Malaria in Tanzania

Considerations for hospital distribution

Using GIS to assess factors influencing malaria incidence

NAGPS pre-conference Graduate Research Forum

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Inspiration

- Time in Tanzania
  - 2004
- Public Health
  - Infectious Disease
    - Global Impact of Malaria
      - In 2015: 212 million cases and 429,000 deaths

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Background

- Malaria
  - caused by *plasmodium* parasite[1]
    - Spread by female mosquitoes
      - *anopheles gambiae (key vector & difficult to control)*
    - 5 species of plasmodium
      - Most dangerous to humans is
        - *Plasmodium falciparum*

- Factors
  - Complex interaction!
    - Vector, host, parasite, and environment
      - Climatic influences: rainfall, temperature, humidity etc.

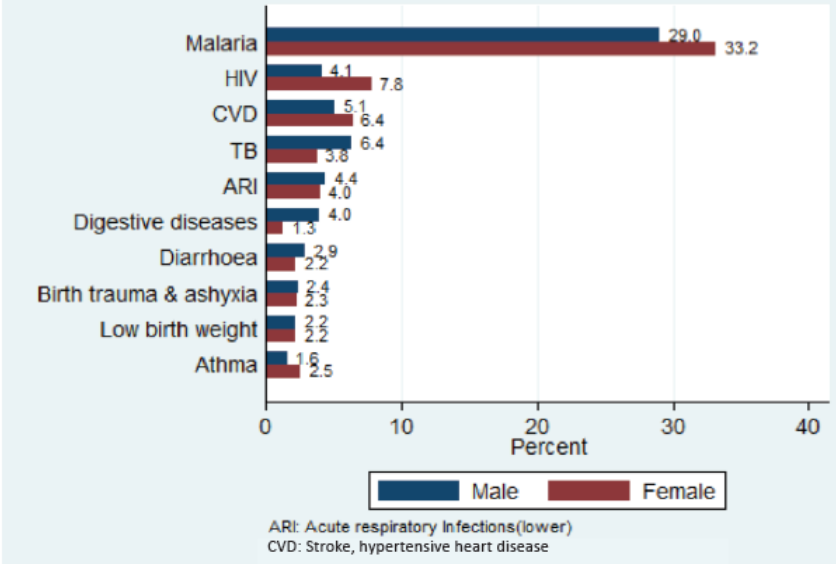
Background Continued

In Tanzania

- Leading cause of death for all ages [2]
  - 32% as of 2011
- 40% of annual national health expenditure [3]
- 40% of all outpatient hospital attendance [4]

Major cause of death by sex for all ages

Figure 1: Distribution of percent of top 10 cause of death by gender, Males=1168 and Females=1167



ARI: Acute respiratory infections(lower)
CVD: Stroke, hypertensive heart disease

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Research Question

Original Question:

Is there an association with hospital distribution and malaria incidence?

Incidence:

- **New Cases.** Mean rate of clinical *plasmodium falciparium* malaria cases per person per year observed. A clinical case is defined as a malaria-attributable febrile episode (body temperature in excess of 37.5 C), typically accompanied by headaches, nausea, excess sweating and/or fatigue, censored by a 30-day window (i.e., multiple bouts of symptoms occurring within the same 30-day period are counted as a single episode). [7]

Inspiration:

- Locale and Malaria
- Why health sites/hospitals?

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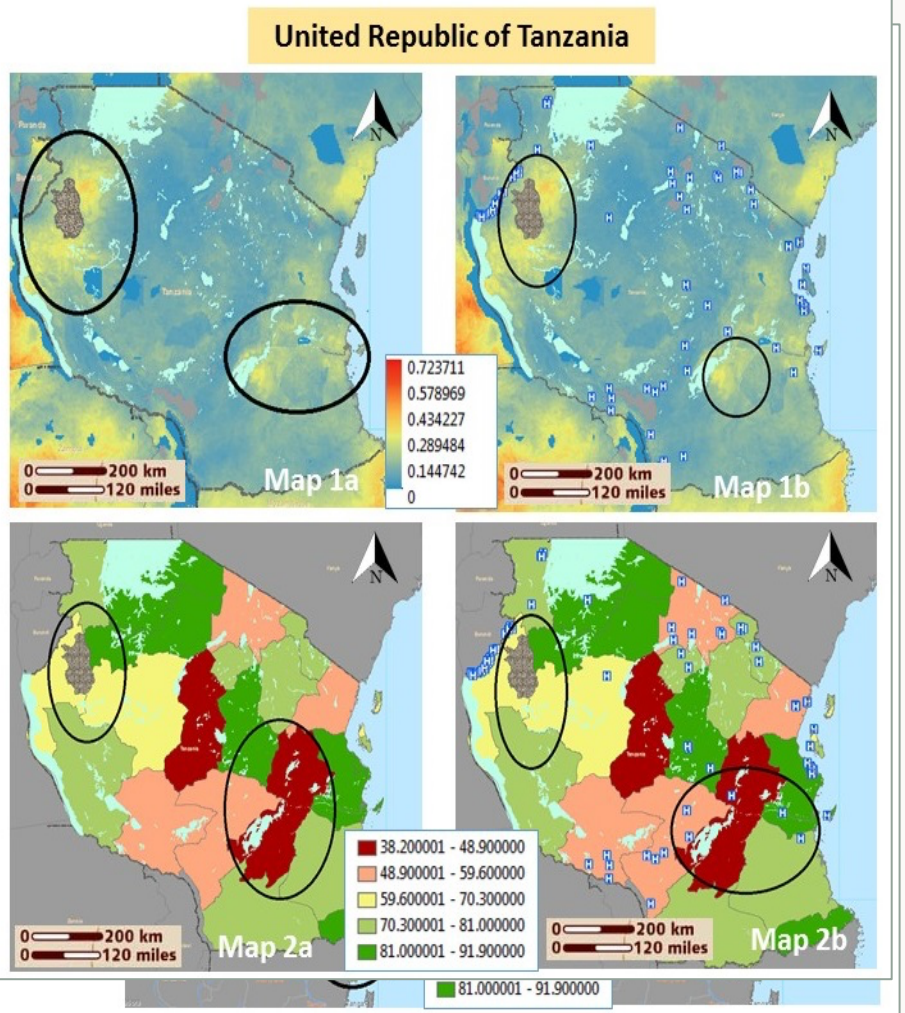
First Comparative Analysis

Map 1a: Raster data indicating parasite incidence rate for *plasmodim falciparum* for all ages (MAP 2015).

Map 1b: *Map1a* with added layer indicating distribution of hospital facilities (OpenStreet 2014).

Map 2a: Vector data indicating percentage of children under age five who slept under any net the night before the survey (SDR 2012)

Map 2b: *Map2a* with added layer indicating distribution of hospital facilities (OpenStreet 2014)



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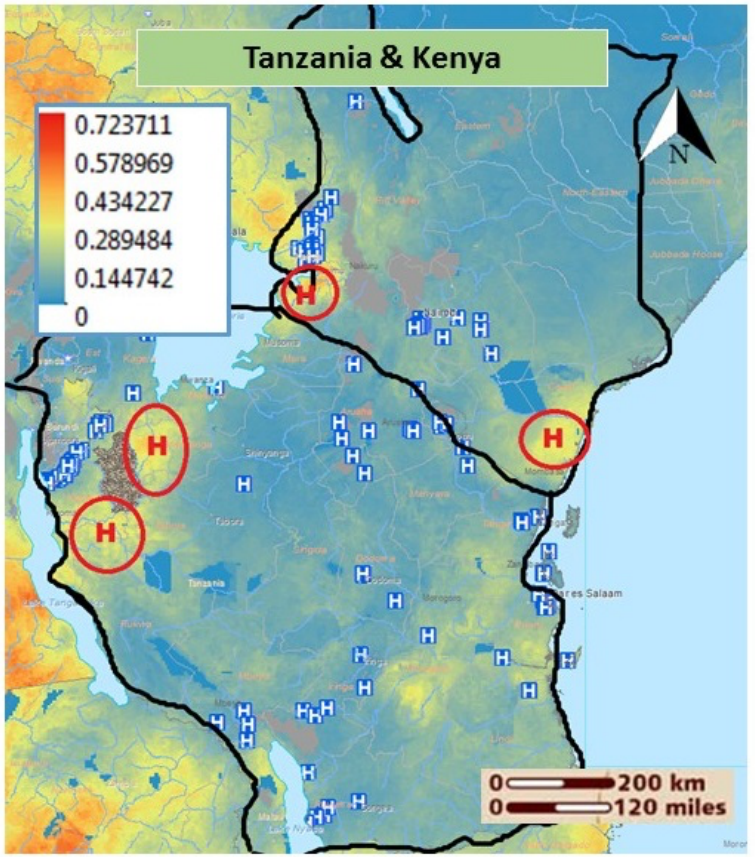
Initial Findings

- Hotspots varied by population and bed net usage, but were similar with low hospital presence (Tanzania)
- High population density, with high bed net usage, with high incidence of malaria, but low hospital presence (Kenya)



Map 5: Recommended sites for new hospital facilities in Tanzania & Kenya. Raster data indicating parasite incidence rate for *plasmodim falciparum* for all ages (MAP 2015) and added indicating distribution of hospital facilities (Open Street 2012 & Open Data 2014)

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2nd Time Around

Better Data, More Data & Better Skills

New Question:

Is there an association with health center distribution and malaria incidence? Considering ITN* usage as a mediator.

Original Hypothesis:

- There will be less health center distribution around areas with comparable ITN* usage and population.

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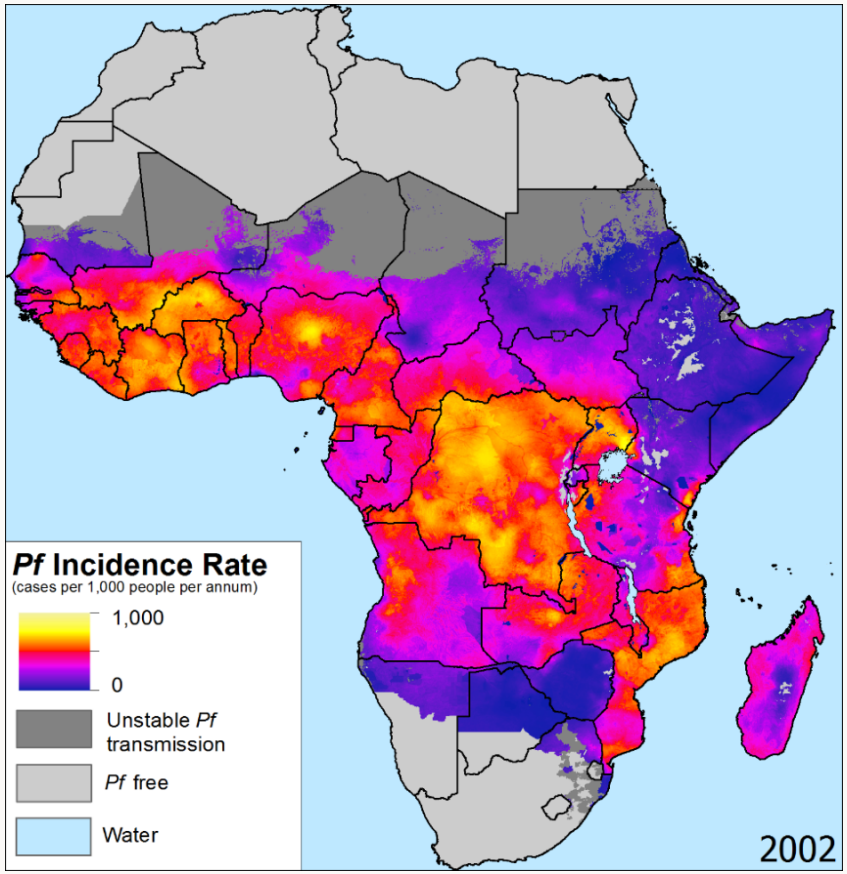
Methods

- **Data Sources:**
  - Geonetwork[10]
  - Natural Earth[12]
  - GCIAR
  - USAID
  - Malaria Atlas Project[7]
  - Map East Africa
- **File Layers:**
  - Malaria Incidence [7]
  - Rainfall [8]
  - Altitude, CGIAR STRM Data [9]
  - Water Bodies [8, 10, 11]
  - Road Network [8, 10, 12]
  - ITN Use [7]
  - Health Sites [13]



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Factors of Interest

- Malaria Incidence (All ages)
- Average ITN Usage
- Health Site Distribution
- Climatic / Environmental Risk Factors
  - Rainfall
  - Altitude
  - Distance to Roads
  - Distance to Waterbody

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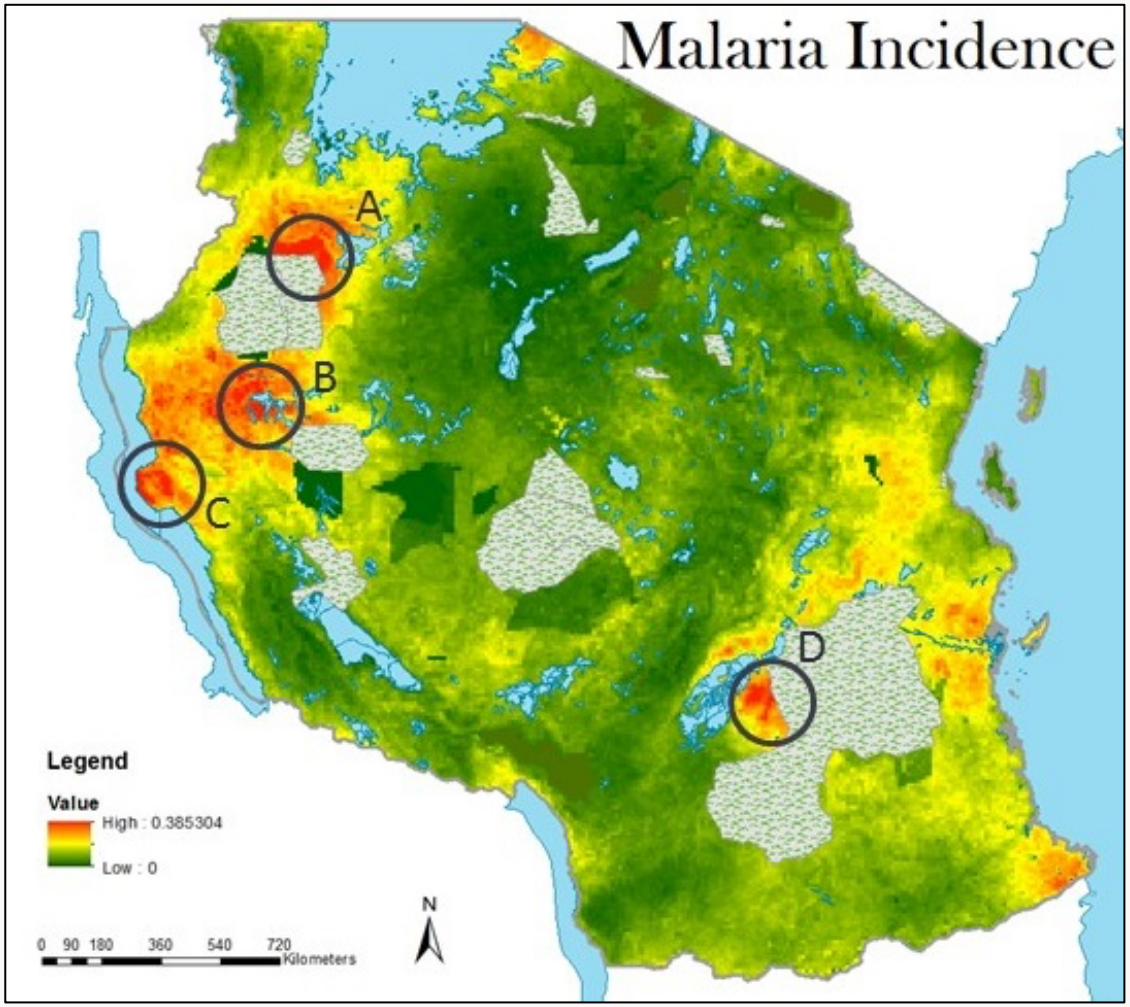
Tanzania

Four high-incidence areas were chosen:

High incidence = rates between 17% and 39%



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Metrics

Risk Factor	Low Risk	Medium Risk	High Risk
Distance to Road	<5km	5-20km	>20km
Distance to Water	>3km	1-3km	<1km
Average Rainfall	<450mm	450-700mm	>700mm
Altitude	>1,110m	650-1,110m	<650m
ITN Use	65-87%	55-64%	30-54%
Hospital Distribution	177 – 262 facilities	91 - 176 facilities	4 - 90 facilities

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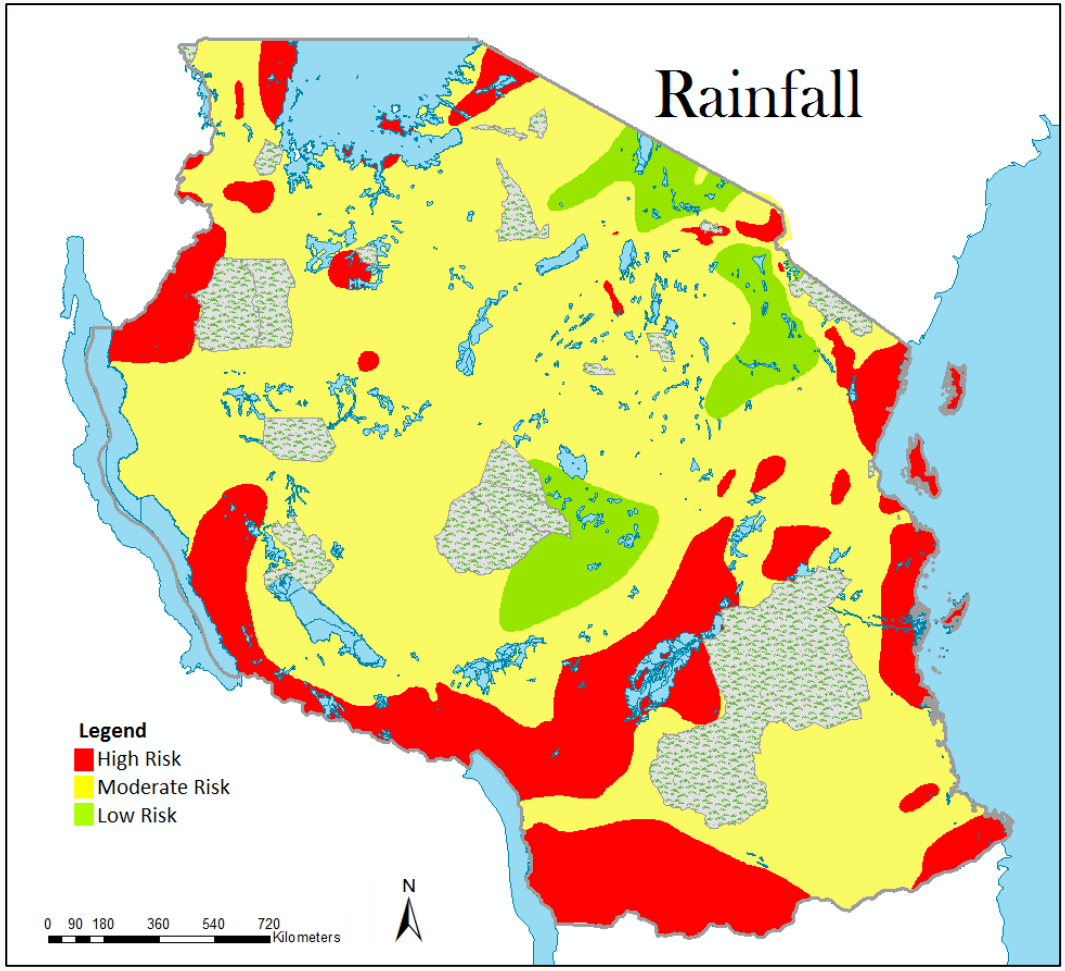
Rainfall

Annual malaria incidence coincides with high rainfall while low incidence coincide with low rainfall. [5]

Low = < 450mm

Med = 450-700mm

High = > 700mm



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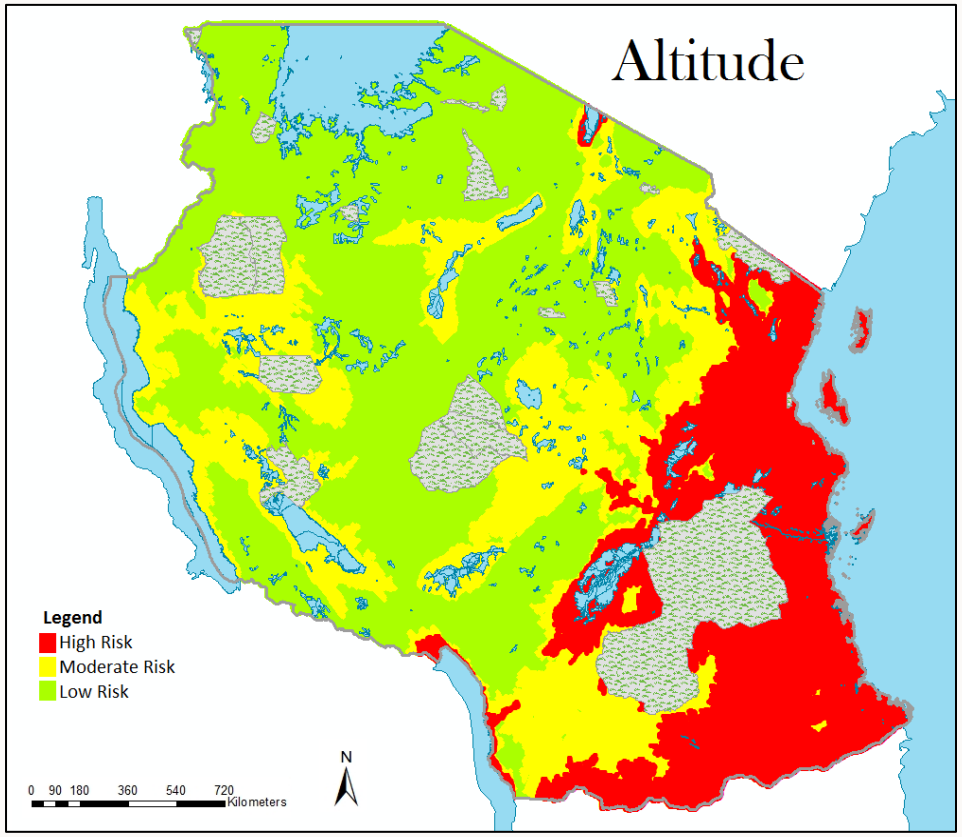
Altitude

There is a proven relationship between altitude and mosquito abundance. “Elevation defines the ecology of malaria transmission through temperature.” [5]

Low = >1,100m

Med = 650-1,100m

High = <650m



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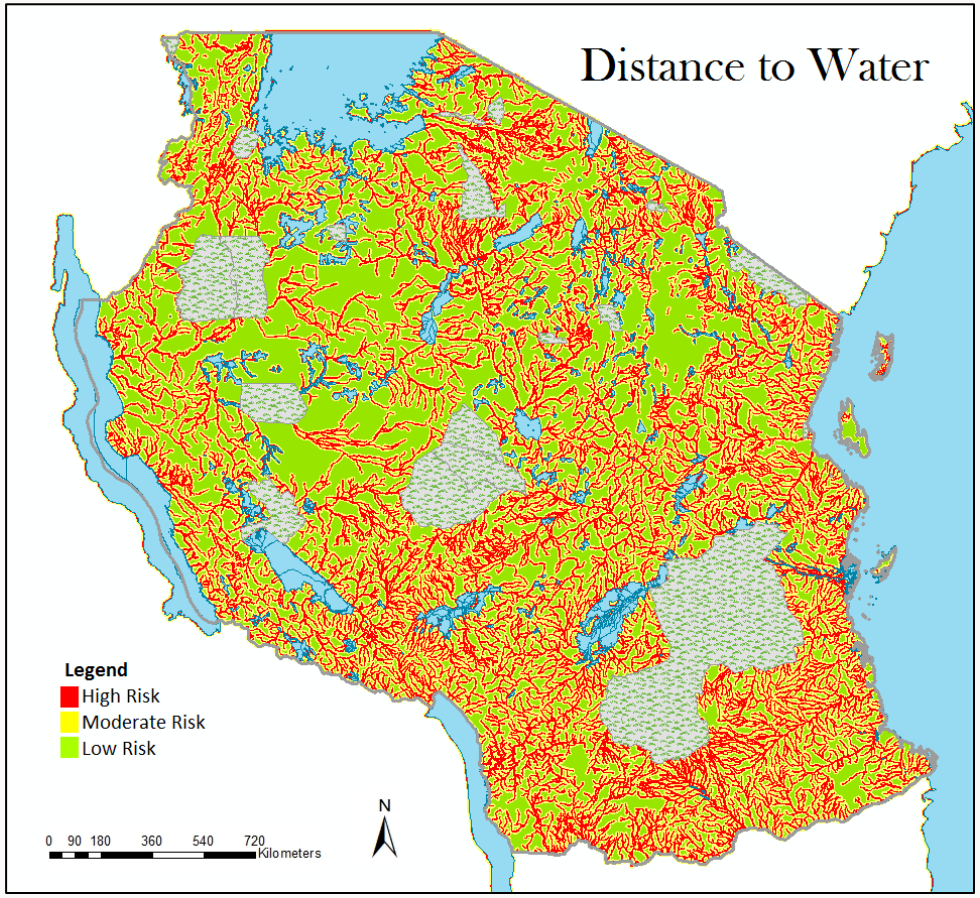
Distance to Water

Water bodies are an important factor influencing the occurrence and distribution of malaria cases because they play a role in providing larval breeding sites for the vector. Water bodies are a direct indicator for malaria risk. [5]

Low = >3k

Med = 1-3k

High = <1k



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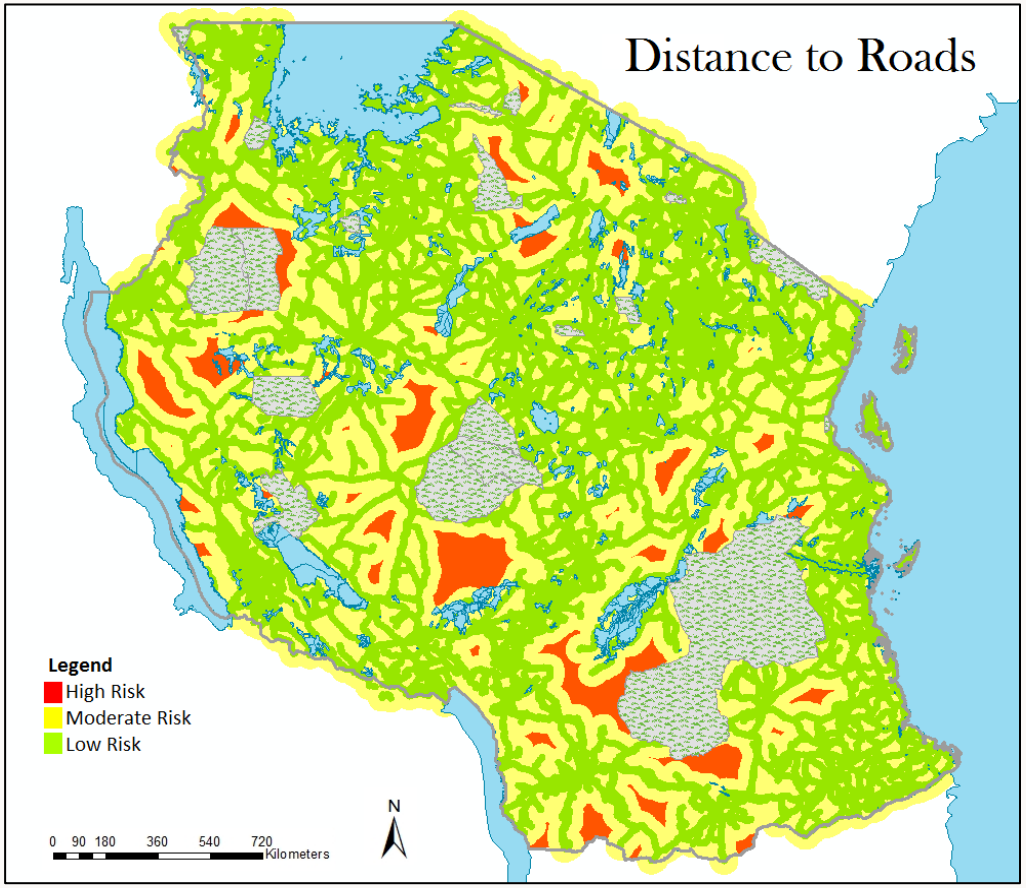
Distance to Roads

Roads were considered due to the possible accessibility and effectiveness of intervention measures against malaria. [6]

Low = <5km

Med = 5-20km

High => 20km



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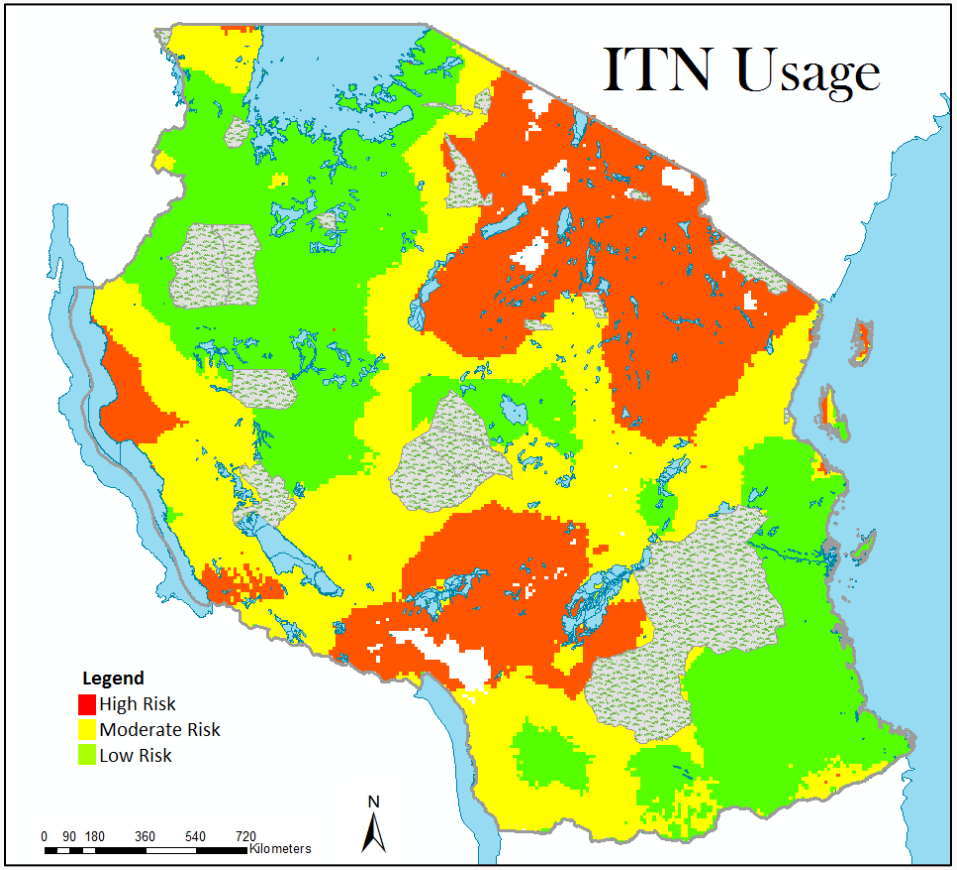
ITN Usage

Bayesian geostatistical models produce national estimates of ITN use (number of people sleeping under a net the previous night) for 5km x 5km. [7]

Low = 65-87%

Med = 55-64%

High = 30-54%



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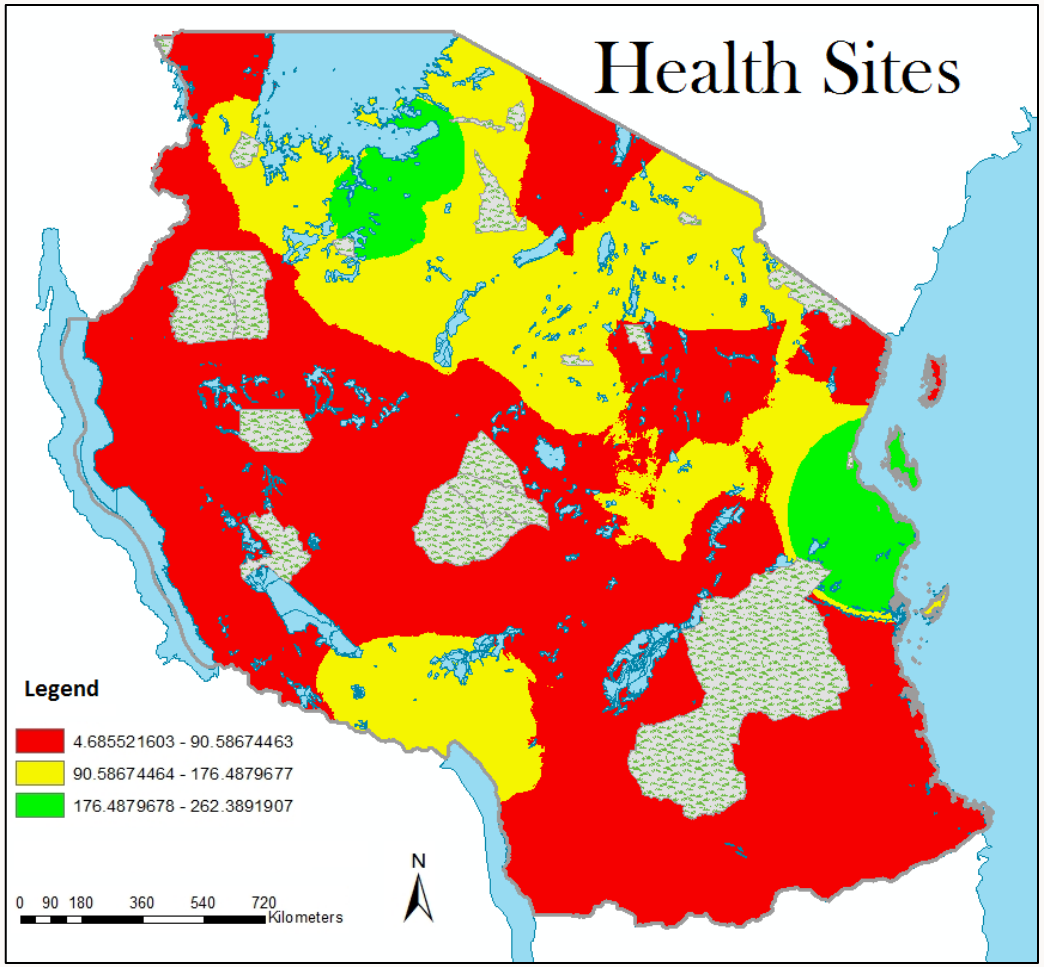
Health Sites

Health sites included hospitals, dispensaries, clinics, and medical centers of public, private and faith based entities.

Low 177-262

Med 91-176

High 4-90



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Preliminary Results

Site	Rainfall	Altitude	Dist. to Water	Dist. to Road	ITN Use	Health Site
A	Moderate	Low	Mixed	Mixed	Low	Moderate-High
B	Moderate	Moderate	Mixed	Mixed	Low	High
C	Moderate	Low-Moderate	Mixed	Low-Moderate	High	High
D	High	High	Mixed	Low-Moderate	Moderate-High	High

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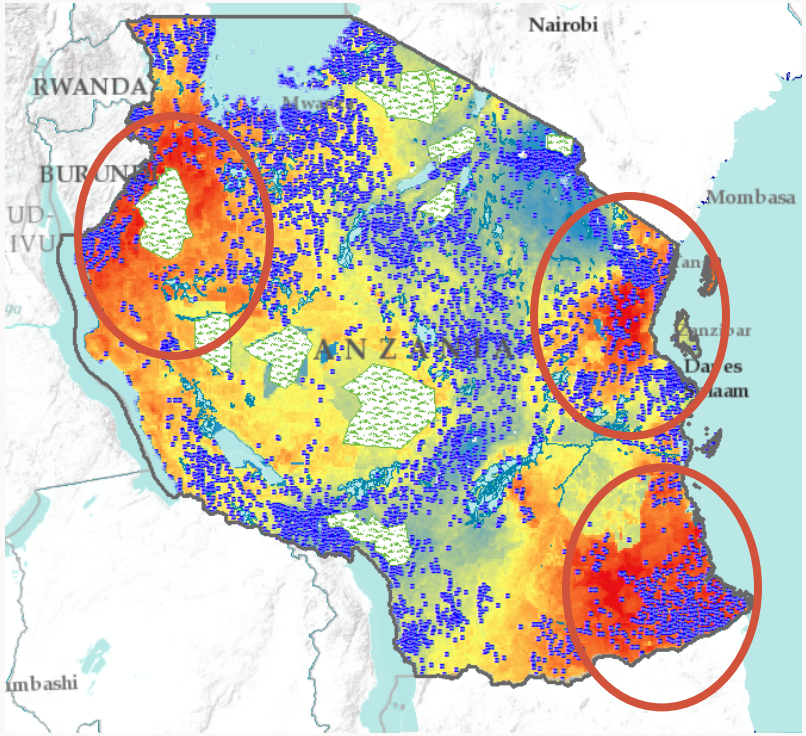
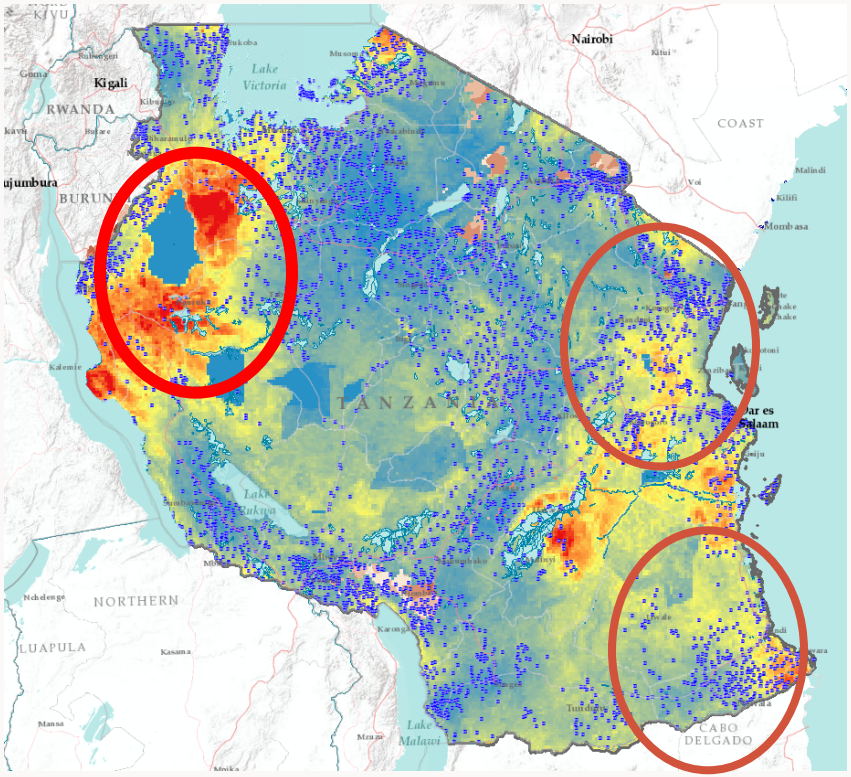
Malaria Incidence & Hospital Distribution

2002



2015



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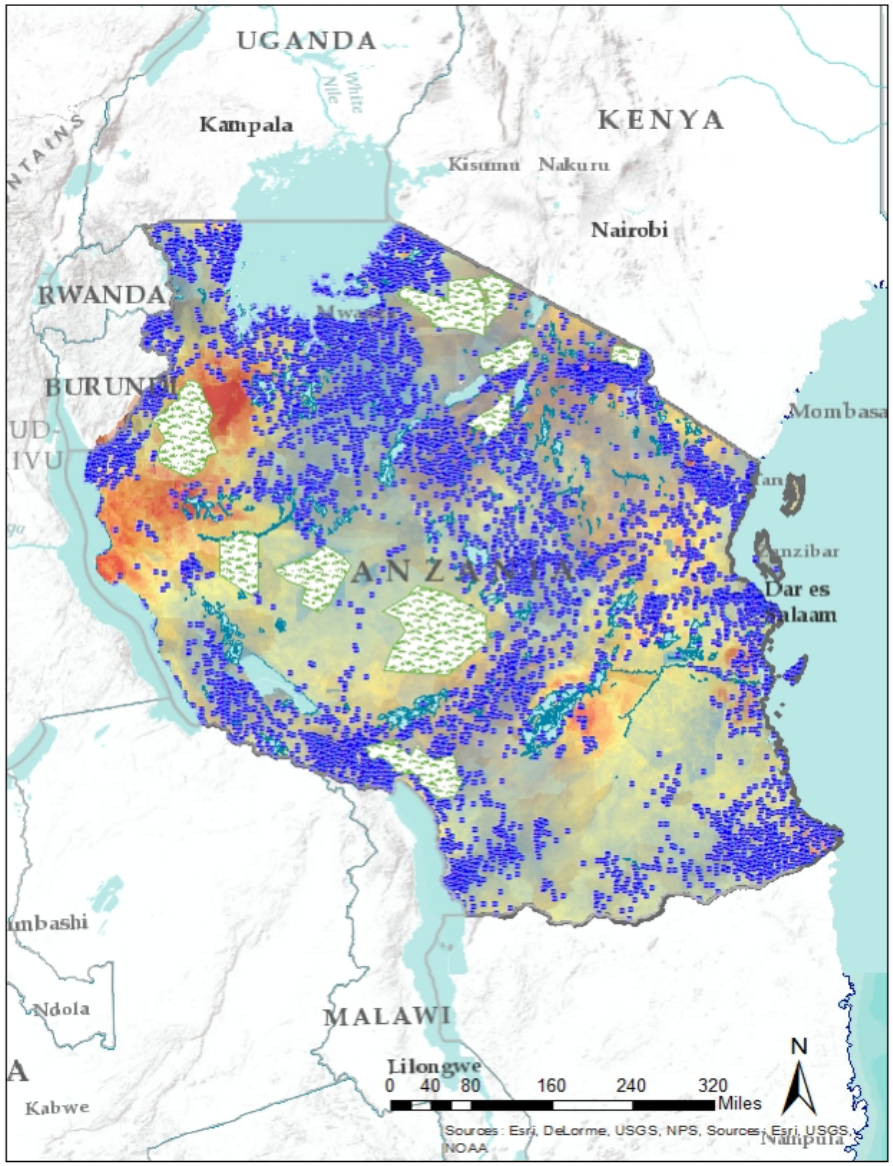
Tanzania Malaria Factors: ITN Use, PR incidence, Population & Helath Site Distribution



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Conclusions

Despite diverse and varying levels of risk for other risk factors, **health sites** seem to be **consistent factor** of **high risk** for chosen high incidence areas. Other than distance to water having relatively comparable mixed presence in the four selected sites, low hospital presence is the only factor of moderate to high risk for all four sites.

I suspect this has a great deal to do with access to medical treatment for malaria, especially since treating symptoms of potential malaria cases early may result in fewer clinical cases, and thus lower incidence.

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Limitations

1. Not all risk factors were considered. Such as:
   Environmental: Humidity, Temperature
   Parasitological: Drug Resistance
2. Directionality not examined. Unable to determine causal relationship.
3. Cross sectional data from differing time periods, due to availability of data.
4. Equally Weighted Risk

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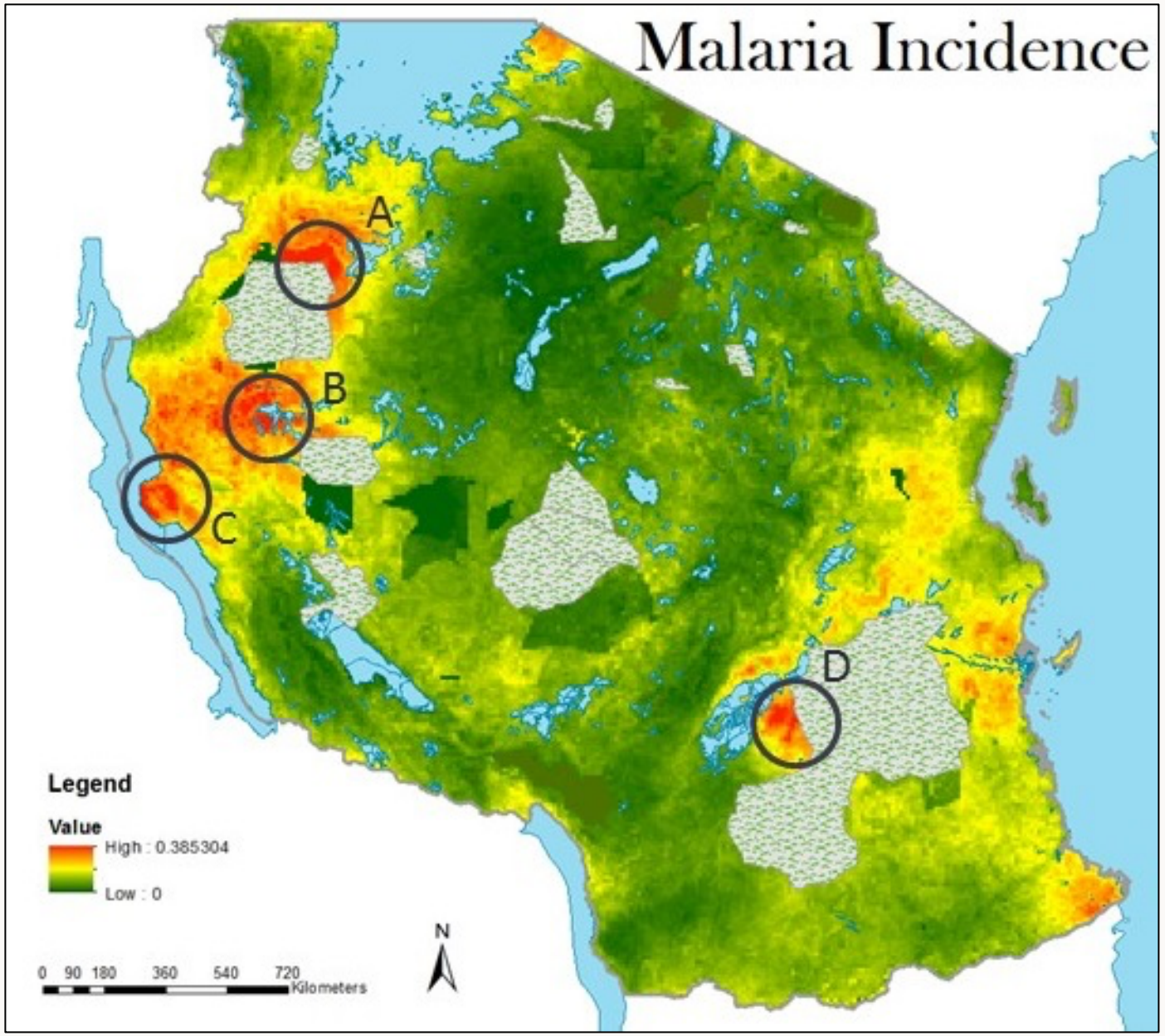
Implications

With the approval of the new malaria vaccine that is being rolled out in a pilot group of nations in Africa, Tanzania not being one of them, health sites will certainly play a vital role in inoculation and vaccination coverage; which, if additional health facilities are not constructed in high incidence areas, will cause subsequent discrepancies and "hot spots" of new malaria cases.

- Future Research - More advanced spatial correlation with more relevant variables!

- On-the ground assessment!! Important.
  - Game reserve and lake role?



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[7] Malaria Atlas Project. http://www.map.ox.ac.uk/

[8] International Livestock Research Institute https://www.ilri.org/

[9] Diva GIS http://www.diva-gis.org/

[10] Geo Network http://geonetwork-opensource.org/

[11] Tanzania National Bureau of Statistics http://www.nbs.go.tz/

[12] Natural Earth http://www.naturalearthdata.com/

[13] Humanitarian Data Exchange https://data.humdata.org/

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