Use of Remote Sensing/Geographical Information Systems (RS/GIS) to identify Environmental Limits of Soil Transmitted Helminthes (STHs) Infection in Boaco, Nicaragua

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Presentation Overview

• Background of the Diseases
  ❖ Helmithiasis (Neglected Diseases)
  ❖ Sanitation
  ❖ Health Impact

• Study Area
  ❖ Boaco, Nicaragua

• In situ data from AMOS

• Remote Sensing
  ❖ MODIS Land Surface Temperature (LST)
  ❖ MODIS Normalized Difference Vegetation Index (NDVI)
  ❖ MODIS Land Cover Land Use Type (LCLU)

• Results

• Conclusions

• Recommendations
Background

- Environment is a major factor for health, both directly or indirectly
  - Sanitation, poverty, neglected diseases
  - Natural environment

- A number of agents of diseases are carried by vectors and reservoirs whose viability depends on given environmental conditions

- Such conditions describe not only the characteristics of the natural environment but also of sanitation

- Such conditions can be inferred with satellite data
  - Temperature
  - Presences of water bodies
  - Soil moisture
  - Vegetation
  - Elevation
  - Precipitation

• Soil transmitted helminthes infection, Helminthiasis, Neglected Diseases

• Impact
  ✷ Reduced physical growth
  ✷ Weak physical fitness
  ✷ Impaired cognitive functions
  ✷ Increase with intensity of infections

Photo courtesy Dr. Ligia Cruz Espinoza

1. UNICEF, 2006. Progress for Children
Background cont.

- *Ascaris lumbricoides*
- Life cycle
- 2 to 3 months after ingestion of the eggs, the mature worms commence egg laying in the intestine
- 2 or 3 weeks outside the host to develop to the infective stage
• Microscopic Evaluation

Ascaris suum zygotes inactivated

Ascaris suum developed larva

Photos Courtesy of Dr. Ligia Cruz Espinoza
Background cont.

http://curezone.com/image_gallery/parasites/ascaris/
In situ data

- *Ascaris lumbricoides*
- *Trichuris trichiura*
- *Ancilostoma duodenale*

- AMOS Health & Hope
  - [http://www.amoshealthandhope.org/Health_for_all/Home.html](http://www.amoshealthandhope.org/Health_for_all/Home.html)
Study area

Mean Land Surface Temperature (Celsius)
Aug 21, 2009 – Aug 15, 2010

- ≤ 26.62
- 27.55
- 28.01
- 28.95
- 29.41
- 29.88
- 30.34
- 31.28
- ≥ 32.21

630 Kilometers

- MODIS Land Surface Temperature (LST) 1:30 pm
- MYD11A1 1 km daily
Study area

Mean Land Surface Temperature (Celsius)
Aug 21, 2009 – Aug 15, 2010

- 26.62
- 27.55
- 28.01
- 28.95
- 29.41
- 29.88
- 30.34
- 31.28
- ≥ 32.21

200 Kilometers

- MODIS Land Surface Temperature (LST) 1:30 pm
- MYD11A1 1 km daily
Study area

- MODIS Land Surface Temperature (LST) 1:30 pm
- MYD11A1 1 km daily

Mean Land Surface Temperature (Celsius)
Aug 21, 2009 – Aug 15, 2010

- ≤ 26.62
- 27.55
- 28.01
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- 29.41
- 29.88
- 30.34
- 31.28
- ≥ 32.21

125 Kilometers
Study area

Mean Land Surface Temperature (Celsius)
Aug 21, 2009 – Aug 15, 2010

- ≤ 26.62
- 27.55
- 28.01
- 28.95
- 29.41
- 29.88
- 30.34
- 31.28
- ≥ 32.21

10 Kilometers

- MODIS Land Surface Temperature (LST) 1:30 pm
- MYD11A1 1 km daily
Remotely sensed data

Mean Land Surface Temperature (Celsius)
Aug 21, 2009 – Aug 15, 2010

- \( \leq 26.62 \)
- 27.55
- 28.01
- 28.95
- 29.41
- 29.88
- 30.34
- 31.28
- \( \geq 32.21 \)

2 Kilometers

- MODIS Land Surface Temperature (LST) 1:30 pm
- MYD11A1 1 km daily
Remotely sensed data

Land Classification 2009

- 0: Agua
- 1: Evergreen Needleleaf forest
- 2: Evergreen Broadleaf forest
- 3: Deciduous Needleleaf forest
- 4: Deciduous Broadleaf forest
- 5: Mixed forest
- 6: Closed shrublands
- 7: Open shrublands
- 8: Woody savannas
- 9: Savannas
- 10: Grasslands
- 11: Permanent wetlands
- 12: Croplands
- 13: Urban and built-up
- 14: Cropland/Natural vegetation mosaic
- 15: Snow and ice
- 16: Barren or sparsely vegetated

2 Kilometers

- MODIS Land Cover Land Use (LCLU)
- MCD12Q1 Combined
- 500 m Yearly
## Remotely sensed data

**Land Classification**

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<tr>
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<td>Evergreen Broadleaf forest</td>
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<td>Deciduous Needleleaf forest</td>
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<td>Deciduous Broadleaf forest</td>
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<tr>
<td>16</td>
<td>Barren or sparsely vegetated</td>
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</table>

- **MODIS Land Cover Land Use (LCLU)**
- **MCD12Q1 Combined**
- **500 m Yearly**
Remotely sensed data

- MODIS Normalized Difference Vegetation Index (NDVI) 16 days
- MYD13Q1 250 m
Remotely sensed data

- MODIS Normalized Difference Vegetation Index (NDVI) 16 days
- MYD13Q1 250 m
LST & *Thrichuris trichuria*

- Wilcoxon Two-Sample Test:
- Normal Approximation
  - $Pr > |z| \ 0.0157$
- $t$ Approximation
  - $Pr > |z| \ 0.0161$
- Kruskal-Wallis Test
  - $Pr > \text{Chi-Square} \ 0.0156$
- Positive: $n=152$
  - mean=26.27
- Negative: $n=244$
  - mean=26.47
LST & *Ascaris lumbricoides*

- Wilcoxon Two-Sample Test:
  - Normal Approximation
  - \( \Pr > |z| < 0.0001 \)
  - \( t \) Approximation
  - \( \Pr > |z| < 0.0001 \)
- Kruskal-Wallis Test
  - \( \Pr > \text{Chi-Square} <0.0001 \)
- Positive: \( n=111 \) mean=26.13
- Negative: \( n=285 \) mean=26.49
LST & *Ancilostoma duodenale*

- Wilcoxon Two-Sample Test:
- Normal Approximation
  - Pr > |z| 0.7824
- t Approximation
  - Pr > |z| 0.7825
- Kruskal-Wallis Test
  - Pr > Chi-Square 0.7813
- Positive: n=10 mean=26.61
- Negative: n=386 mean=26.39
## Land Cover

Prevalence considering all three parasites together

- Evergreen broad leaf forest
- Woody savannas
- Croplands
- Croplands/natural vegetation mosaic

<table>
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<tr>
<th>Land Class</th>
<th>Posit.</th>
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Preliminary Conclusions

• Although not clear limits could be suggested for any of the species of soil transmitted helminthes considered, a mean LST greater than 30.8 Celsius at 1:30 PM seems to be more favorable for prevalence of *Trichuris trichuria*.

• As expected, the prevalence of infection for all three species seems to increase with the increase of LST

• MODIS LST shows potential as a tool to identify areas at risk of Helminthiasis however studies covering larger range in temperature are needed to more clearly show such applicability

• Due probably to the small area of the study site, it was not possible to suggest the applicability of MODIS Normalized Difference Vegetation Index (NDVI) and Land Cover under the study conditions