



The Night Light Development Index (NLDI): a spatially explicit measure of human development from satellite data

C. D. Elvidge, K. E. Baugh, S. J. Anderson, P. C. Sutton, and T. Ghosh

Ana Carolina de Faria Santos – 138592

População, Espaço e Meio Ambiente – SER457/CST310

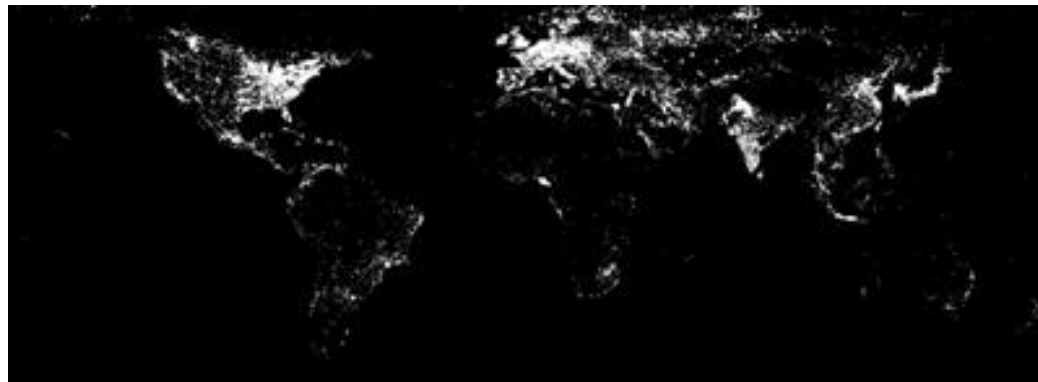
Dra. Silvana Amaral Kampel e Dr. Antonio Miguel Vieira Monteiro

Elvidge et al. The Night Light Development Index (NLDI): a spatially explicit measure of human development from satellite data. **Social Geography**, v. 7, p. 23–35, 2012.

LUZES NOTURNAS – DMSP/OLS

- Produtos advindos de uma classe de satélites de observação que detectam luzes de origem antropogênica na superfície terrestre
- Emissão gerada pelas luzes elétricas
- U.S. Air Force Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) - 1992 a 2013
- Suomi National Polar-orbiting Partnership (Suomi-NPP) Visible Infrared Imaging Radiometer Suite (VIIRS) - 2011 - atual

DMSP/OLS F15 2003 Nighttime
Lights Composite



ELVIDGE, C.D. et al. Why VIIRS data are superior to DMSP for mapping nighttime lights. **Proceedings of the Asia-Pacific Advanced Network**, v. 35, p. 62-69, 2013.

BENNETT, M.M.; SMITH, L.C. Advances in using multitemporal night-time lights satellite imagery to detect, estimate, and monitor socioeconomic dynamics. **Remote Sensing of Environment**, n. 192, p. 176-197, 2017.

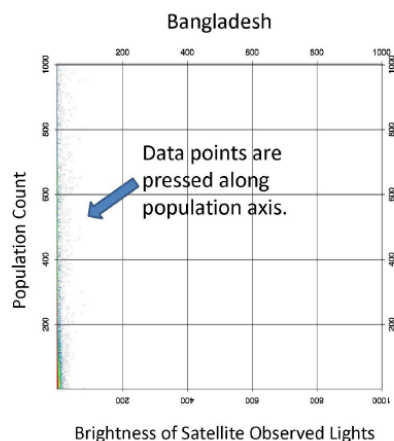


Figure 1. Scattergram of population versus the brightness of satellite observed lighting for Bangladesh in 2006. Note that the data points are compressed along the population axis with very little expansion along the lighting axis.

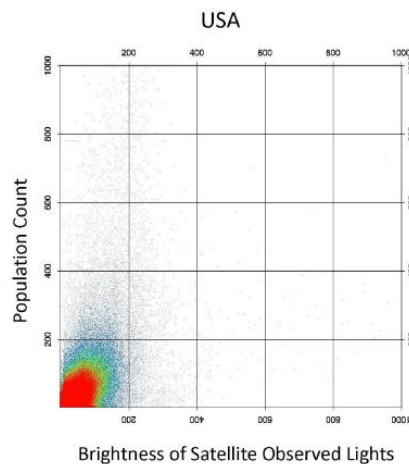


Figure 2. Scattergram of population versus the brightness of satellite observed lighting for USA in 2006. Note that the data cloud has a circular shape and is pressed against both axes at the origin.

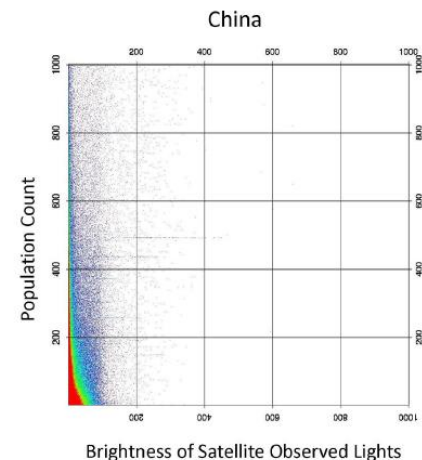


Figure 3. Scattergram of population versus the brightness of satellite observed lighting for China in 2006. Note that the data points are aligned along the population axis with evidence of expansion along the lighting axis.

- Avaliar o nível de desenvolvimento utilizando os padrões dos Gráficos de Dispersão
- Normalização:
 - Tamanho da população
 - Extensão da área

COEFICIENTE DE GINI

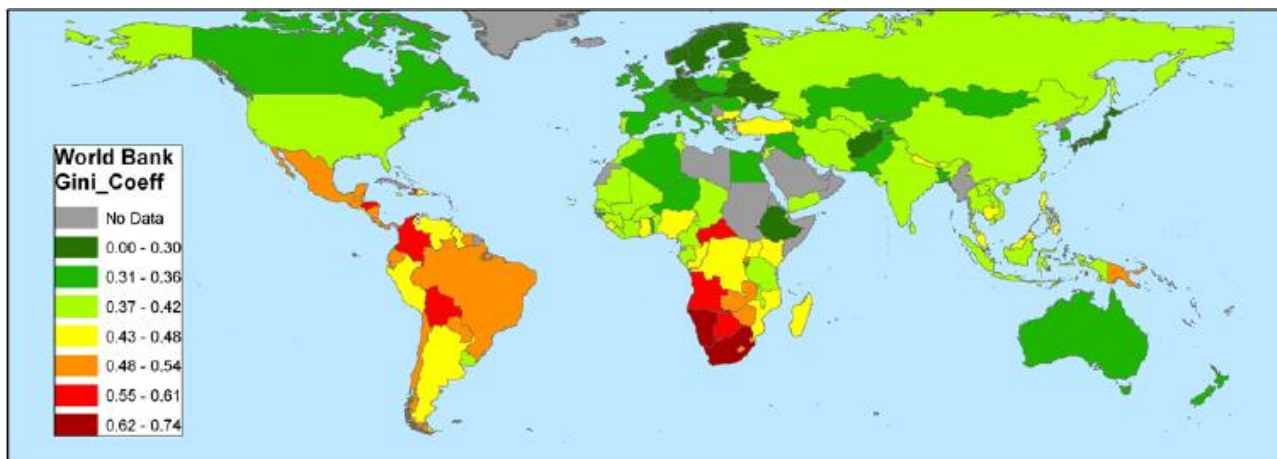
- Medir o grau de qualidade da distribuição de renda anual em uma população
- Não espacial – independe do espaço

Pontos Fortes:

- Independente da escala
- Independente da População
 - Fluxo de Capital

Limitações:

- Variação no Método de Coleta
 - Dados insuficientes
 - Subdivisão dos dados



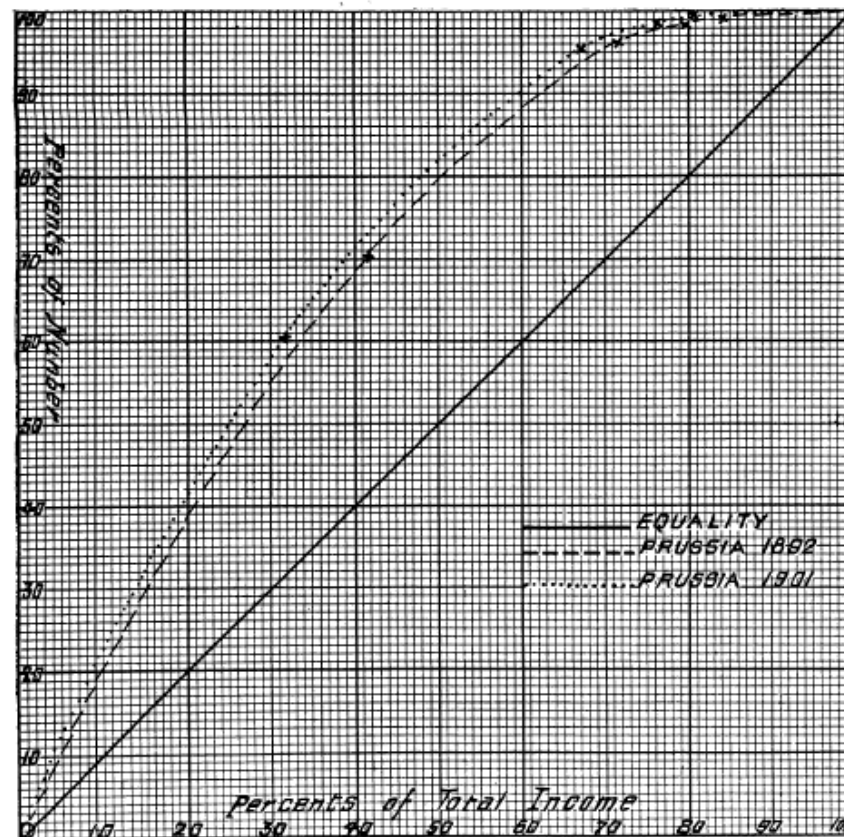
- Curva de Lorenz (Lorenz, 1905)

COEFICIENTE DE GINI - CURVA DE LORENZ

- Renda acumulada x população acumulada
 - Mais pobre ao mais rico

- 45° - Igualdade

- Valores de 0 (igualdade) a 1



$$G = 1 - \sum_{k=0}^{k=n-1} (X_{k+1} - X_k)(Y_{k+1} + Y_k)$$

onde:

- G = coeficiente de Gini
- X = proporção acumulada da variável "população"
- Y = proporção acumulada da variável "renda"

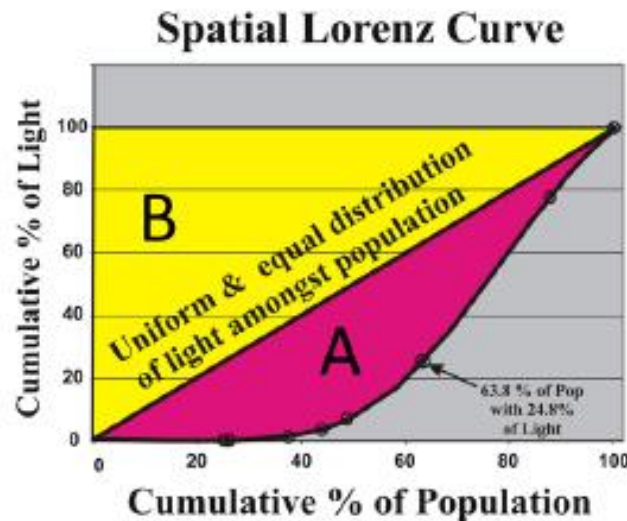
Amaral, S.K.; Monteiro, A.M.V. (2017)

Lorenz, M. O. Methods of measuring the concentration of wealth. Publications of the American Statistical Association, v. 9, n. 70, p. 209–219, 1905.

OBJETIVOS

É possível estimar as disparidades na distribuição de renda através da relação de luzes noturnas com uma grade de dados populacionais?

- Co-distribuição de luzes noturnas e pessoas → Curva de Lorenz



The NLDI metric

$$\frac{A}{B}$$

A 'NLDI' of 1.0 implies one person lives where all the light is and everyone else is in the dark.
 A 'NLDI' value of 0.0 implies light is distributed equally amongst all people.

DADOS DE ENTRADA

Luzes Noturnas:

- DMSP/OLS 2006 - cloud-free composites
- Baugh et al. (2010) – processamento
- ND convertido para Radiância

População:

- Landsan grid 2006

- Obtidos de forma independente
- Mesma Projeção Cartográfica
- Mesma Resolução Espacial

- Espaço Celular – Tabela de Atributos com valores de população e de luzes

CÁLCULO NLDI

**10 km x 10 km
Population Grid**

0	0	8	6	0	0	0	0	8	8
0	0	1	1	2	1	2	1	4	1
1	1	3	2	3	4	4	4	3	1
1	1	4	6	6	5	10	5	5	2
1	2	5	5	10	18	10	18	18	3
1	3	5	5	10	38	50	38	16	4
2	2	5	10	10	58	180	58	16	10
15	5	5	5	10	38	50	38	18	3
4	3	5	5	10	18	10	18	16	2
0	2	5	6	6	5	10	5	5	1

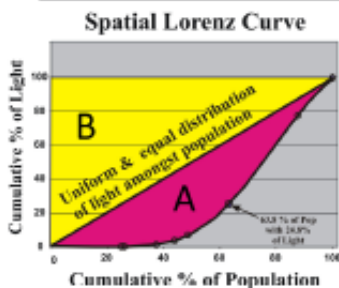
**10 km x 10 km
DMSP OLS Image**

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	2	8	8
0	0	0	0	2	2	16	1	2	0
0	0	0	0	2	50	158	58	5	0
0	0	0	0	10	158	355	150	16	2
5	0	0	0	2	50	158	58	5	0
0	0	0	0	0	5	16	5	2	0
0	0	0	0	0	0	0	0	0	0

Analysis of the population grid relative to the light grid (above) produces a table that contrasts % of Population to % of light in any given country or area (See table below).

Light Level (DN)	Pop in DN	Cum % of Light	Cum % of Pop
0	205	0.0	25.0
1	50	0.1	26.2
2	90	1.5	37.2
5	55	3.7	43.9
10	40	7.2	48.8
50	120	24.8	63.4
150	200	77.6	87.6
255	100	100.0	100.0

Total Pop = 820 Total Light = 1137



The NLDI metric

A (pink area)

B (yellow area)

A 'NLDI' of 1.0 implies one person lives where all the light is and everyone else is in the dark.
 A 'NLDI' value of 0.0 implies light is distributed equally amongst all people.

Figure 5. A graphical representation of the Gini coefficient. The coefficient is calculated as the area between the Lorenz curve and the diagonal divided by the area above the diagonal.

➤ Mesma fórmula do Coeficiente de Gini

➤ Níveis Espaciais

- Global
- Nacional
- Subnacional
- Grade

➤ Correlação com Índices Nacionais

- Gini coefficient (World Bank, 2010),
- Electrification rates (International Energy Agency, 2010),
- Human Development Index (World Bank, 2010),
- Human Security Index (www.humansecurityindex.org),
- Percent urban (World Bank),
- GDP per capita (World Bank, 2010),
- Percent living on \$2 or less per day (World Bank, 2010),
- Multidimensional poverty index (World Bank, 2010),
- ecological footprint (Global Footprint Network, 2010),
- total primary energy consumption per person (DOE Energy Information Administration, 2010),
- Electric power consumption per person (DOE EIA, 2010).

Night Light Development Index (NLDI)

- NLDI mede o nível de igualdade na distribuição de luz
- Países mais desenvolvidos possuem baixo valor de NLDI e quanto menor o desenvolvimento, mais alto será o valor do NLDI
 - Valores similares podem refletir diferentes desenvolvimentos*

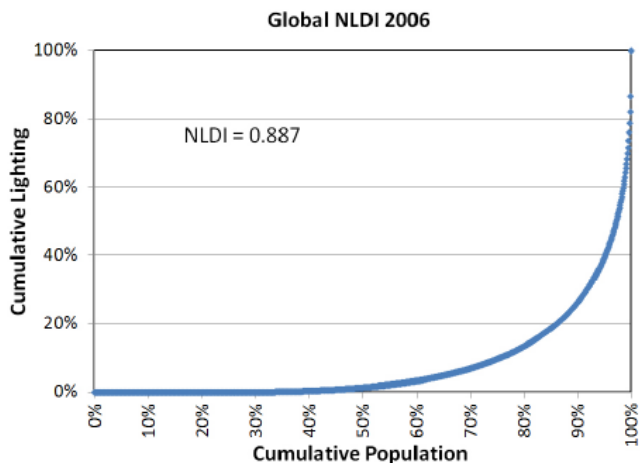
Em qual escala o NLDI pode ser usado como um proxy espacial para estimar renda ou outras variáveis de desenvolvimento?

Salvati, L. et al. An empirical assessment of human development through remote sensing: Evidences from Italy. *Ecological Indicators*, v. 78, p. 167–172, 2017

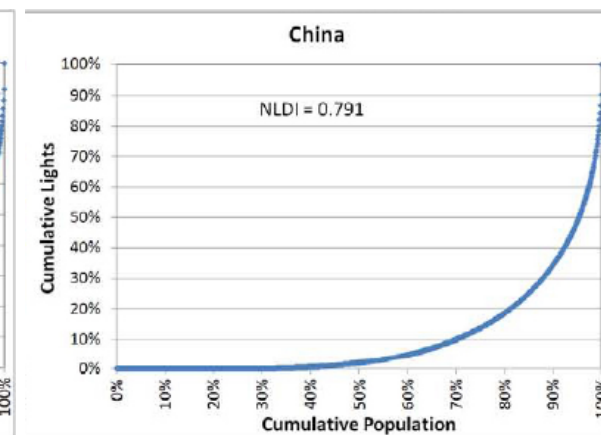
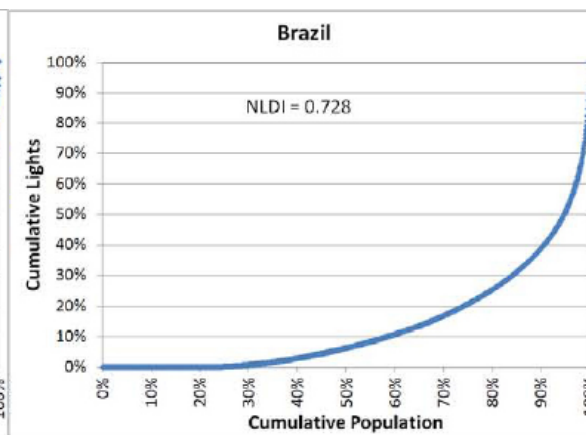
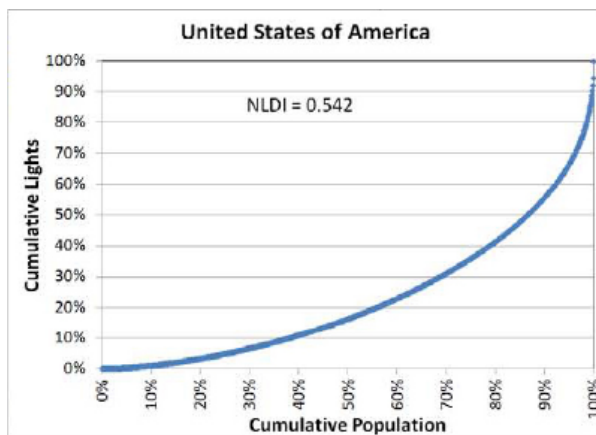
NLDI

National Level NLDI's

Arranged from low to high



COUNTRY NAME	NLDI
1 Singapore	0.520353
Puerto Rico	0.533734
United States	0.542142
Virgin Is.	0.547139
United Kingdom	0.567949
Syria	0.726687
New Zealand	0.727511
63 Brazil	0.727715
Saudi Arabia	0.729619
Kyrgyzstan	0.73193
Vanuatu	0.979758
Burundi	0.980956
Kiribati	0.984707
Papua New Guinea	0.985408
Solomon Is.	0.998823



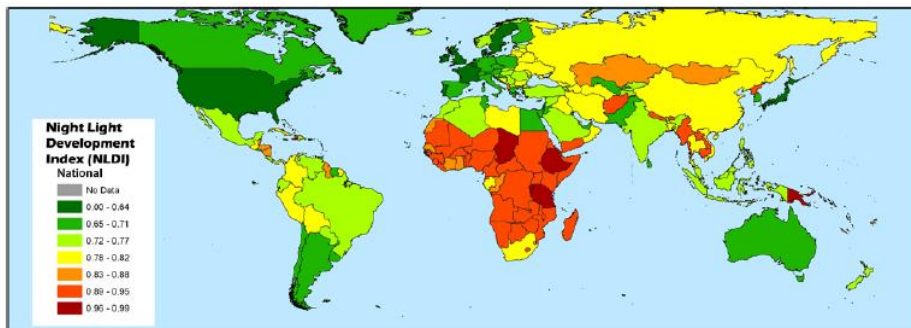


Figure 10. Map of national NLDI values.

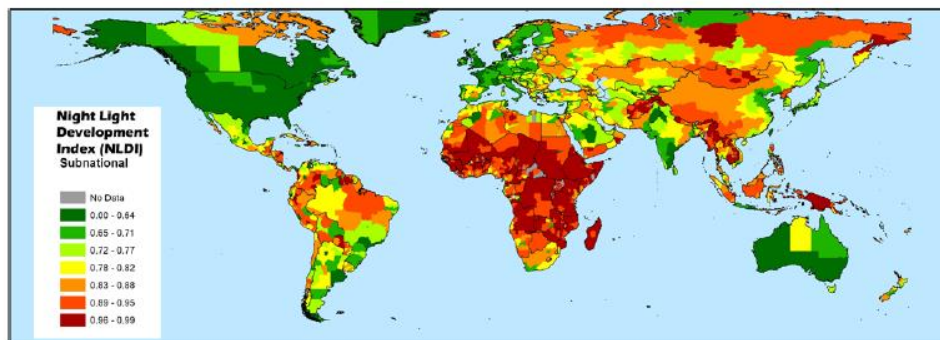


Figure 11. Map of subnational NLDI values.

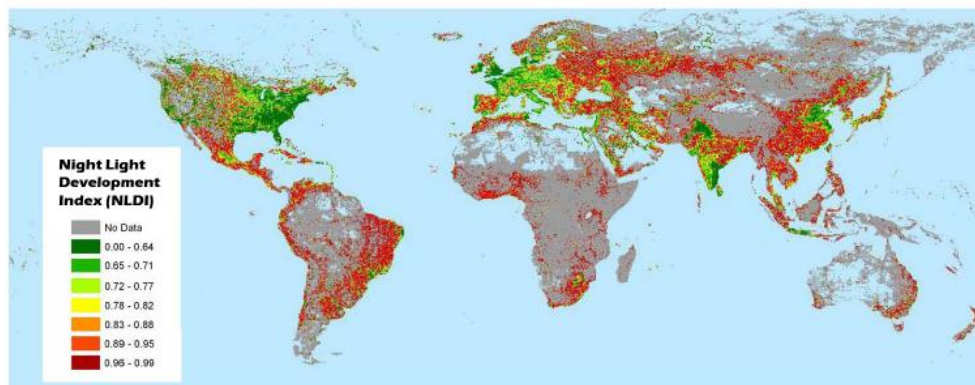
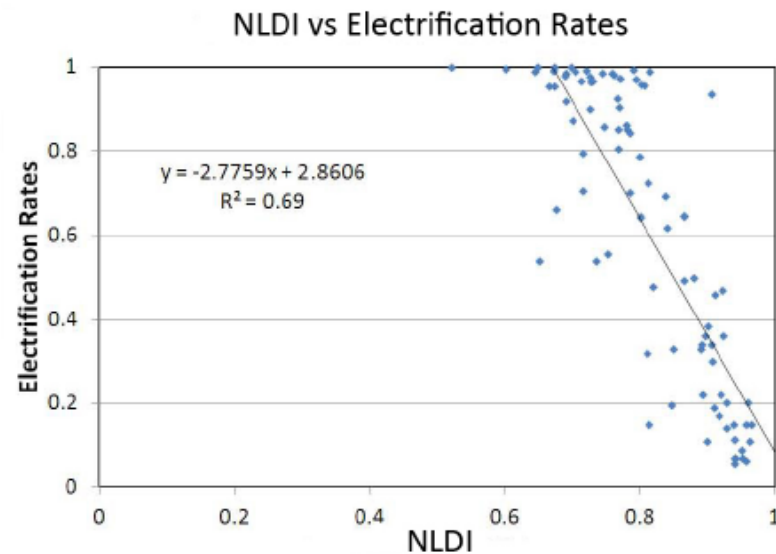
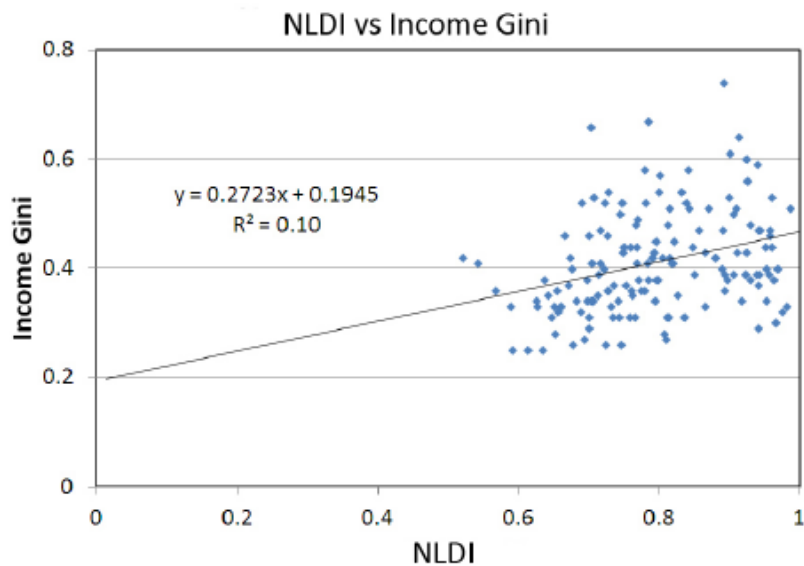


Figure 12. NLDI values produced on a 0.25 degree spatial grid.



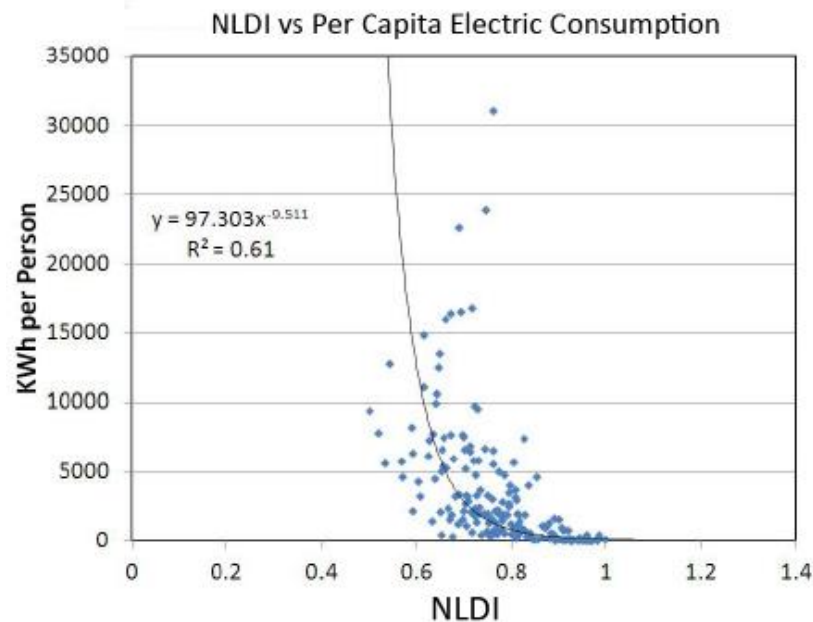
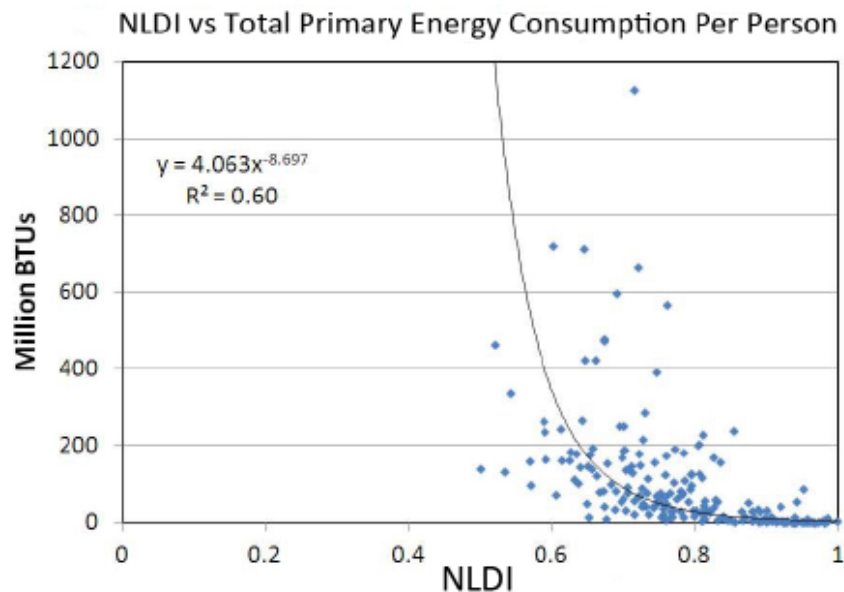
Correlação com Índices Nacionais



- Não correlacionado
- Áreas mais iluminadas → Mais população
- Várias distribuições de renda individuais

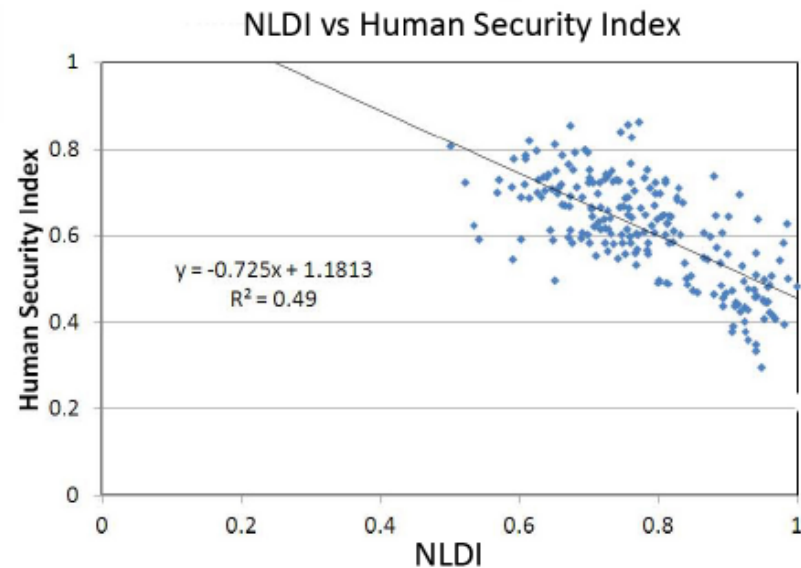
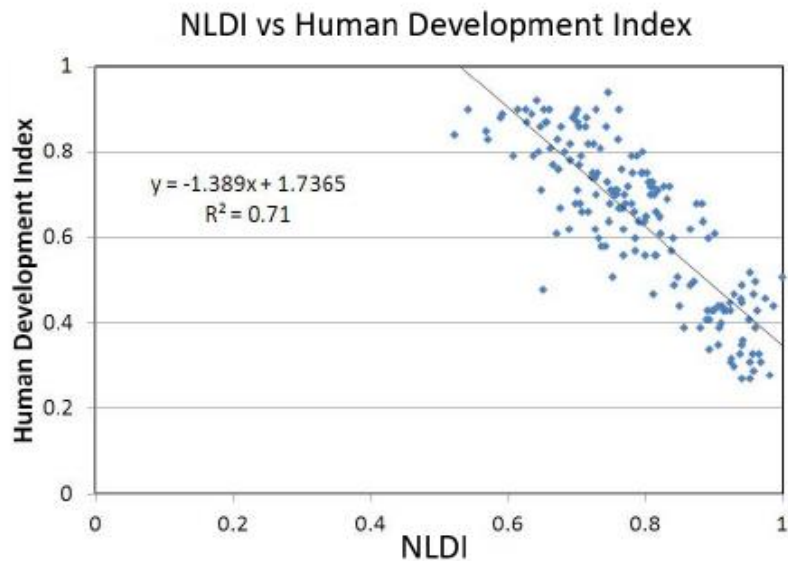
- Inversamente correlacionado
- Acesso a eletricidade → desenvolvimento?

Correlação com Índices Nacionais



- Relação exponencial
- Aumento consumo → Menor NLDI
- Medida de Desenvolvimento Social

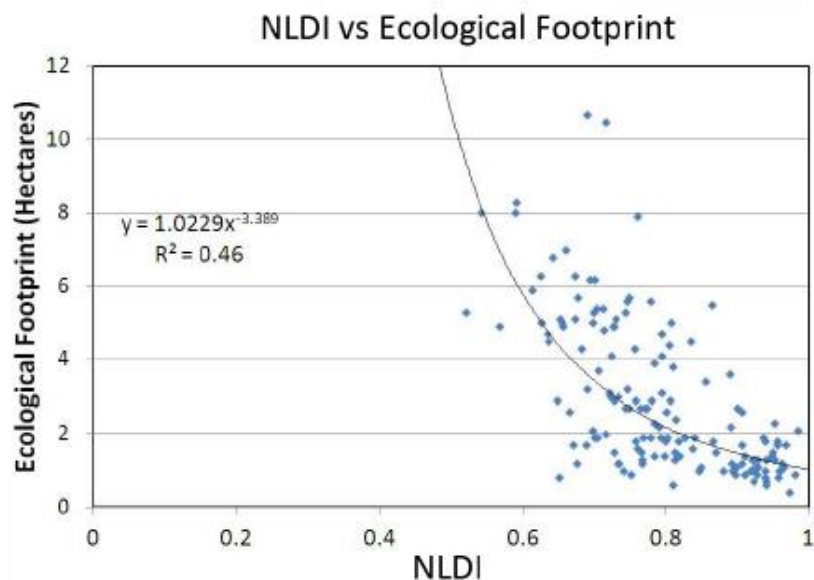
Correlação com Índices Nacionais



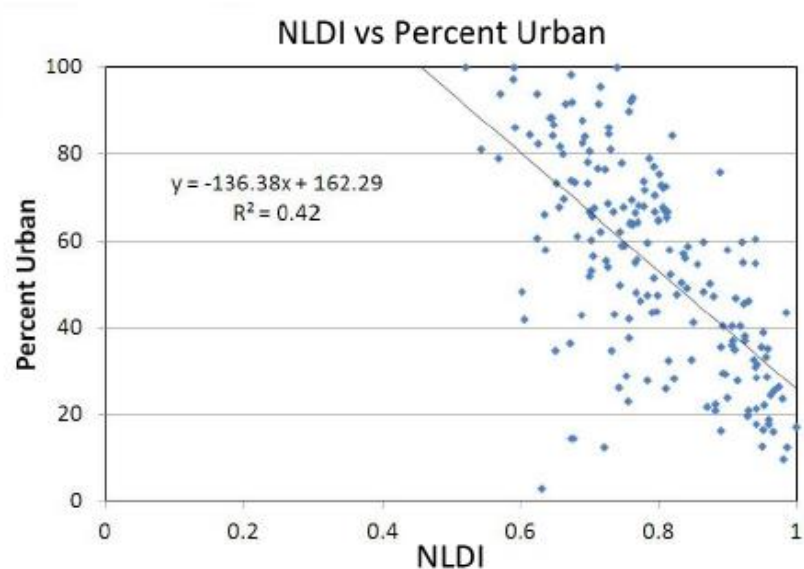
- Inversamente correlacionado
- NLDI interessante substituto

- Levemente correlacionado

Correlação com Índices Nacionais

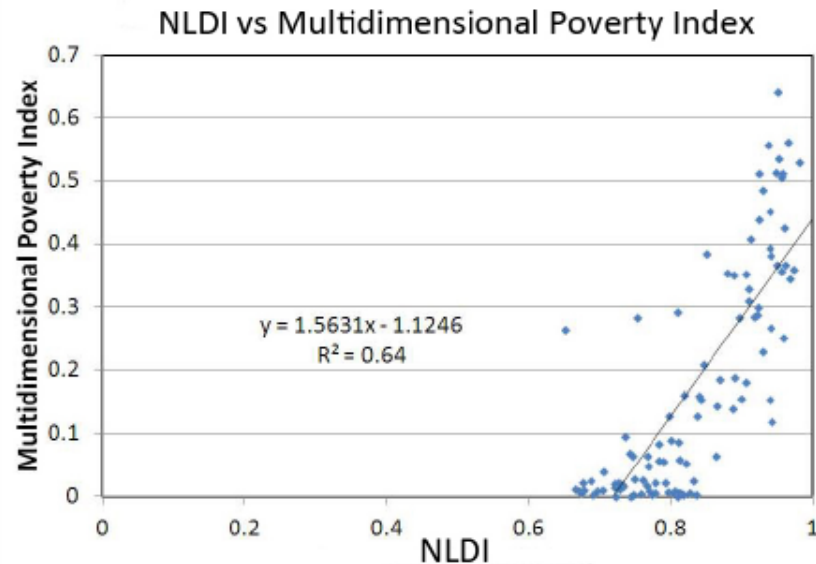
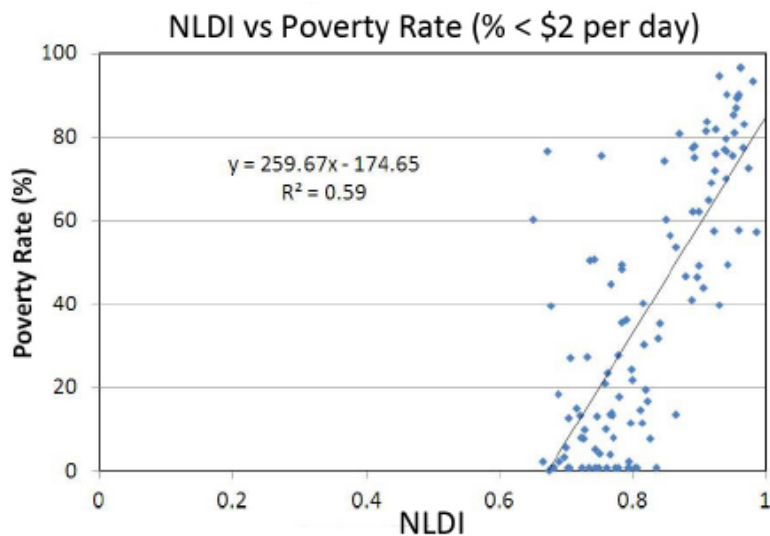


- Relação exponencial
- Medida de impacto



- Baixíssima correlação
- Indica outra medida para NLDI
- Urbanização não implica desenvolvimento

Correlação com Índices Nacionais



- Diretamente correlacionado
- Pobreza → Desenvolvimento

CONSIDERAÇÕES FINAIS

- NLDI pode ser gerado em diferentes níveis de agregação espacial
 - Correlação mais forte – IDH → substituto?
 - Não Correlação – Coeficiente de Gini
- } NLDI é um Índice de Desenvolvimento
- Medida espacial de distribuição de riqueza
 - Alta taxa de eletrificação *
 - Diferenças na distribuição espacial de pessoas*

Salvati, L. et al. An empirical assessment of human development through remote sensing: Evidences from Italy. Ecological Indicators, v. 78, p. 167–172, 2017

OBRIGADA!

Ana Carolina de Faria Santos – I38592

População, Espaço e Meio Ambiente – SER457/CST310

Dra. Silvana Amaral Kampel e Dr. Antonio Miguel Vieira Monteiro

Elvidge et al. The Night Light Development Index (NLDI): a spatially explicit measure of human development from satellite data. **Social Geography**, v. 7, p. 23–35, 2012.