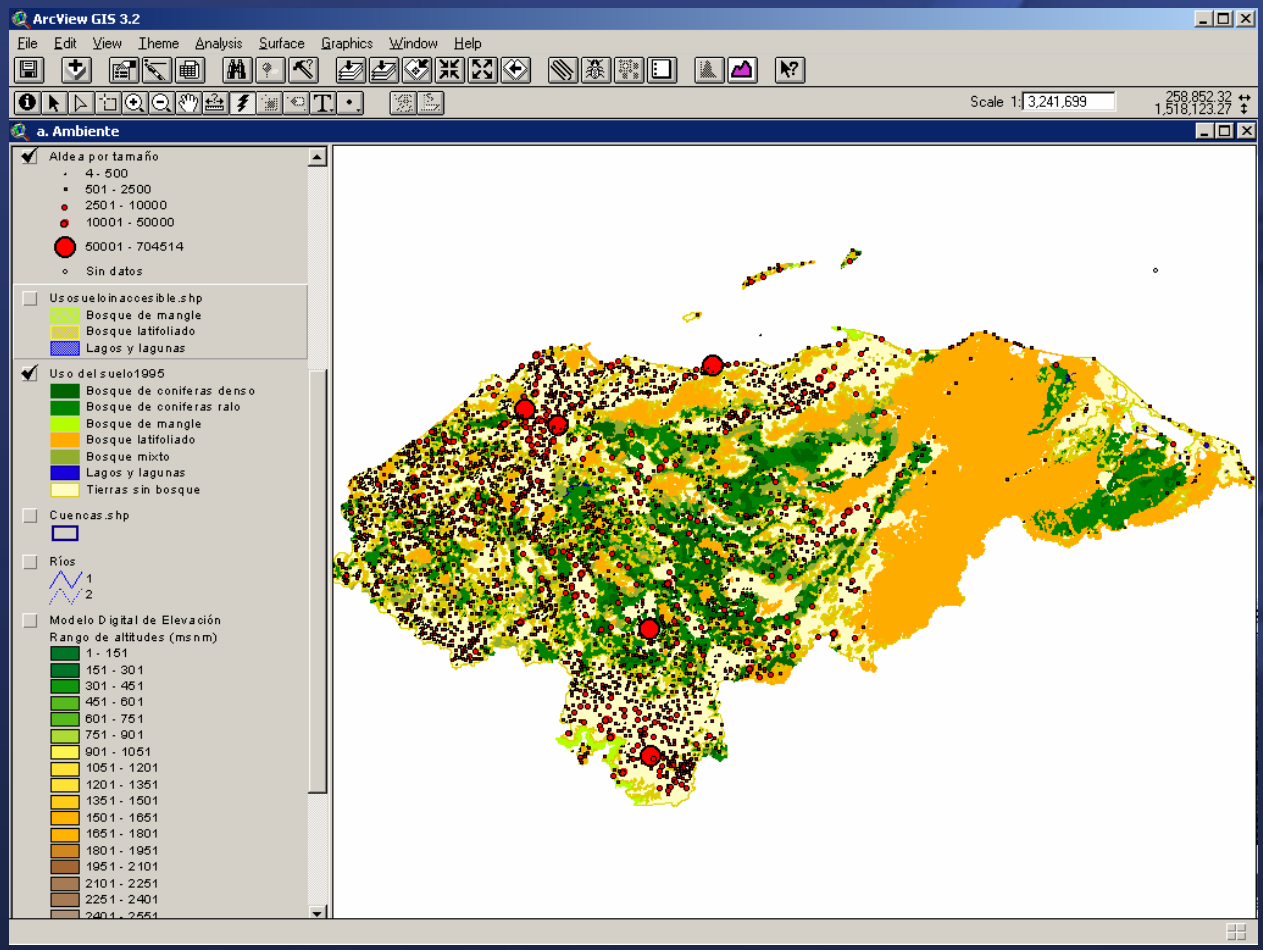
Municipal density



Community

Population size interpolation

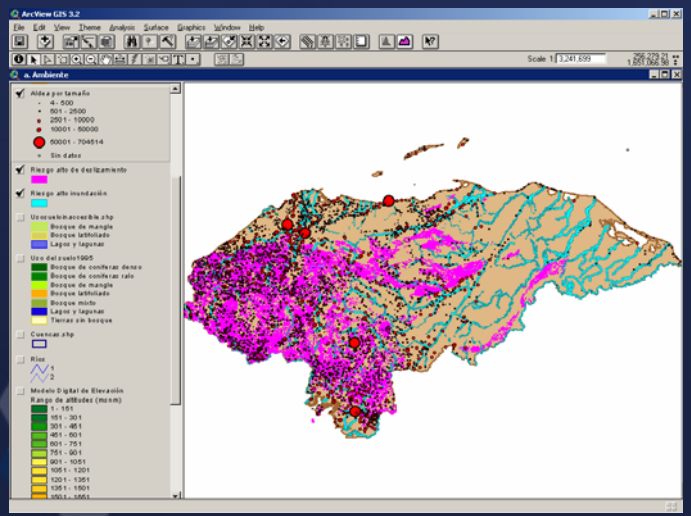
Land Use and Communities Distribution Overlapping

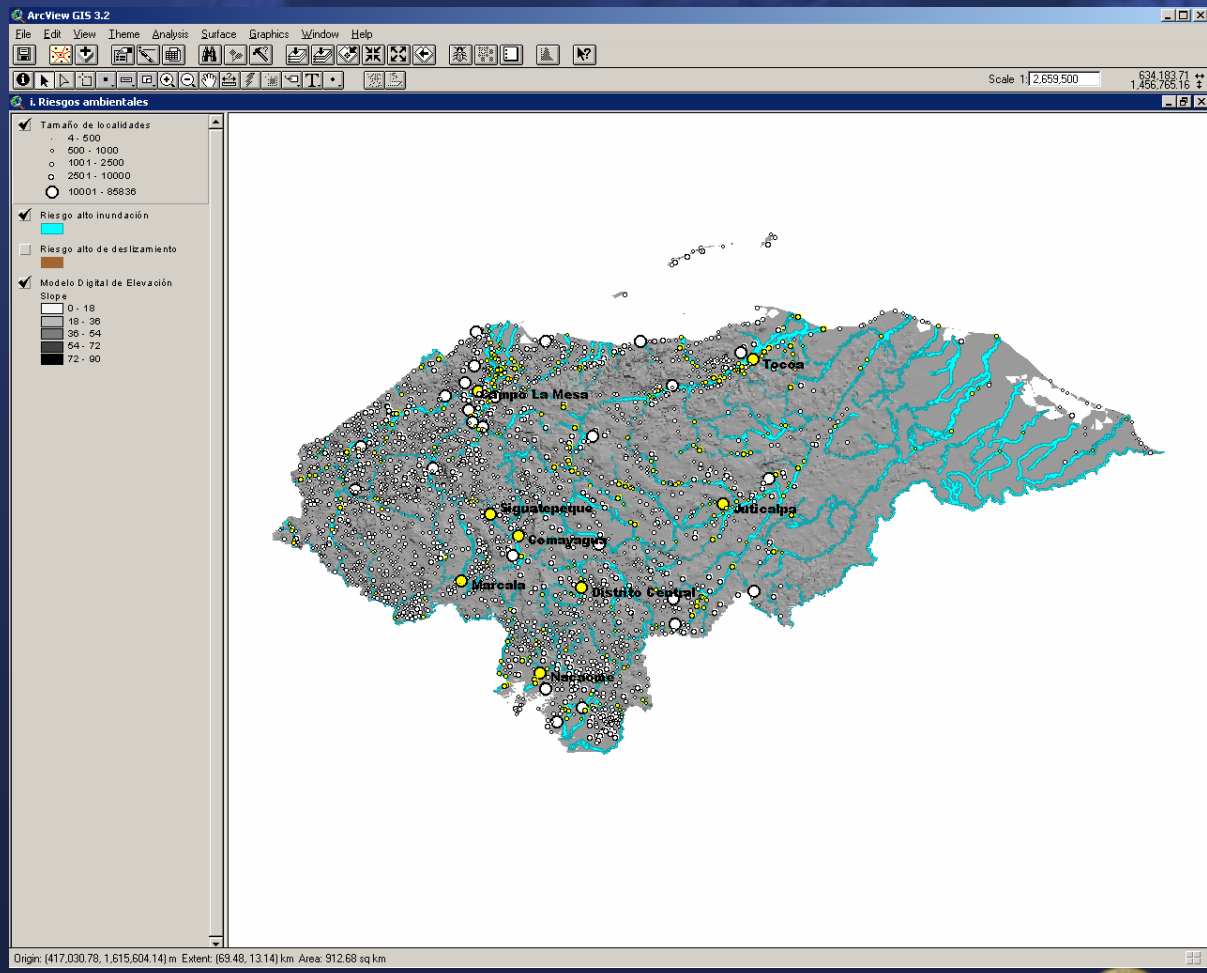


Evergreen broadleaf forest, mangrove swamps and inner water masses delineate places with difficult access.

Overlapping Environmental Risks and Population

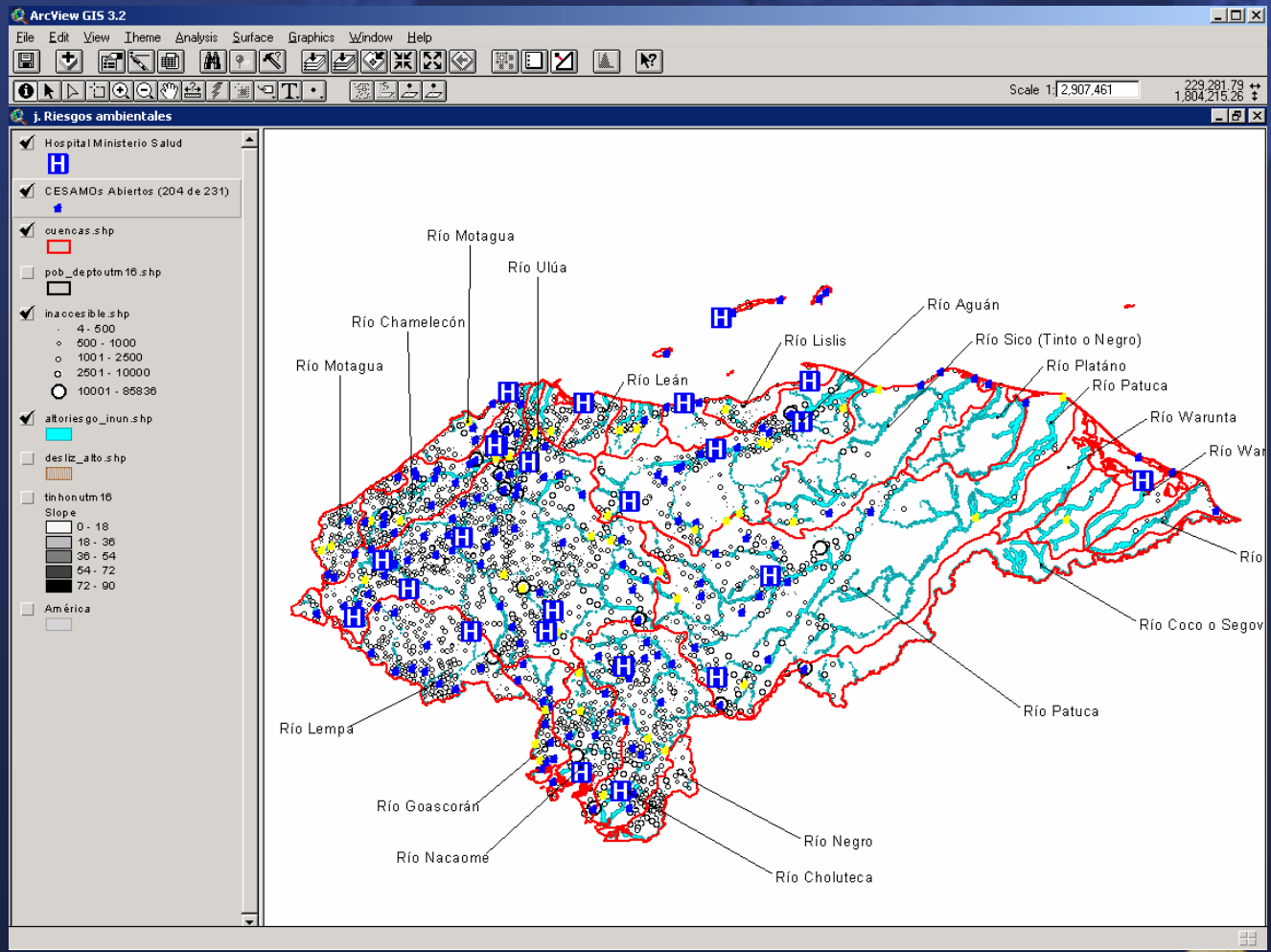
- Flooding High Risk (around 1 km from rivers)
  - 458 communitites
  - and 824 889 people
- High Risk of Landslides
  - 90 Communitites
  - and 53 501 people.





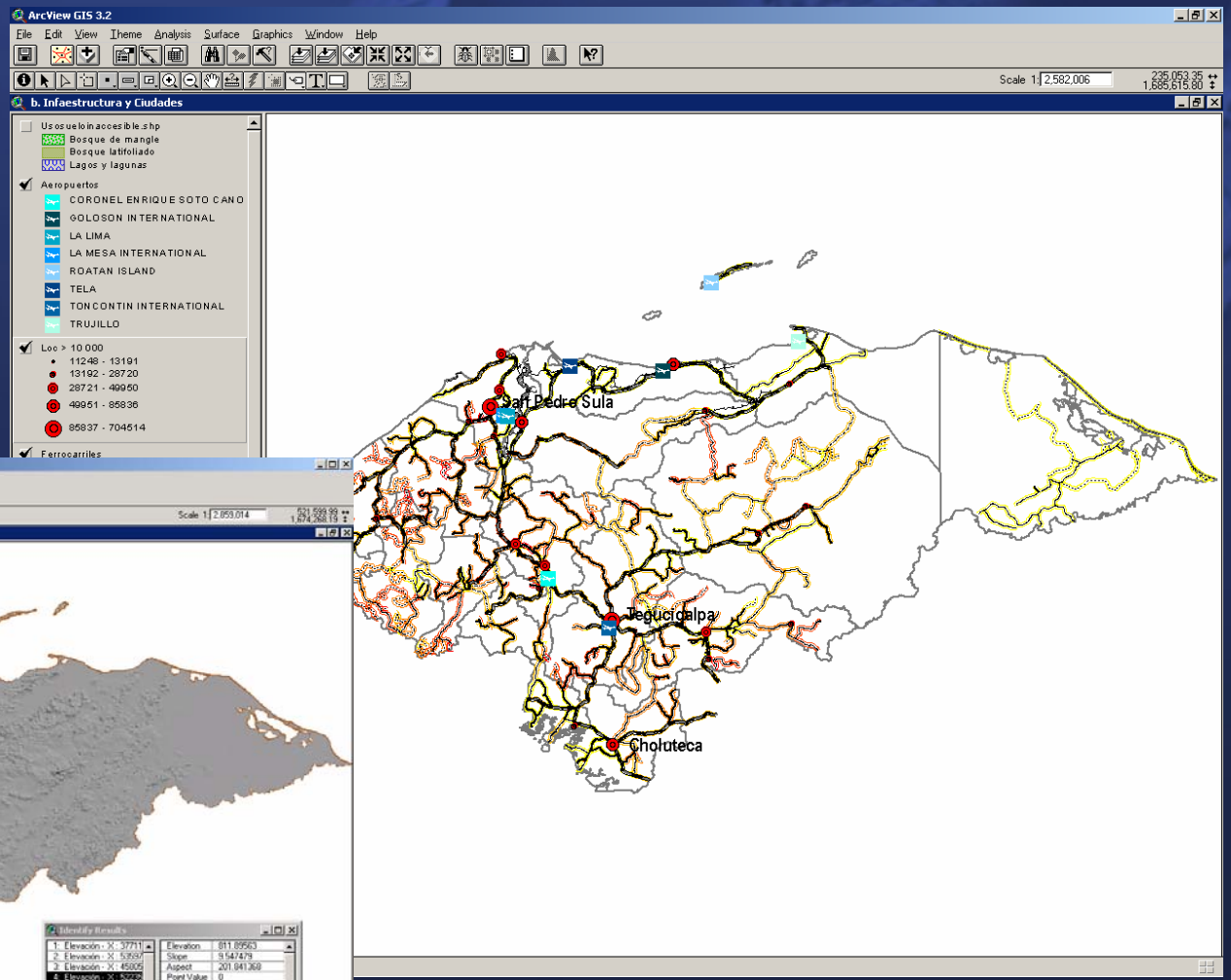
Differential emergency response of PHC

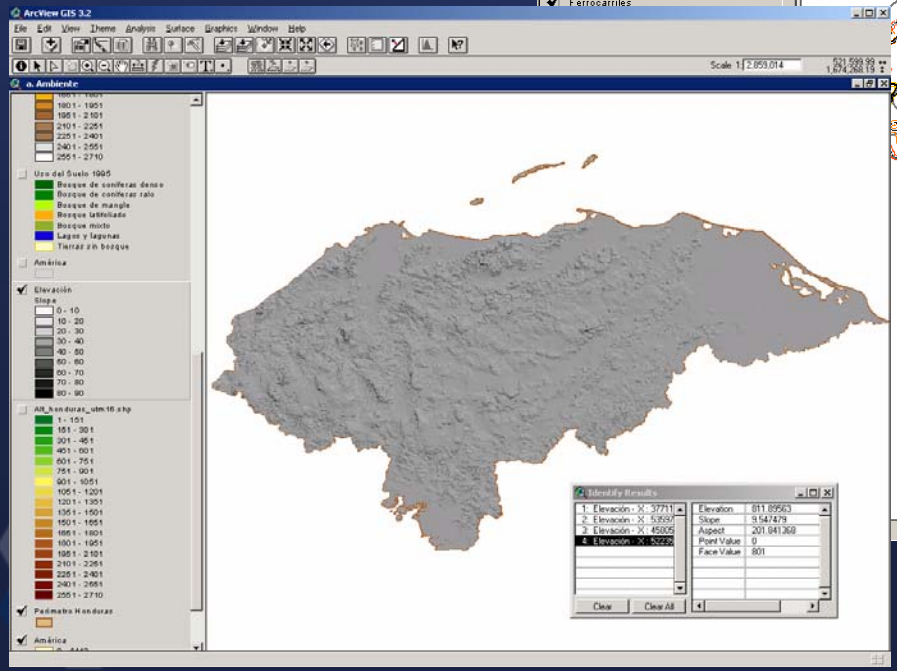
- 45 out of the 204 geo-referred PHC (22%) are located inside high risk flooding areas.



Slope measurement and assign values to points and lines (from TIN)

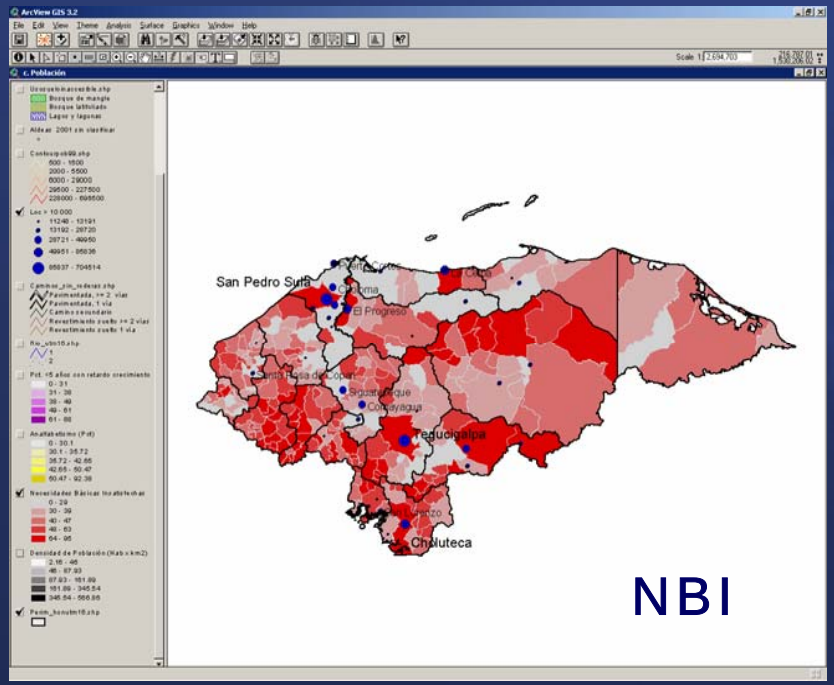
- **Roads and localities:**
  - Slope
  - Highest point
  - Lowest point
  - Aspect

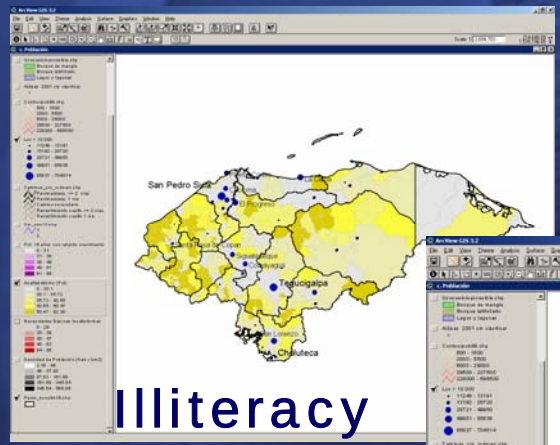


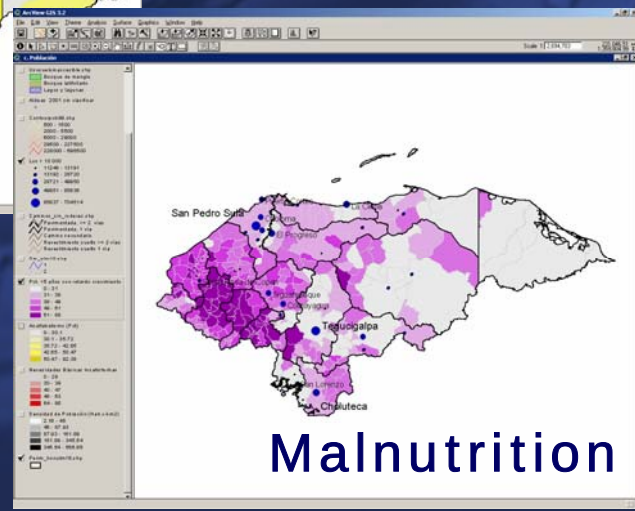


Slope Value Assignation

Unmet Basic Needs (NBI), Illiteracy and Municipal Malnutrition







NBI municipal Index: [2].

- **Low quality material dwellings (waste materials walls)**
- **Dwellings without basic sanitation services (drinking water and sewerage)**
- **Crowding (more than 3 people per room).**
- **Households with school age children (7 - 12 y) not in the school**
- **Household with high economic burden (more than 3 people depending on one worker and less than 3 years of study among the parents)**

Source : [2] SECRETARIA DE SALUD DE HONDURAS-Representación OPS-Honduras.
ANALISIS DE SITUACIÓN DE SALUD SEGÚN CONDICIONES DE VIDA (ASIS-SCV) HONDURAS, 2000.
http://www.secsalud.hn/boletines/epidemiologico/asis.htm
INCAP. Censos Nacionales de Talla en Escolares de Primer Grado de Educación Básica,

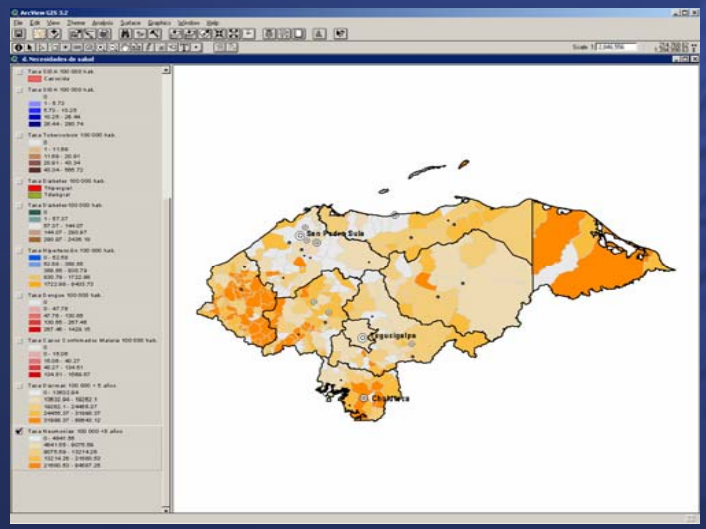
Morbidity Indicators
National Magnitud, 1999 [3].

Main Causes	Number	Rate x 100,000
Acute Infectious Diseases	455914	7538.00
Diarrheas	247142	4086.00
Malaria	51911	858.00
Dengue	18068	298.00
Classic Dengue	17999	297.50
Diabetes mellitus	12014	199.00
Tuberculosis	4392	73.00
AIDS	983	16.00

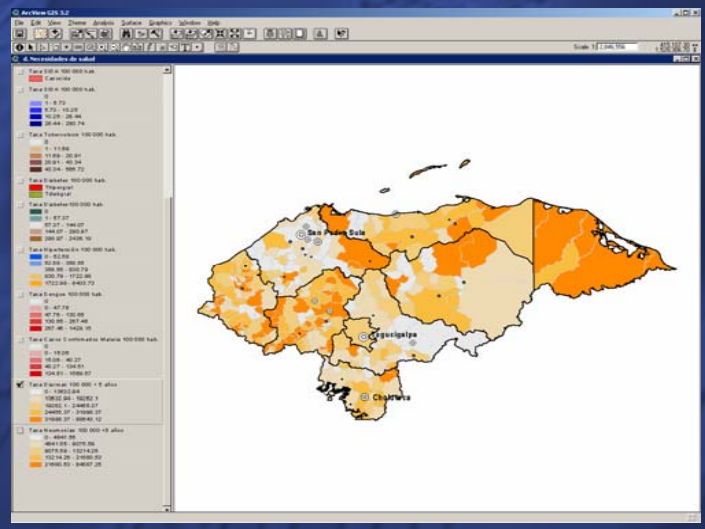
[3] http://www.secsalud.hn/boletines/epidemiologico/asis.htm#IV

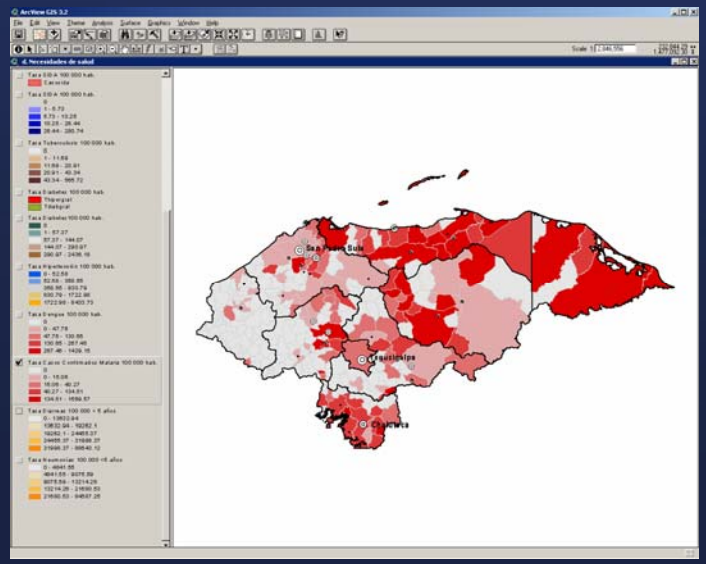
Municipal Infectious Diseases, 2001

Pneumonias

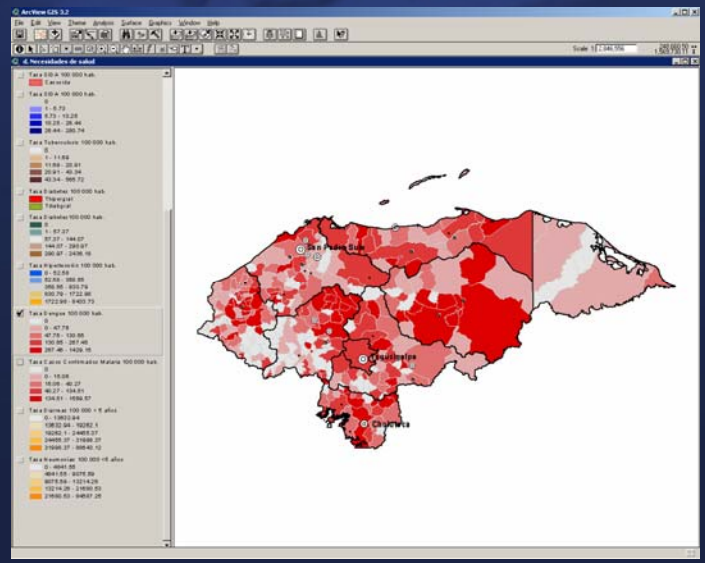


Diarrheas



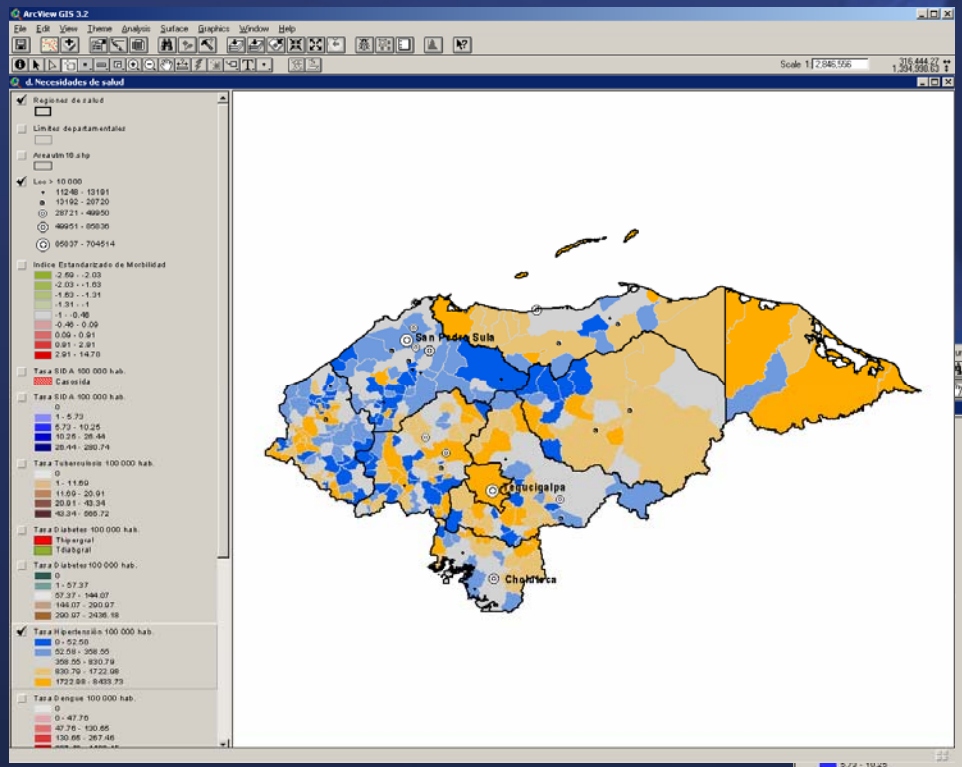


Malaria



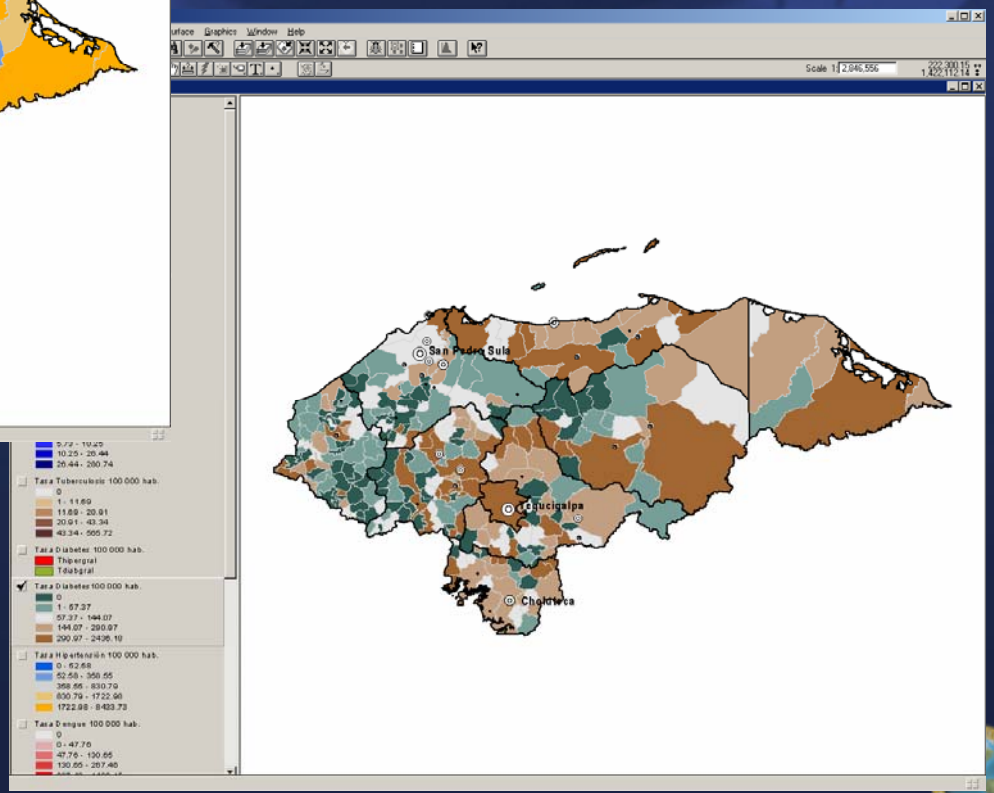
Dengue

Municipal distribution of chronic diseases, 2001



Hypertension

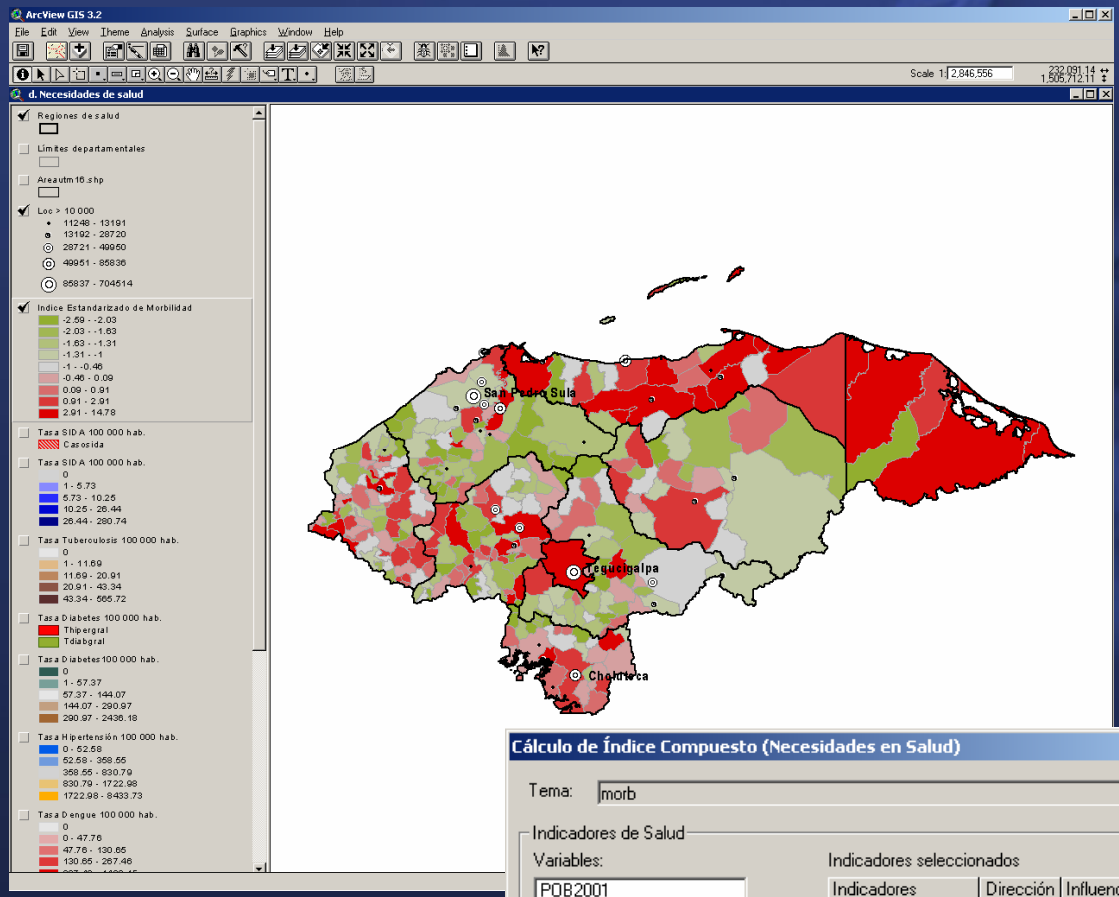
Diabetes

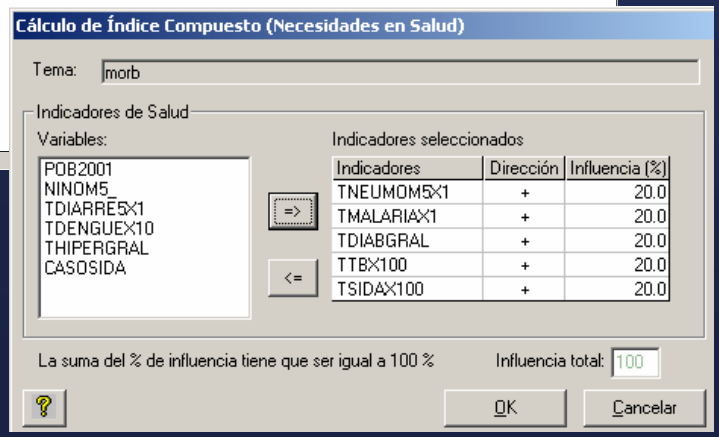


Morbidity Indicators Correlation

Variables	TNEUMOM5X1	TDIARRE5X1	TMALARIAX1	TDENGUEX10	THIPERGRAL	TDIABGRAL	TTBX100	TAIDSX100
TNEUMON 5X1 00	1.00 (1.00,1.00) N = 298	0.47 (0.38,0.55) N = 298	-0.01 (-0.12,0.11) N = 298	0.06 (-0.05,0.17) N = 298	0.05 (-0.06,0.17) N = 298	-0.04 (-0.15,0.08) N = 298	0.05 (-0.06,0.17) N = 298	-0.02 (-0.13,0.10) N = 298
TDIARRE5 X10 0	0.47 (0.38,0.55) N = 298	1.00 (1.00,1.00) N = 298	0.16 (0.05,0.27) N = 298	0.14 (0.02,0.25) N = 298	0.29 (0.18,0.39) N = 298	0.21 (0.10,0.32) N = 298	0.35 (0.24,0.44) N = 298	0.08 (-0.03,0.19) N = 298
TMALARIA X10 0	-0.01 (-0.12,0.11) N = 298	0.16 (0.05,0.27) N = 298	1.00 (1.00,1.00) N = 298	0.04 (-0.07,0.16) N = 298	0.08 (-0.03,0.19) N = 298	0.28 (0.17,0.38) N = 298	0.16 (0.05,0.27) N = 298	0.10 (-0.01,0.21) N = 298
TDENGUE X10 0	0.06 (-0.05,0.17) N = 298	0.14 (0.02,0.25) N = 298	0.04 (-0.07,0.16) N = 298	1.00 (1.00,1.00) N = 298	0.13 (0.02,0.24) N = 298	0.06 (-0.05,0.18) N = 298	-0.02 (-0.13,0.10) N = 298	0.03 (-0.09,0.14) N = 298
THIPERGR AL X 100	0.05 (-0.06,0.17) N = 298	0.29 (0.18,0.39) N = 298	0.08 (-0.03,0.19) N = 298	0.13 (0.02,0.24) N = 298	1.00 (1.00,1.00) N = 298	0.55 (0.47,0.63) N = 298	0.18 (0.07,0.29) N = 298	0.08 (-0.04,0.19) N = 298
TDIABGRA L X 100	-0.04 (-0.15,0.08) N = 298	0.21 (0.10,0.32) N = 298	0.28 (0.17,0.38) N = 298	0.06 (-0.05,0.18) N = 298	0.55 (0.47,0.63) N = 298	1.00 (1.00,1.00) N = 298	0.18 (0.07,0.29) N = 298	0.17 (0.06,0.28) N = 298
TTB X 100	0.05 (-0.06,0.17) N = 298	0.35 (0.24,0.44) N = 298	0.16 (0.05,0.27) N = 298	-0.02 (-0.13,0.10) N = 298	0.18 (0.07,0.29) N = 298	0.18 (0.07,0.29) N = 298	1.00 (1.00,1.00) N = 298	0.08 (-0.03,0.20) N = 298
TAIDS X 1000000	-0.02 (-0.13,0.10) N = 298	0.08 (-0.03,0.19) N = 298	0.10 (-0.01,0.21) N = 298	0.03 (-0.09,0.14) N = 298	0.08 (-0.04,0.19) N = 298	0.17 (0.06,0.28) N = 298	0.08 (-0.03,0.20) N = 298	1.00 (1.00,1.00) N = 298

Morbidity Standardized Index

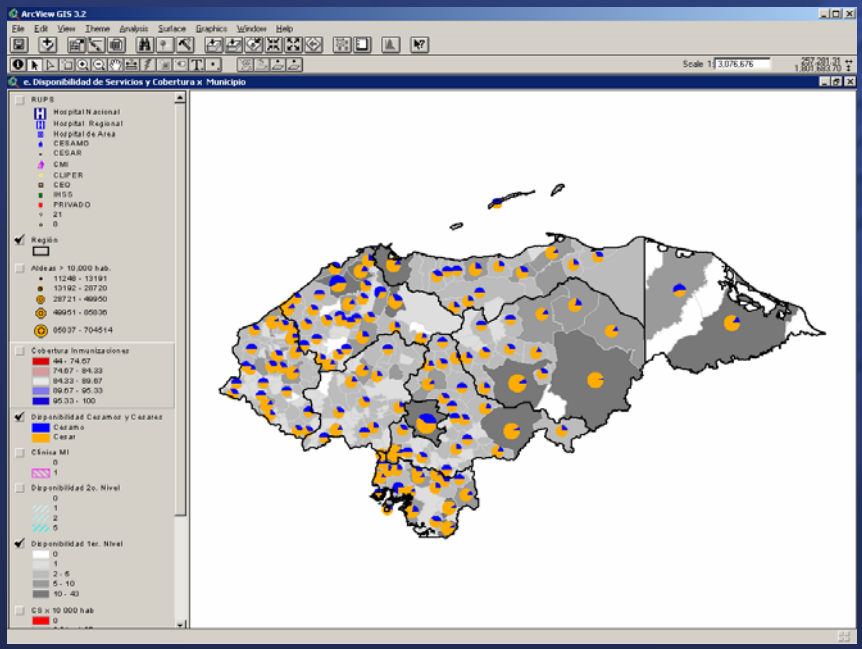


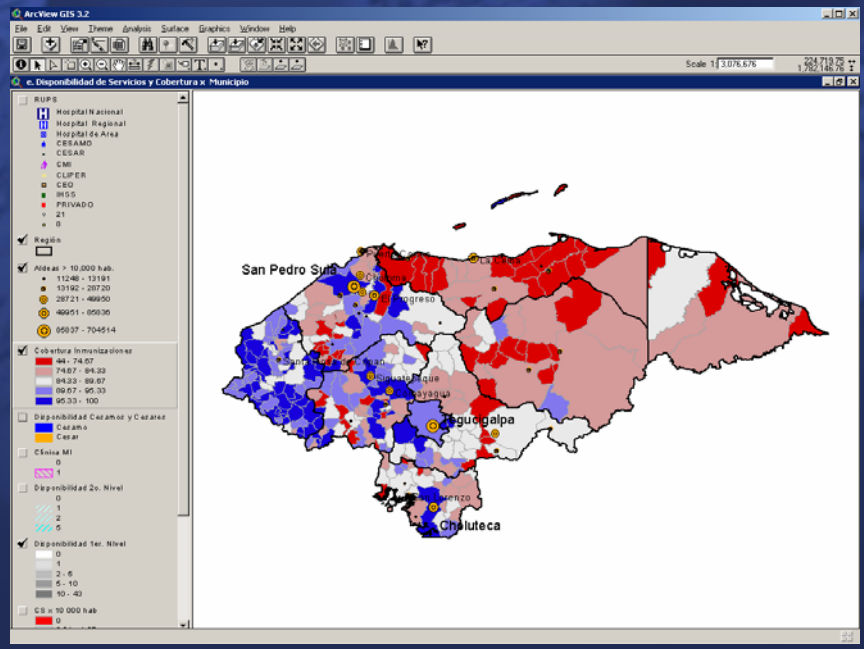


- **Sum of normalized values of morbidity indicators (Z score)**
- **RATES X 100 000:**
  - **Pneumonias Rate among children under 5**
  - **Malaria Rate Dengue Rate**
  - **Tuberculosis Rate**
  - **AIDS Rate**
  - **Diabetes Rate**

- Developed with SIGEpi 1.0

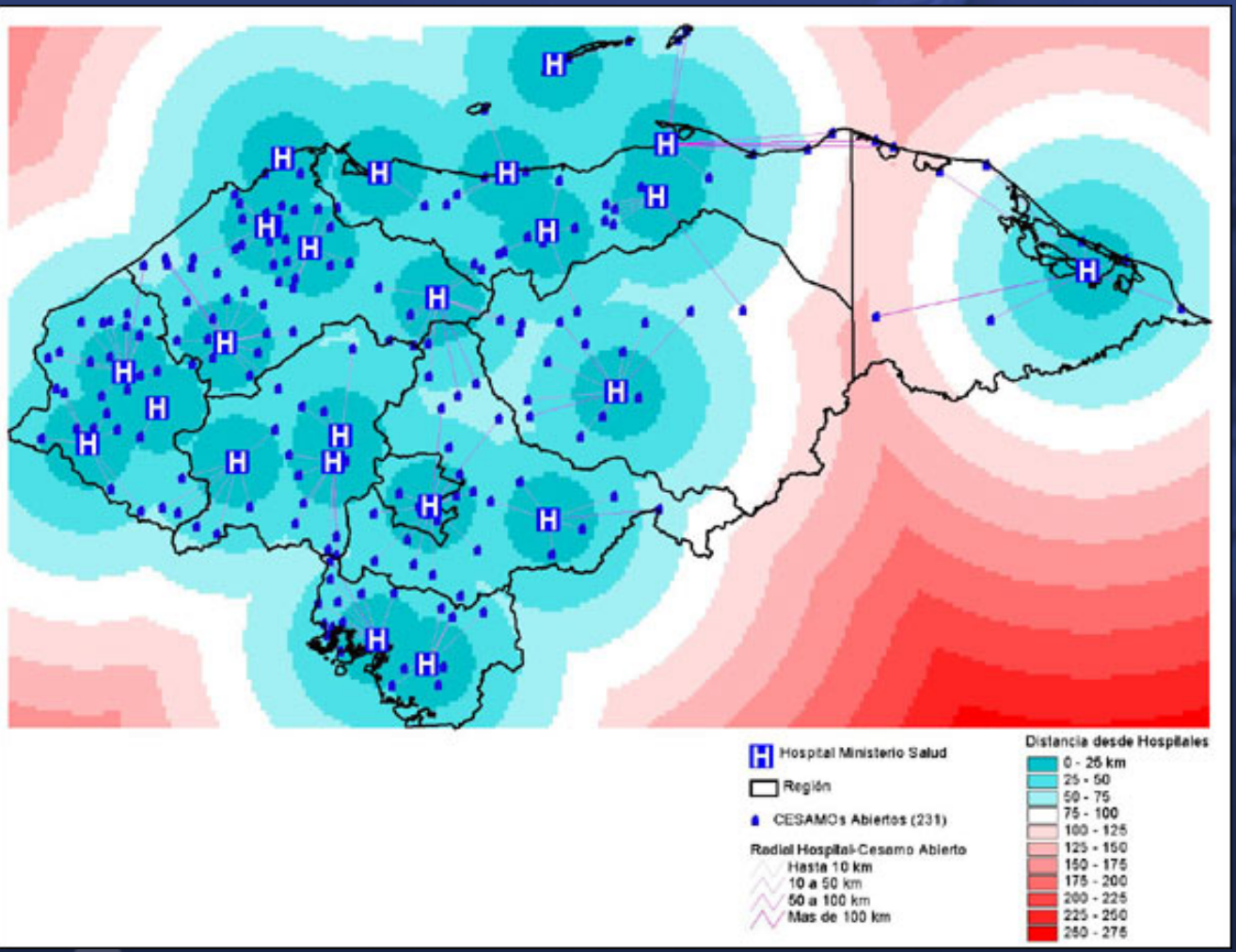
Municipal Distribution of Health Services, 2001

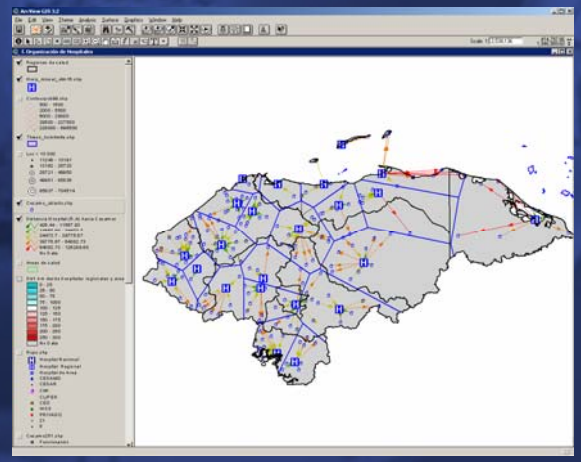




- Primary Health Services
  - Total
  - CESAMO / CESAR
- Immunization coverage

Hospitals Spatial Organization, 2001





- GRID distances
- Thiessen Polygons
- Spider Diagrams
- Relationship with PHC centers in the administrative area

Identification of low coverage, accessibility and high health needs critical areas

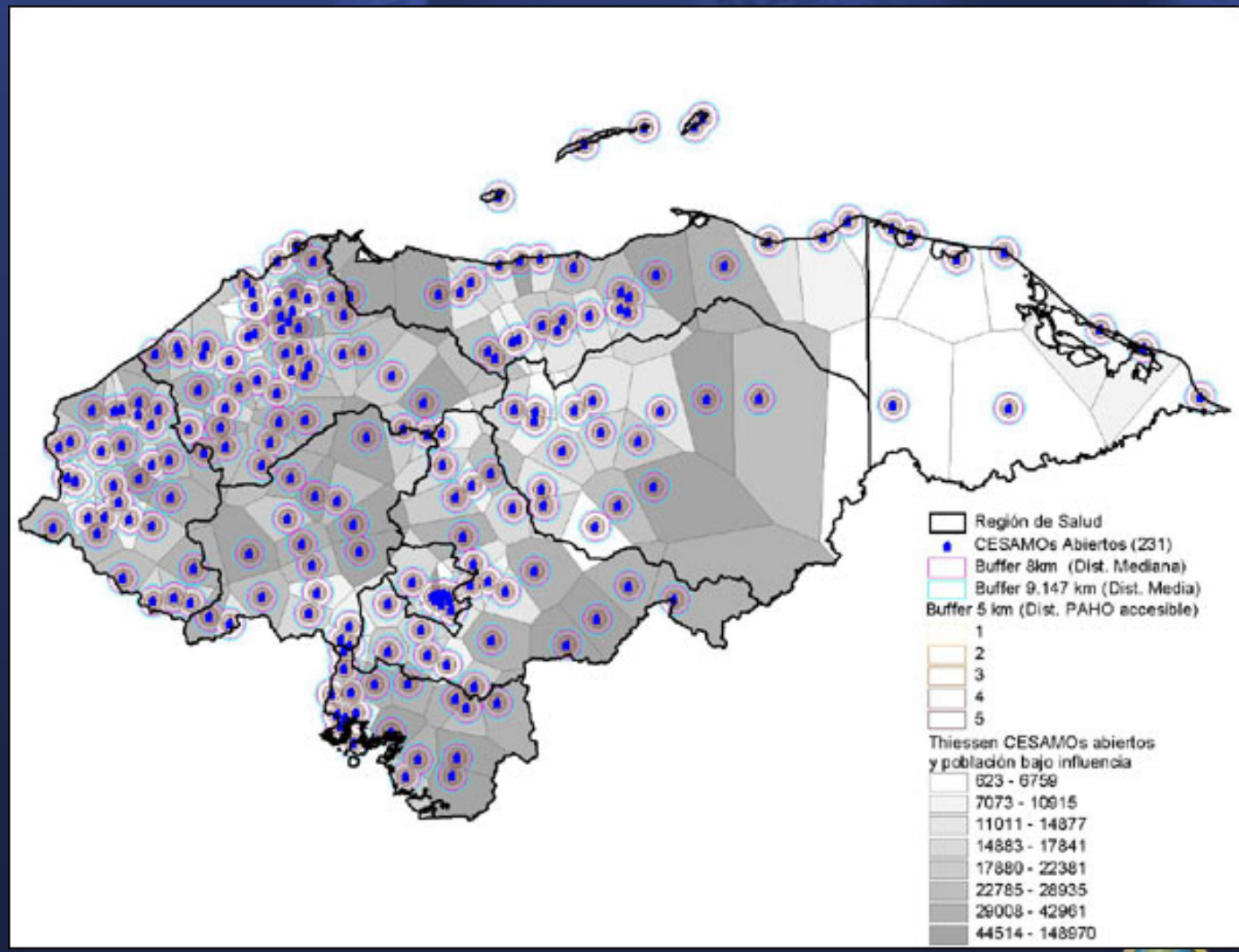
- Measurement of the interaction between Health Services and Population in terms of:

  - Geographic Potential Coverage:
    - Thiessen Polygons
    - Buffers
    - Differences
  - Geographic Accessibility:
    - Distances and slopes to nearest PHC facility
    - Distances to nearest paved roads
    - Average slope of the nearest paved road
    - Locality surrounding slopes

- Distances in km
- Slope in % where 100% = 45 degrees

Geographic potential coverage of PHC centers “CESAMOS”

- Thiessen Polygons:
  - 545 km^2
- Concentric ring buffers
  - 5 km PAHO
  - 8 km median
  - 9.1 km mean distances



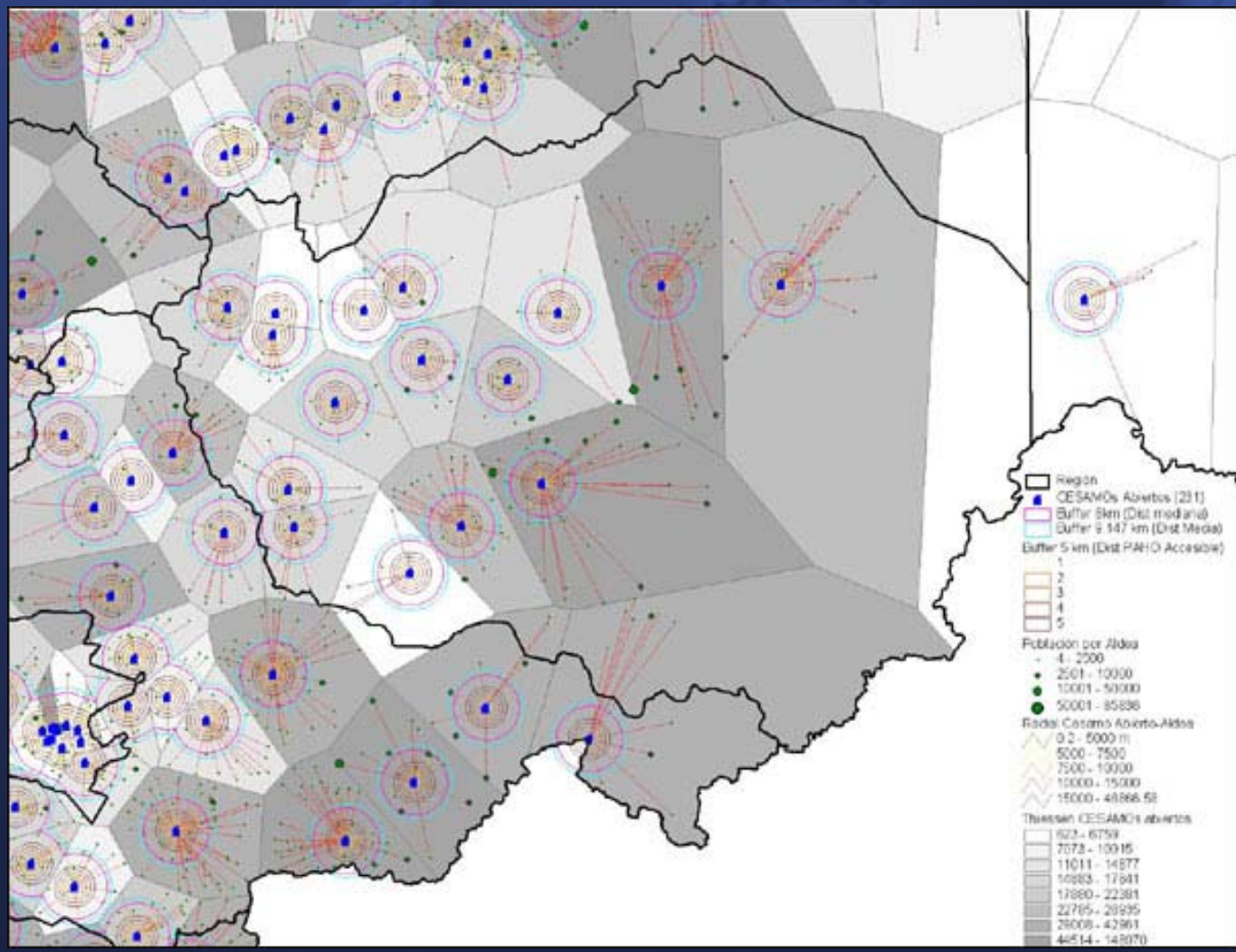
Communities in geographic catchment's area

Thiessen Polygons catchment's area cover:

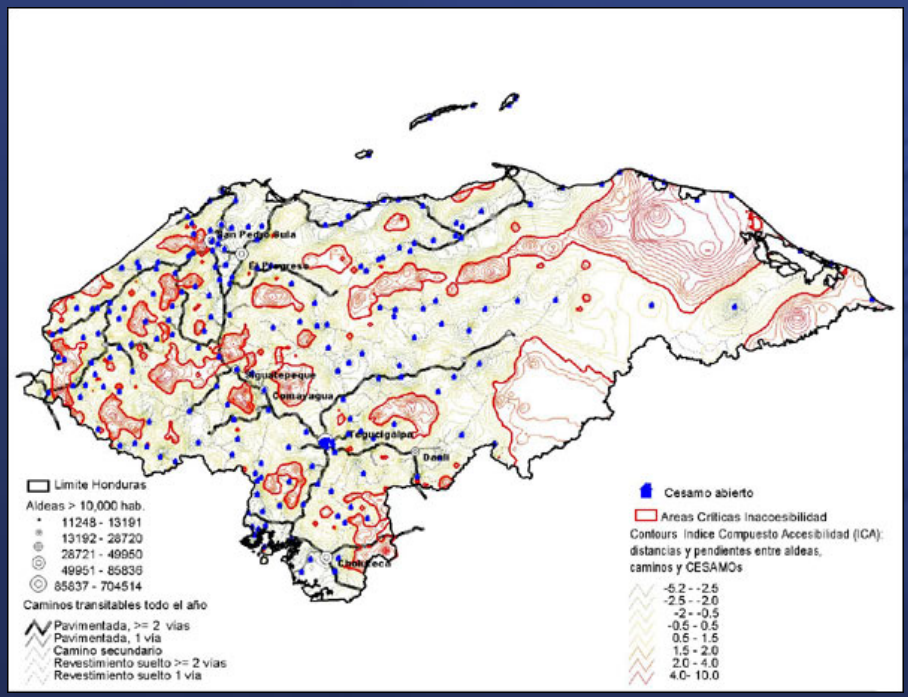
- 19 communities and 148 979 people
- 148 979 / 5 = 29 794 families

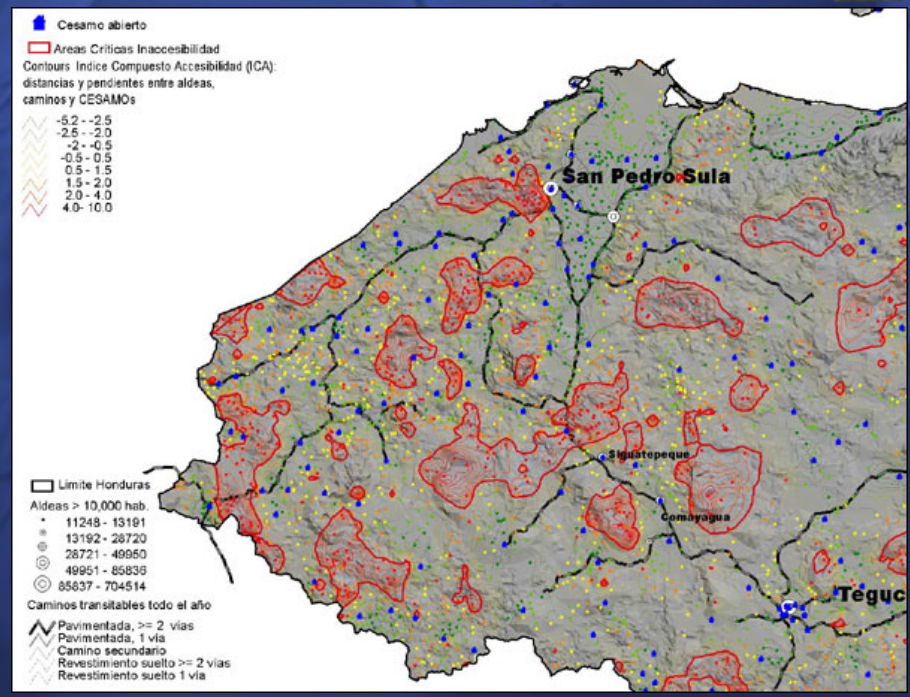
Beyond 8 km Buffer of CESAMOS are:

- 1 883 communities
- 2 085 862 people



Low accessibility critical areas





Accessibility Index (ICA constructed with SIGEpi 1.0)

- Distances (km) and slopes to nearest facility
- Slopes Calculation of z scores
- Linear interpolation of community's ICA Values Selection of 2 Std Deviation values of ICA to define critical areas

RESULT:

In Low Accessibility Critical Areas there are **807** communities with en **638, 856** inhabitants.

Further analysis and What-if scenarios

- **Complete de definition of critical areas:**
  - **with highest health needs indicators**
  - **include land use indicators**
  - **rural-urban**

- **Over critical areas**
  - **opening nearest closed facility CESAMO with a physician**
  - **opening nearest alternative services CESARES (rural centers) located al least at 5 km away from paved roads**

Impact

- **Resources for the Secretary of Health:**
  - On the Congress, was possible negotiate new posts for physicians
  - Re-allocation of budget to open or close health centers
- **The GIS application has been installed in four strategic areas of his administration:**
  - Ministry of Health PC
  - Epidemiology
  - Health Planning
  - Disasters and emergencies
- **The Presidency Social Commission has asked advisory from PAHO to design a Situation Room based on GIS**

Team Work

Main collaborators in this project:

- **Geog. Patricia Najera Aguilar**, *Short Term Professional in GIS, AIS/DD/PAHO*
- **Dr. Carlos Castillo Salgado,** *Area manager of Health Analysis and Information Systems in AIS/DD/PAHO*
- **MCC. Manuel Vidaurre Arenas,** *Information Systems Specialist AIS/DD/PAHO*
- **Ing. Ramón Martínez Piedra,** *Short Term Professional in GIS, AIS/DD/PAHO*
- **Dr. Enrique Loyola Elizondo**, *Regional advisor AIS/DD/PAHO*

Ministry of Health, Honduras

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- **Dr. Humberto Cosenza,** *External Coop.*
  Dr. Marco Tulio Carranza, *Epidemiologist*
  Dra. María del Socorro Iteriano, *UPEG*
- **Dr. Godofredo Andino,** Disasters and national emergencies
- **Dr. Orlando Solórzano**, *Epidemiology*
- **Ing. César Rodríguez,** *Epidemiology*
- **Dra. Doris Rodríguez**, *Statistics*
- **Dra. Marza Montes,** *- UPEG*
- **Dra. Ana Lucia Estrada**, *- UPEG*
- **Ing. Javier Garcia,** *PRIESS/BID*

PWR Honduras

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- **Dr. Luis Miguel Amendola,** *National Professional*
- **Ing. Edwin Cruz**, *GIS Consultant*
- Ing. Carlos Riedel, *Network Administrator PWR/Honduras*
- **Dr. Guillermo Guibovich,** *Epidemiologist AIS, PWR/Honduras*

CIGEO/UNITEC:

- **Lic Ramón Sarmiento,** *Vicerrector - UNITEC*
- **Ing. Heidi Mendoza,** *Coordinator CIGEO/UNITEC*
- **Ing. José Luis Portillo,** *Cartography CIGEO/UNITEC*

Data Sources

Ministry of Health

- Morbidity
  - **HAS Rates 2000 municipal**
  - **Epi-municipal 2001**
- Unmet Basic Needs (NBI)
- Health Centers Attributes

PAHO PWR

- SIG-OPS GIS project
- Health indicators in “Shapefile”
- Data base documentation

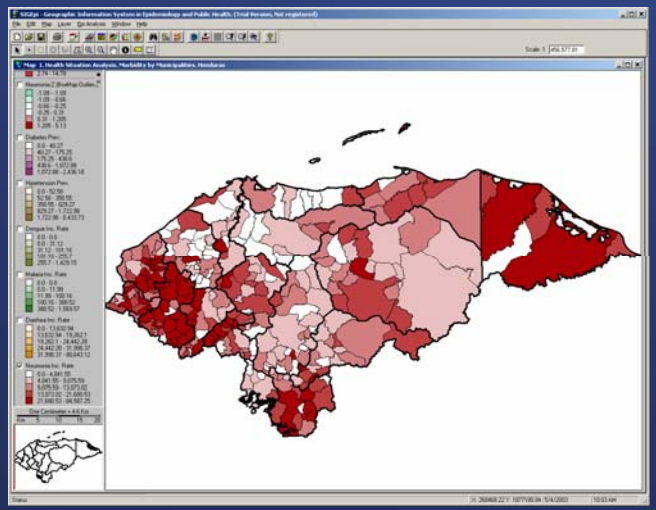
Other institutions in Honduras

- SINIA Environment, Land Use
- UNITEC Flooding, Landslides
- IGN/INE 2001 Census communities

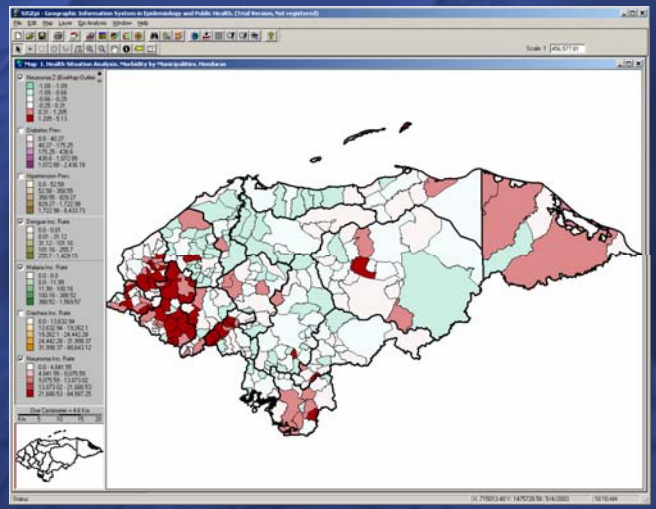
AIS / PAHO HQ

- Conceptual and operational model
- USGS DEM transformation
- INCAP data malnutrition indicators
- Projections
- Geo-coding
- Statistical Analysis
- Spatial Analysis
- GIS application

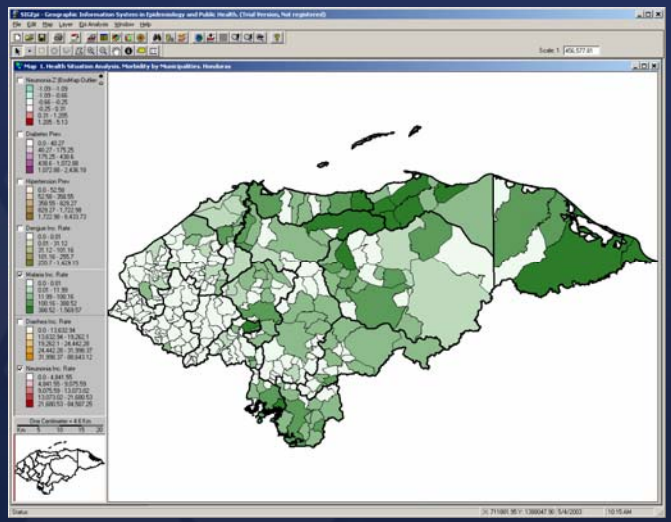
Exploratory Analysis of Morbidity Indicators



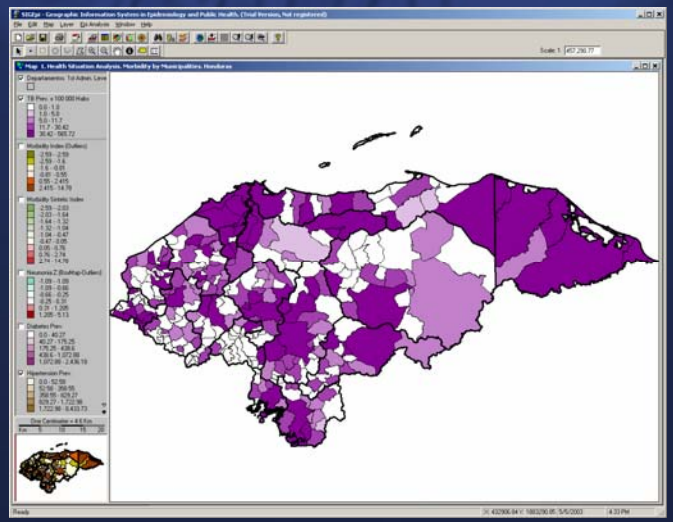
Pneumonia



Pneumonia (Outliers, Box-plot map)

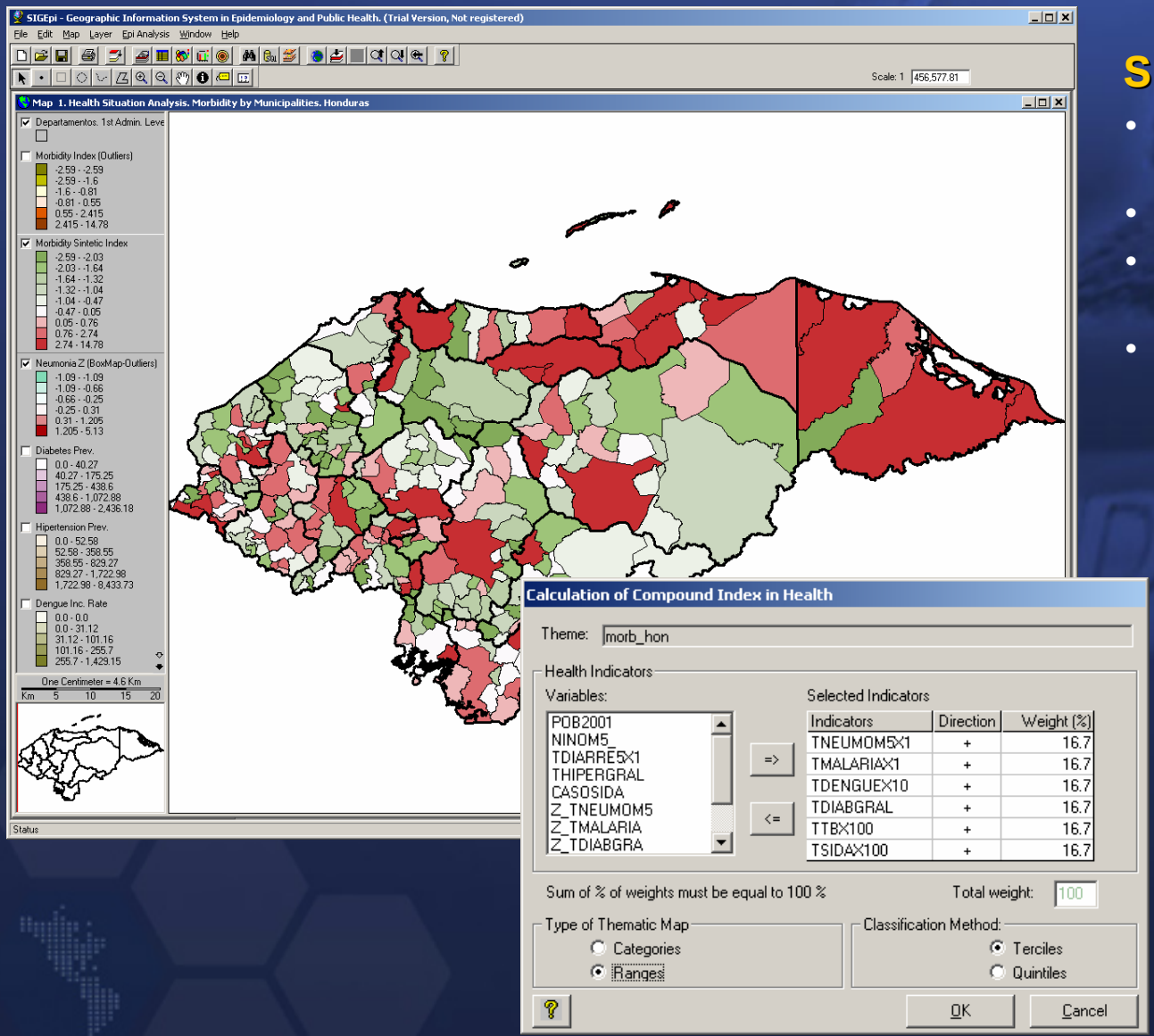


Malaria



Tuberculosis

Index of Morbidity



SIGEpi procedures

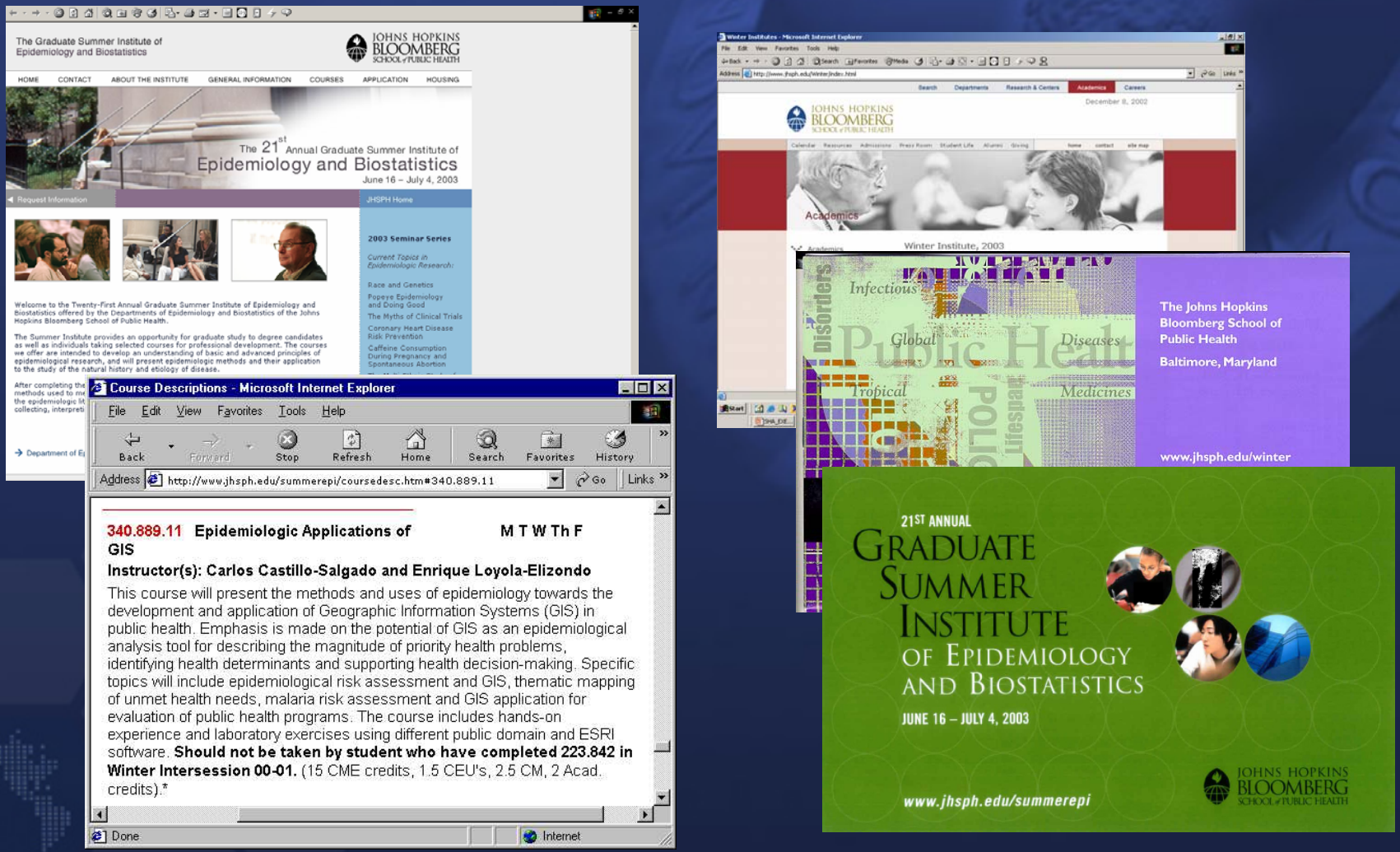
- Thematic mapping of health indicators.
- Correlation analysis.
- Box-plot maps (outlier detection)
- Construction of a composite index of morbidity Zscore:
  - Pneumonia rate in children less that 5 yrs X 100,000
  - Malaria x 100 000,
  - Dengue x 100 000,
  - Tuberculosis x 100,000,
  - AIDS x 100,000,
  - Diabetes x 100,000).

Compound Health Index dialogue box. **SIGEpi**

How SIGEpi is improving Health and Equity in the Americas?

- Specific design of analytical procedures to identify and locate inequalities integrated in a GIS
- Distribution strategy focused on priority countries and sub-regions:
  - Training
  - Software
  - Technical cooperation
  - Materials
- Technical support in the development of applications to ID sub national and frontier problems

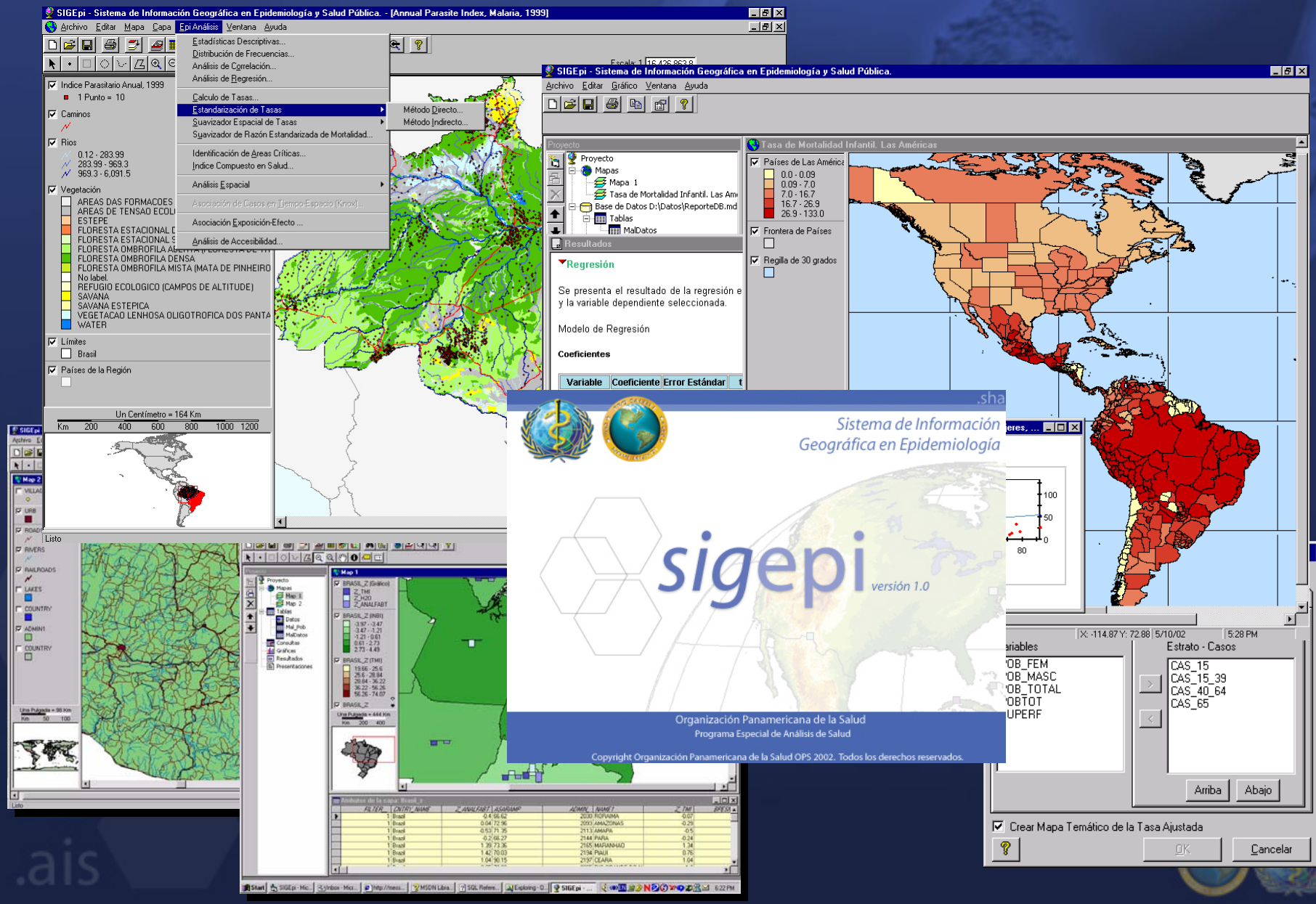
PAHO/JHU Epidemiologic applications of geographic information systems course (1)



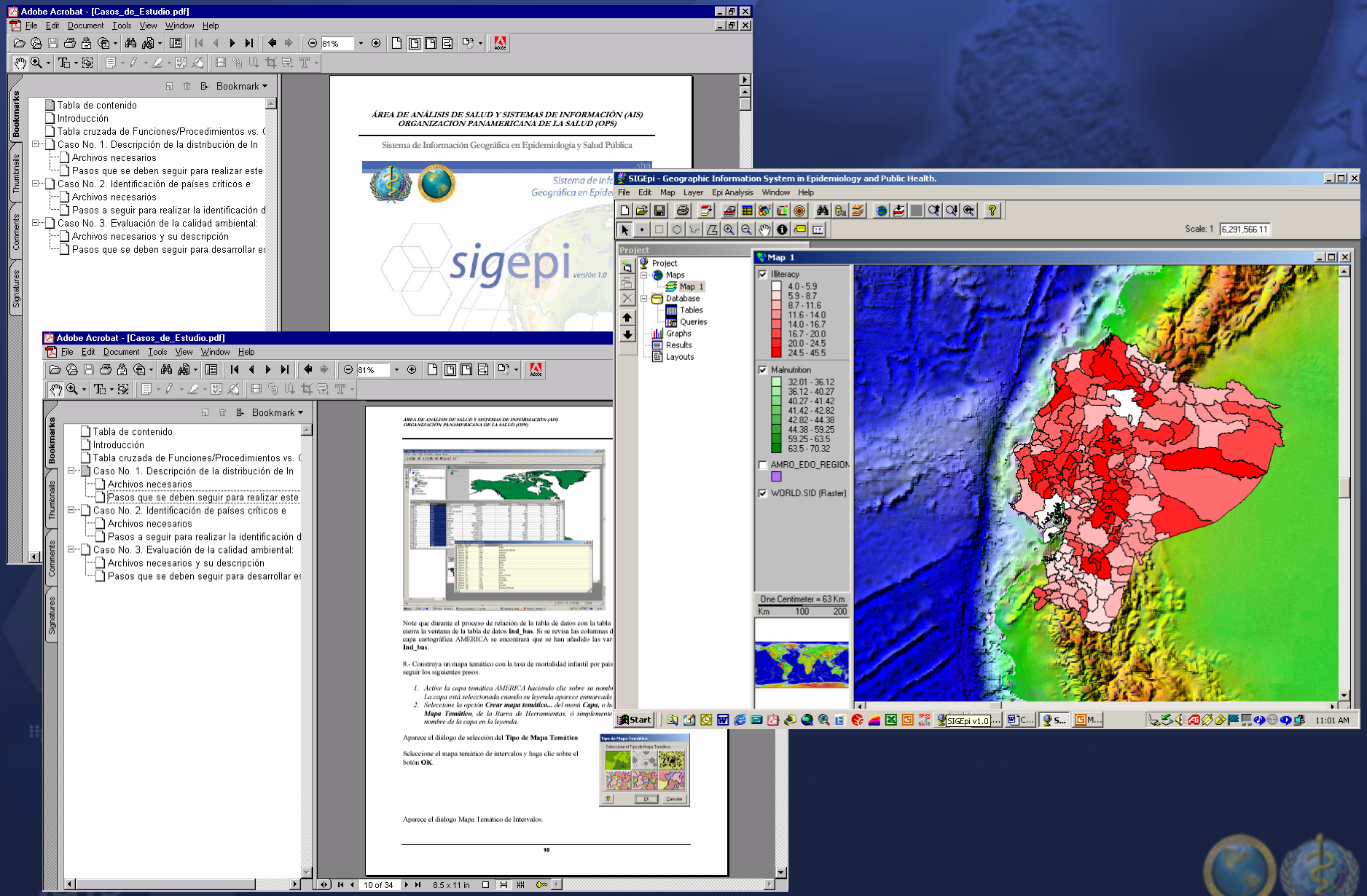
PAHO/JHU Epidemiologic applications of geographic information systems course (2)

Geographic Information Systems in Health: Basic Concepts

SIGEpi – GIS for Epidemiology and PH



Case Studies for SIGEpi



New PAHO/AIS Web Site in GIS-Epi

PAHO acknowledges ESRI's generous donation of MapObjects to be integrated in SIGEpi