Estimating the Information and Communication Technology Development Index (IDI) using nighttime satellite imagery

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Indicators of the IDI

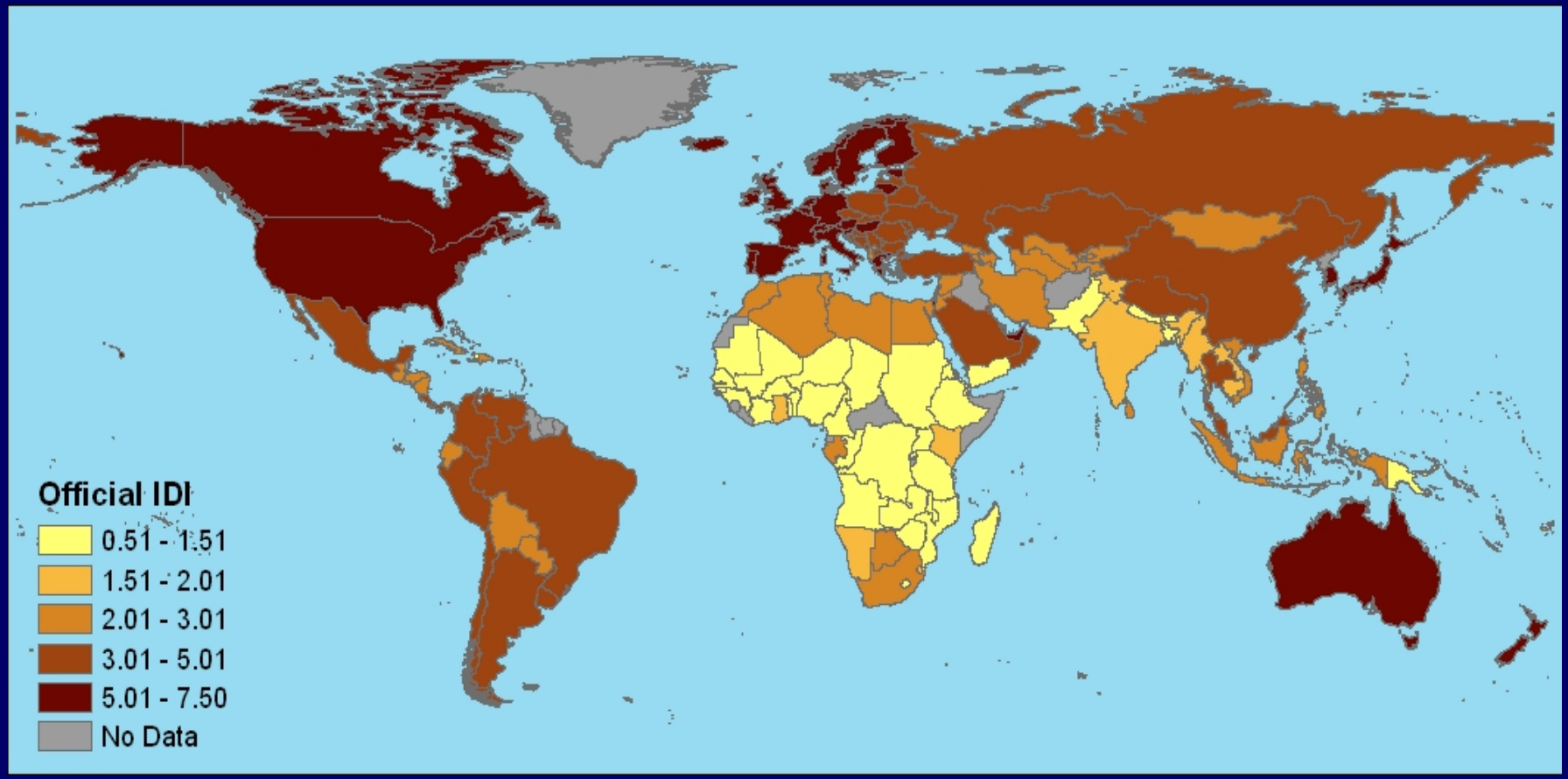
- IDI developed by the International Telecommunication Union (ITU), United Nations agency
- Includes ICT access, ICT use, and ICT skills
- ICT access –
  - Fixed telephone lines per 100 inhabitants
  - Mobile cellular telephone subscriptions per 100 inhabitants
  - International internet bandwidth (bit/s) per internet user
  - Proportion of households with a computer
  - Proportion of households with internet access at home

Indicators of the IDI

- ICT use –
  - Internet users per 100 inhabitants
  - Fixed internet broadband subscribers per 100 inhabitants
  - Mobile broadband subscriptions per 100 inhabitants

- ICT use –
  - Adult literacy rate
  - Secondary school enrollment ratio
  - University enrollment ratio

Map of official IDI values of the countries of the world (2007)



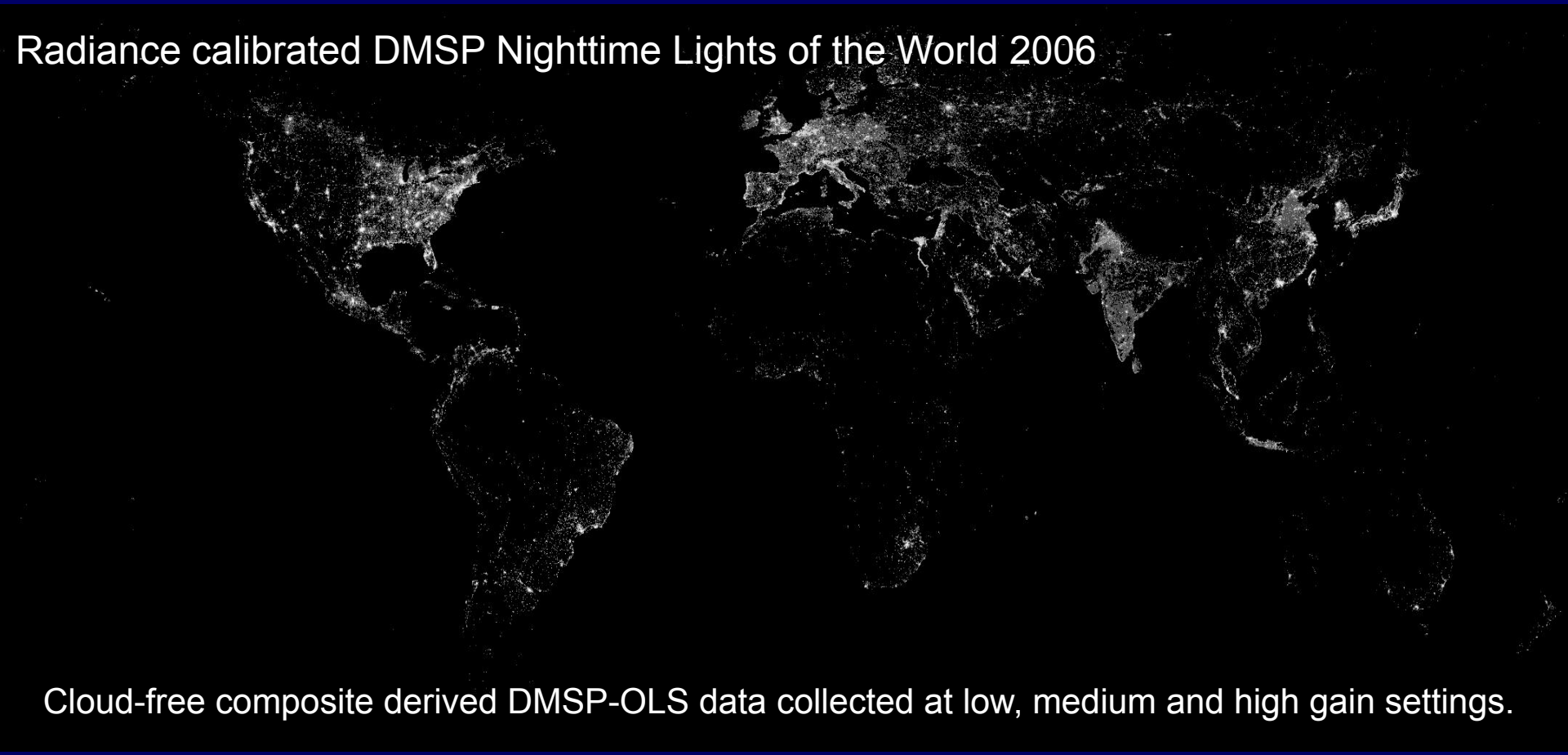
There is a relation between IDI and Gross Domestic Product (GDP) per capita of countries

Objectives

- Is it possible to assess which countries are moving ahead and which countries are lagging behind in ICT development from the nighttime satellite imagery?
- Estimate the IDI of countries by using GDP per capita estimated from nighttime satellite imagery and LandScan population grid
- Attempt at creating a disaggregated map of IDI

Data Used

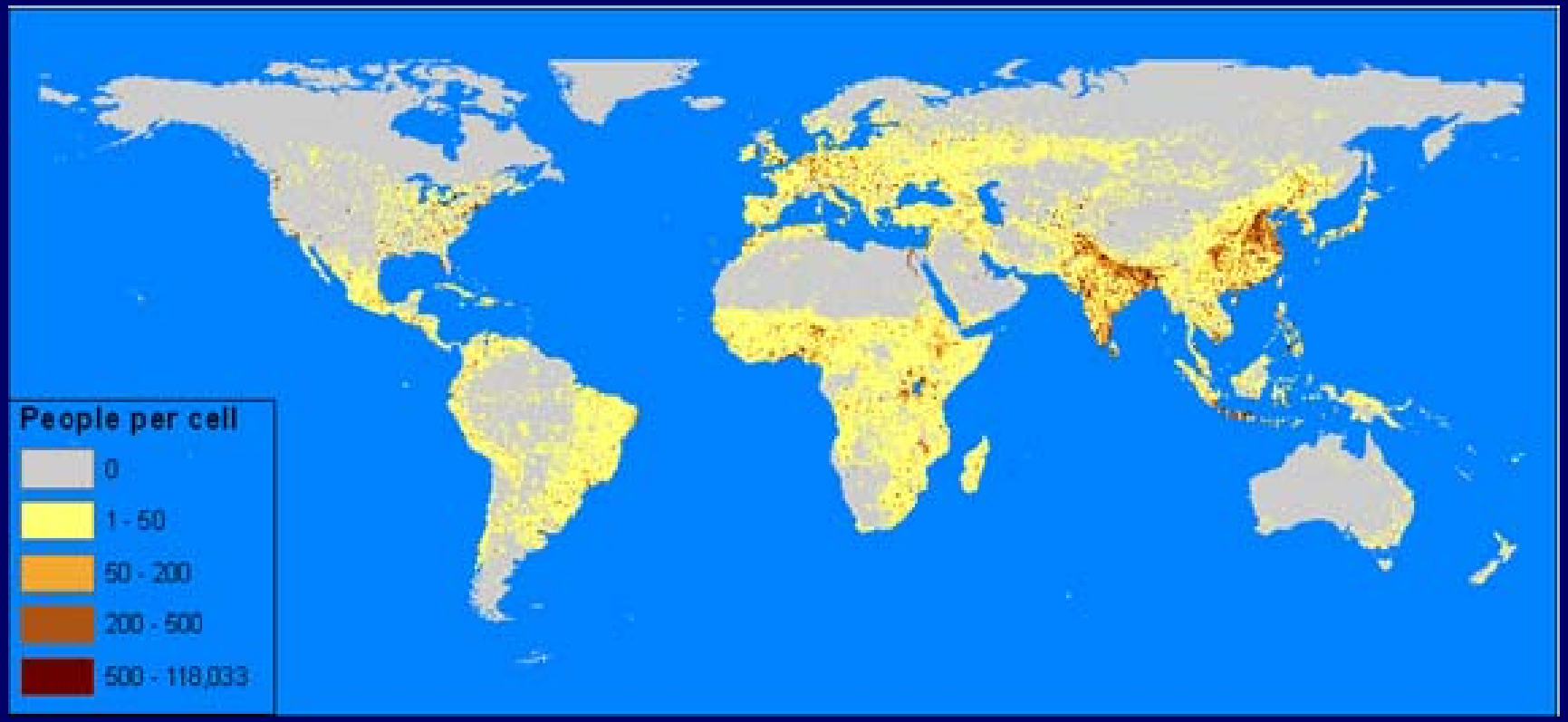
Merged stable lights and radiance calibrated image of 2006



Cloud-free composite derived DMSP-OLS data collected at low, medium and high gain settings.

30 arc-second grid or approximately 1 km^2 at the equator

LandScan population grid



- US Laboratory Department of Energy, Oak Ridge National Laboratory
- Representing ambient population count per cell
- 30 arc-second grid or approximately 1 km^2 at the equator

Other data sources

- Official GDP data (2006) of all the countries of the world (PPP US$)

  2008 World Development Indicators and CIA World Factbook

- Official GSP data (2006) of the states of the US, Mexico, India, and China

  US Bureau of Economic Analysis, Instituto Nacional de Estadistica Geografia (INEGI), Central Statistical Organization, National Bureau of Statistic of China

- Informal economy estimates (2005 and 2006)

  Estimates made by Friedrich Schneider (University of Linz, Austria) using the Dynamic Multiple Indicators Multiple Causes (DYMIMIC) model

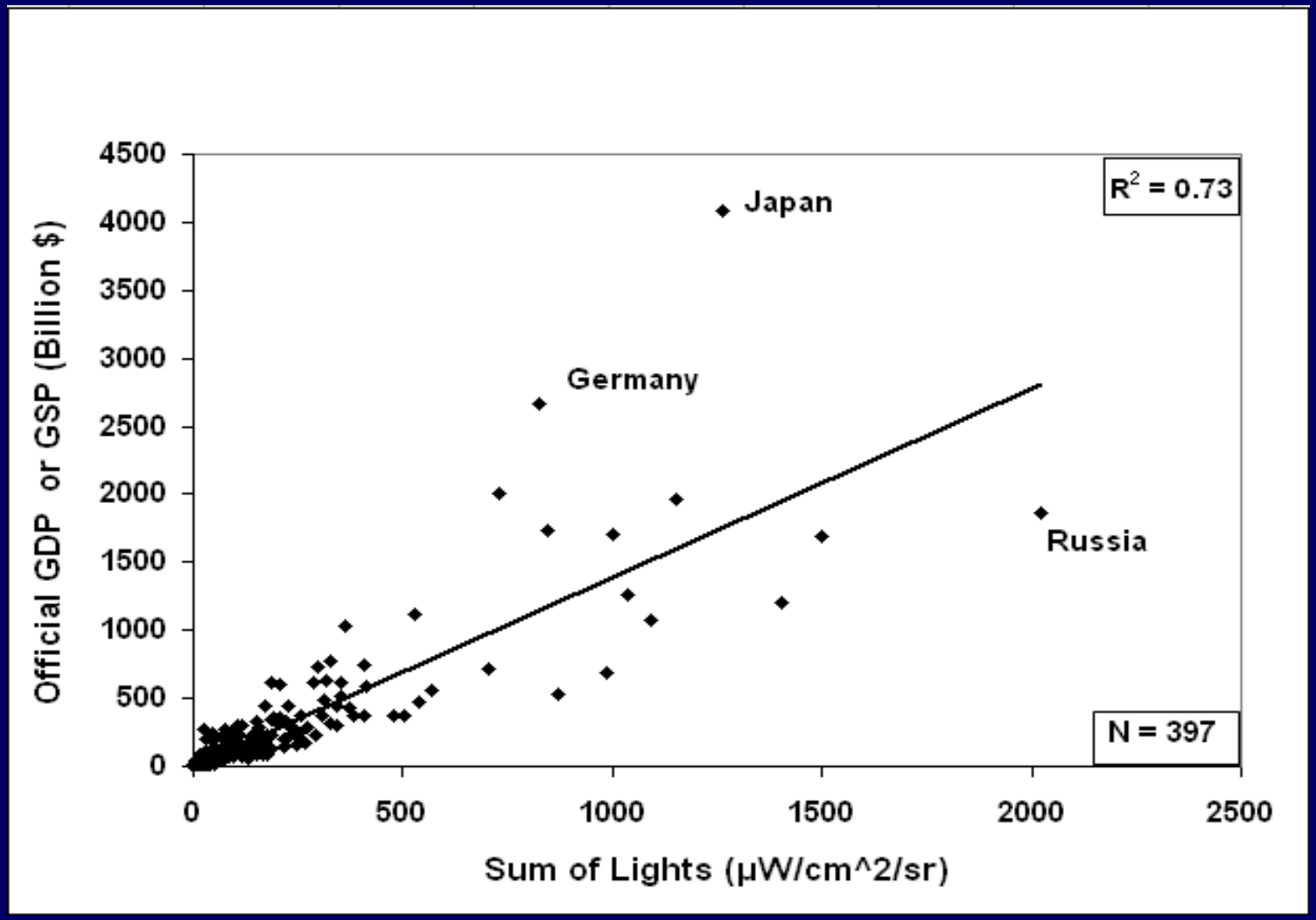
- Percentage contribution of agriculture towards GDP (2005 & 2006)

  World Development Report of 2008, and CIA World Factbook

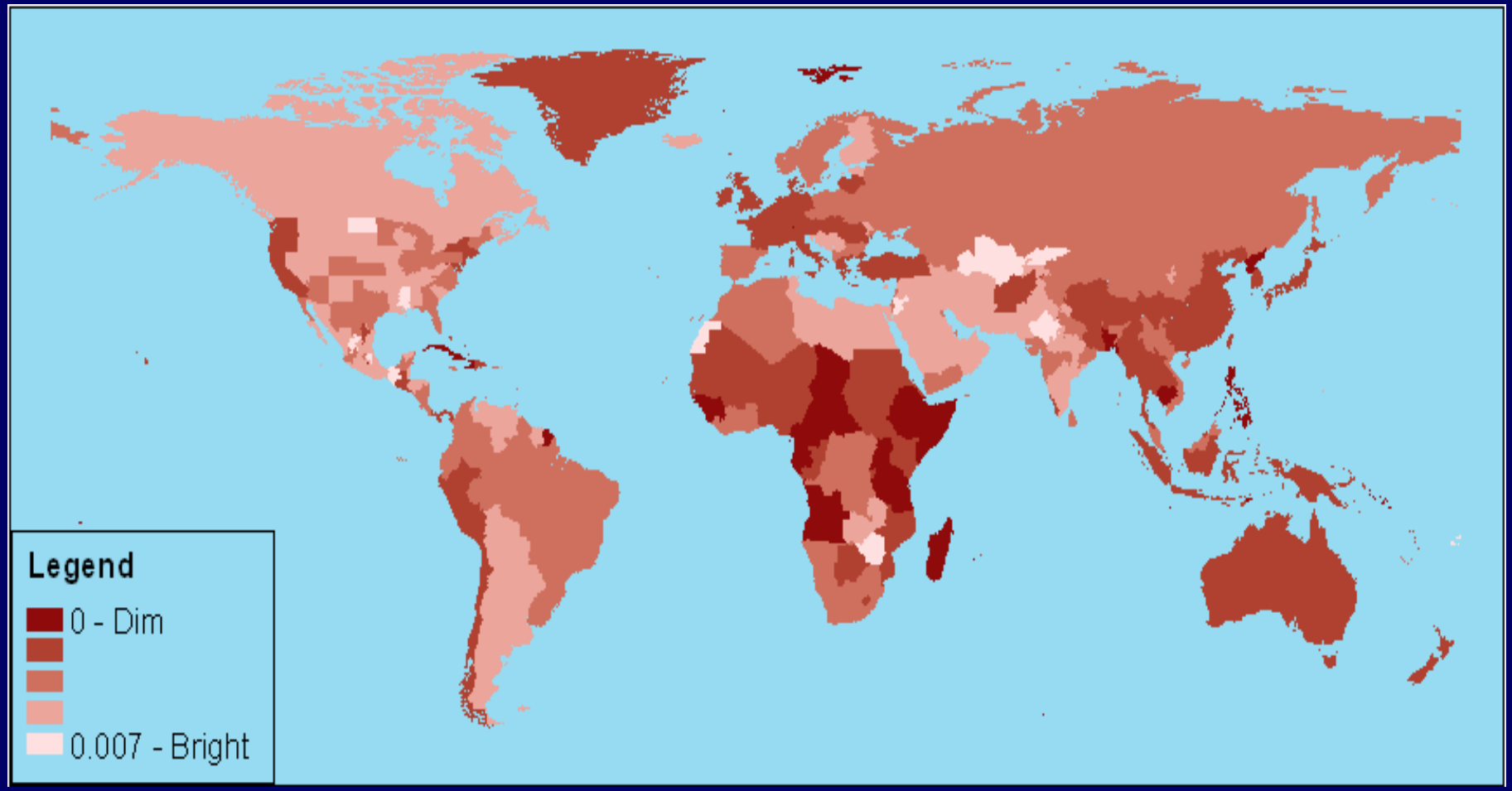
- IDI of the countries of the world (2007)

  International Telecommunication Union

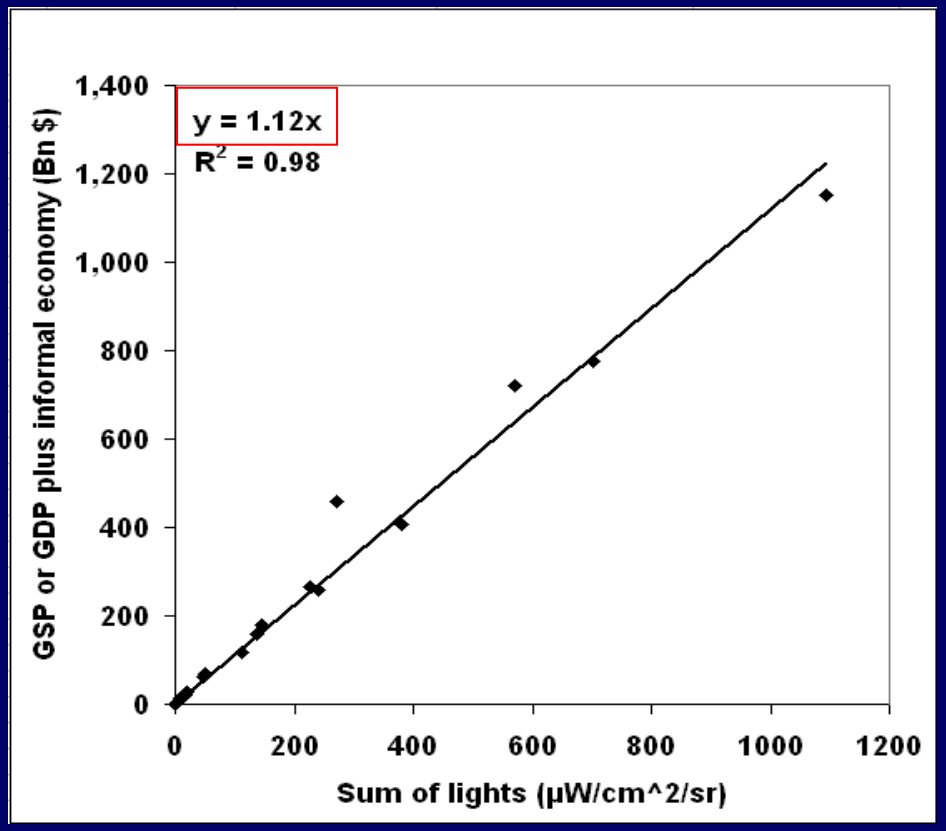
Large errors result when estimating GDP based on DMSP nighttime lights if all the data are pooled. We attribute this to differences in lighting technology and lighting preferences.



Map showing ratio of sum of lights to official GDP_i of the countries and GSP_i of the states of the U.S., Mexico, China and India



Estimating coefficients

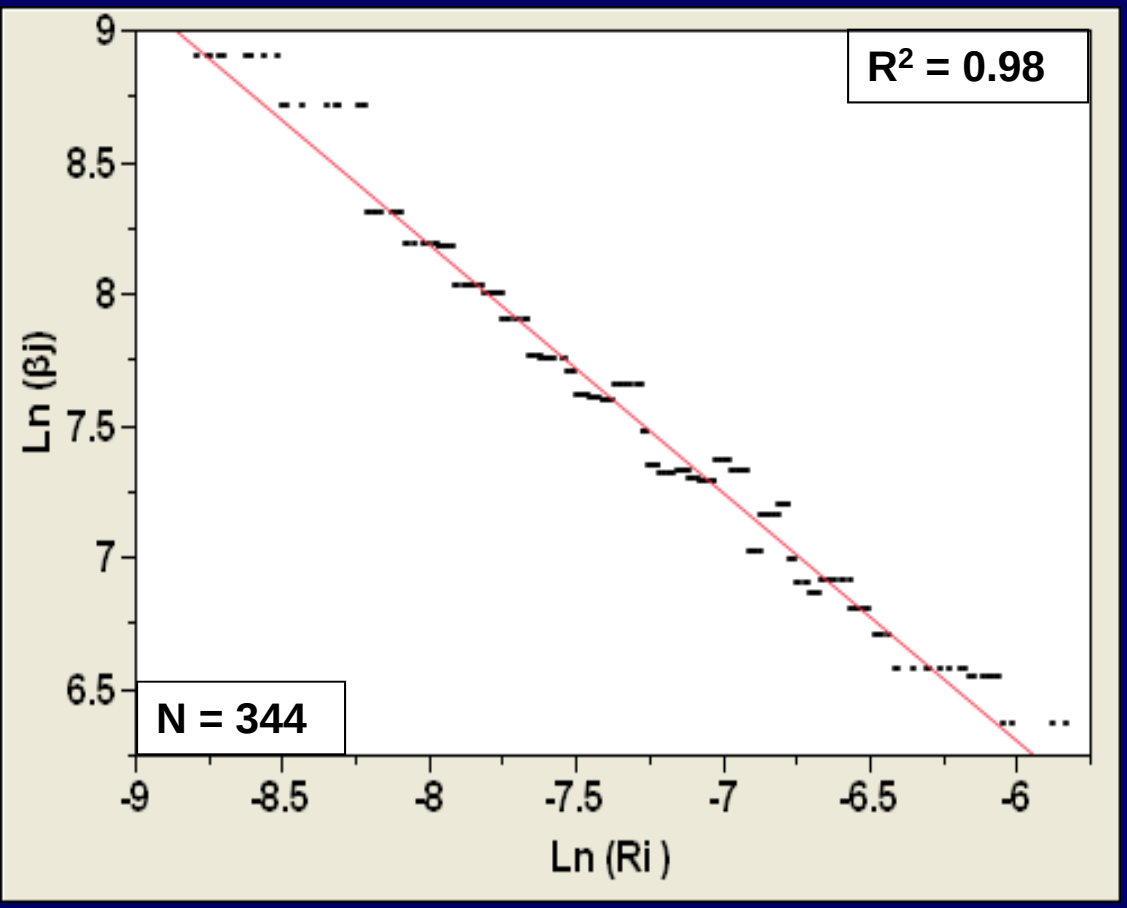


Showing the calibration regression of the twenty-fifth group

- Ratios (R_i) of the 397 administrative units sorted into ascending groups
- Binned into groups of 20 with 10 overlapping administrative units in each group (Total of 36 groups)
- Establishing calibration – regressing Sum of lights (SL_i) to GDP or GSP plus Schneider's informal economy estimates ($GDPS_i$ or $GSPS_i$) for each of the 36 groups
- Intercept was set to 0
- R^2 of 0.9 was obtained for all the groups
- Estimated coefficients β_j was obtained for each group j

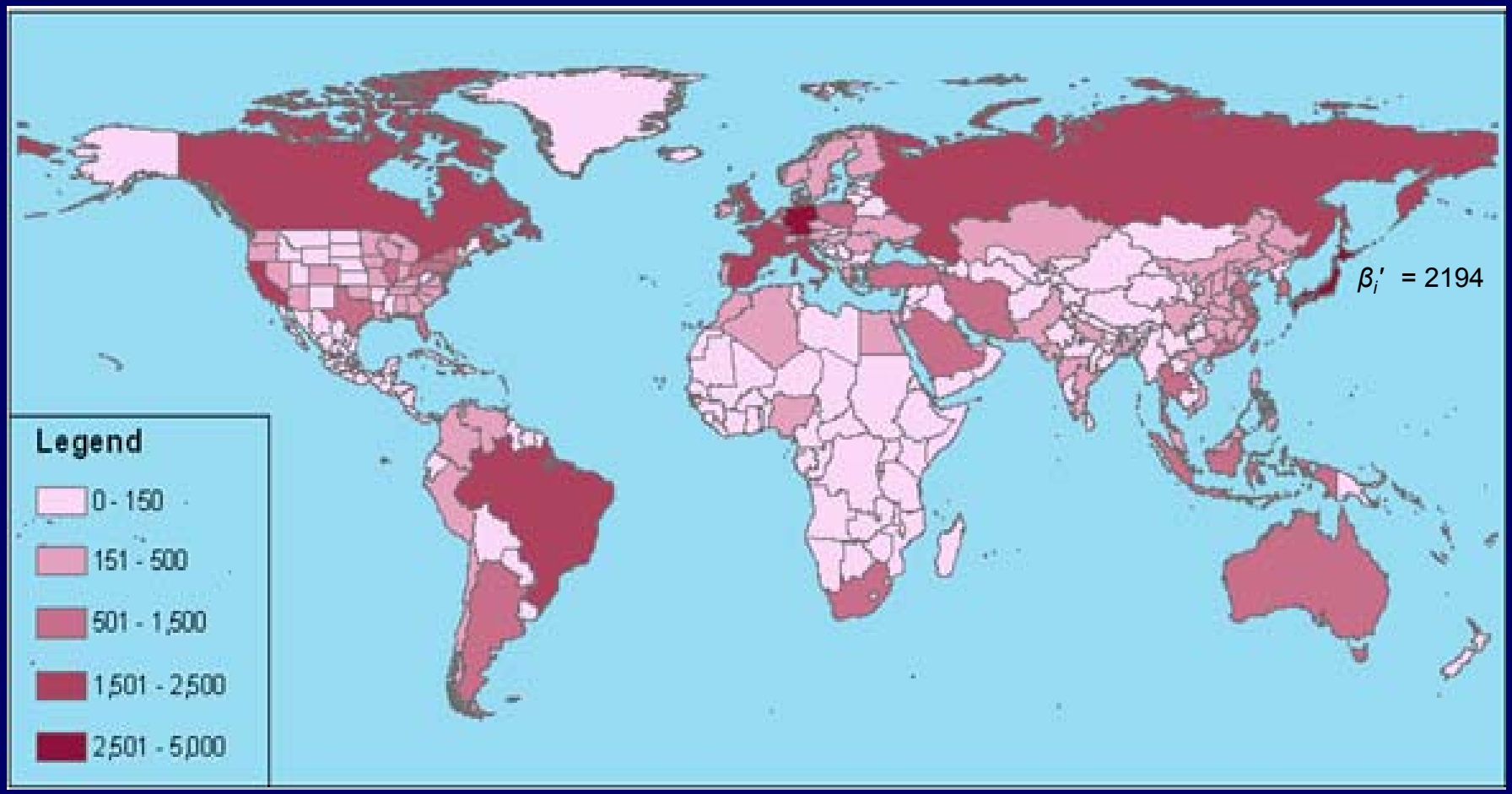
Estimating unique coefficients

For the administrative units



A logarithmic regression is used to derive a function for estimating the unique coefficient ($\beta i'$) for estimating GDP / GSP for any state or country based on R_i, the ratio of their brightness divided by GDP / GSP and estimated coefficients across all groups $\beta_i' = \text{Exp}\ (0.65 - 0.94 * \ln\ (R_i))$.

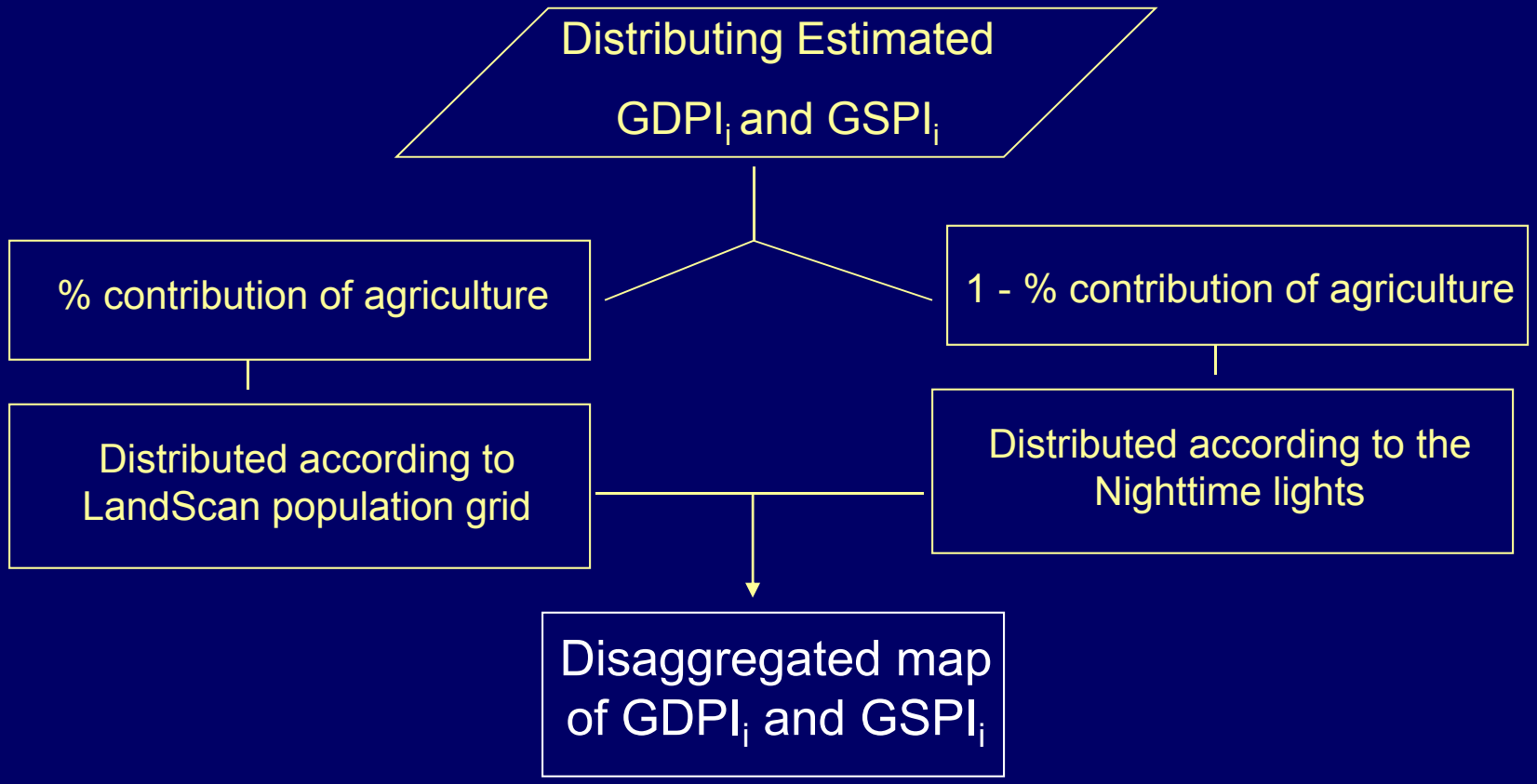
Estimating $GDPI_i$ for the countries and $GSPI_i$ for the states of the China, India, Mexico, and the U.S. (in billions of US dollars)



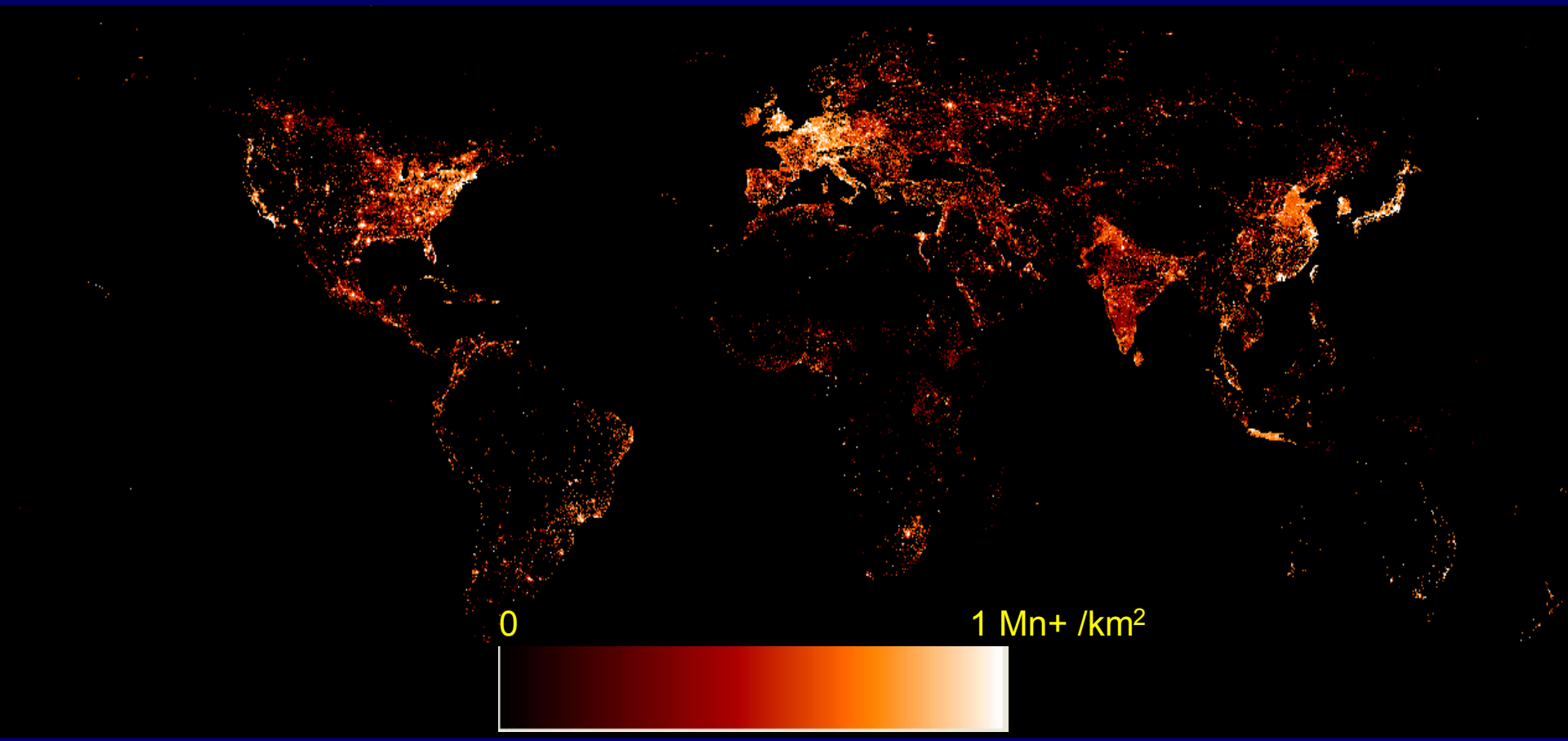
$$SLi \times \beta i' = GDPI_i$$

$$SLi \times \beta i' = GSPI_i$$

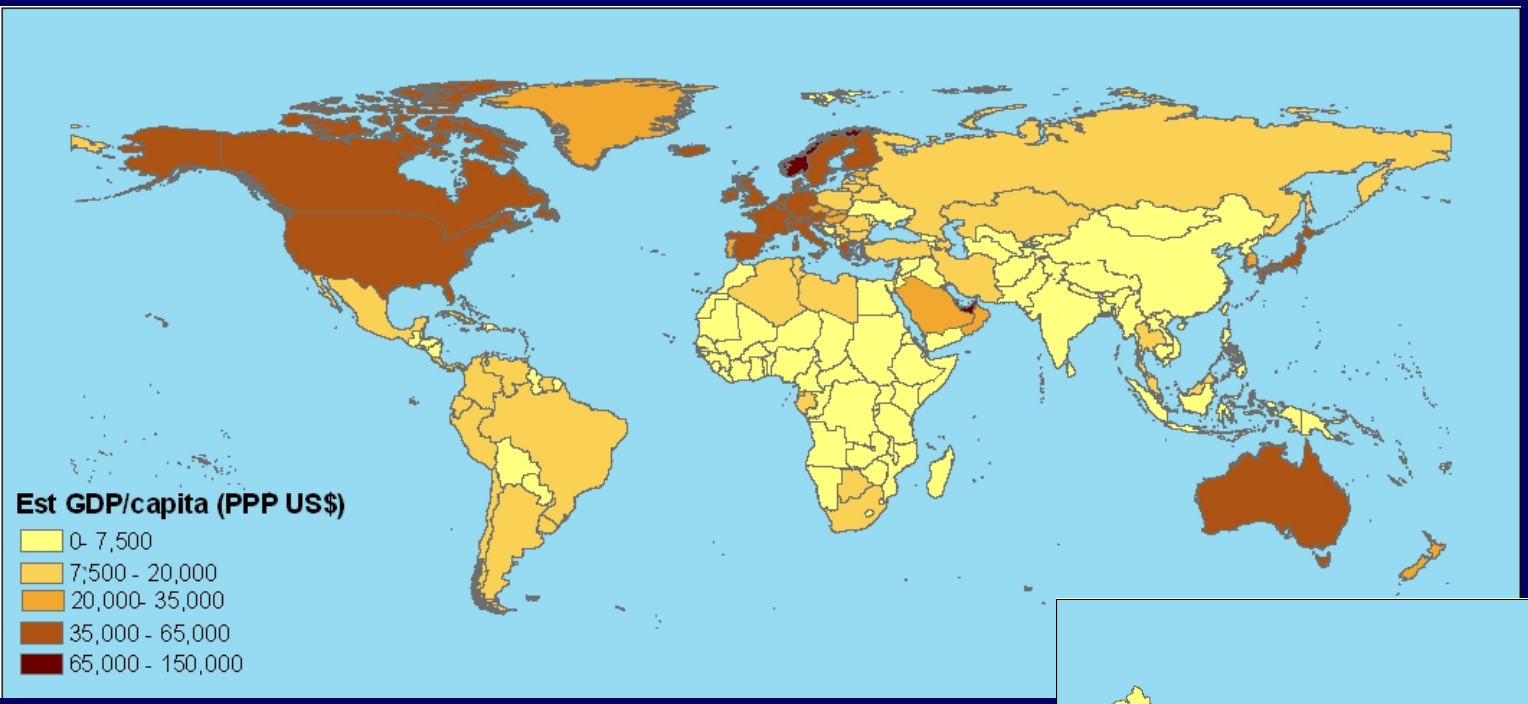
Distributing estimated $GDPI_i$ and $GSPI_i$

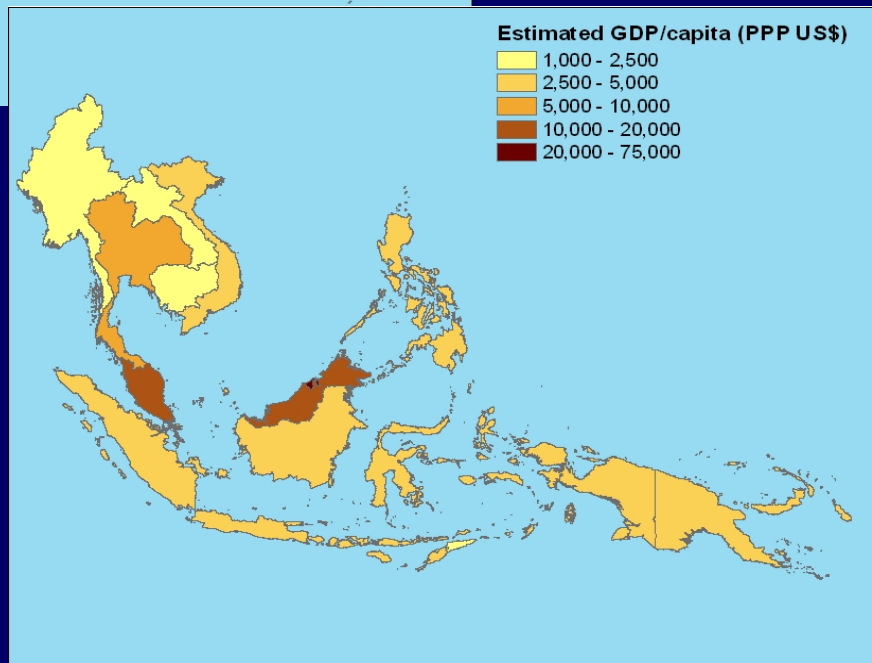


Disaggregated map of estimated total economic activity



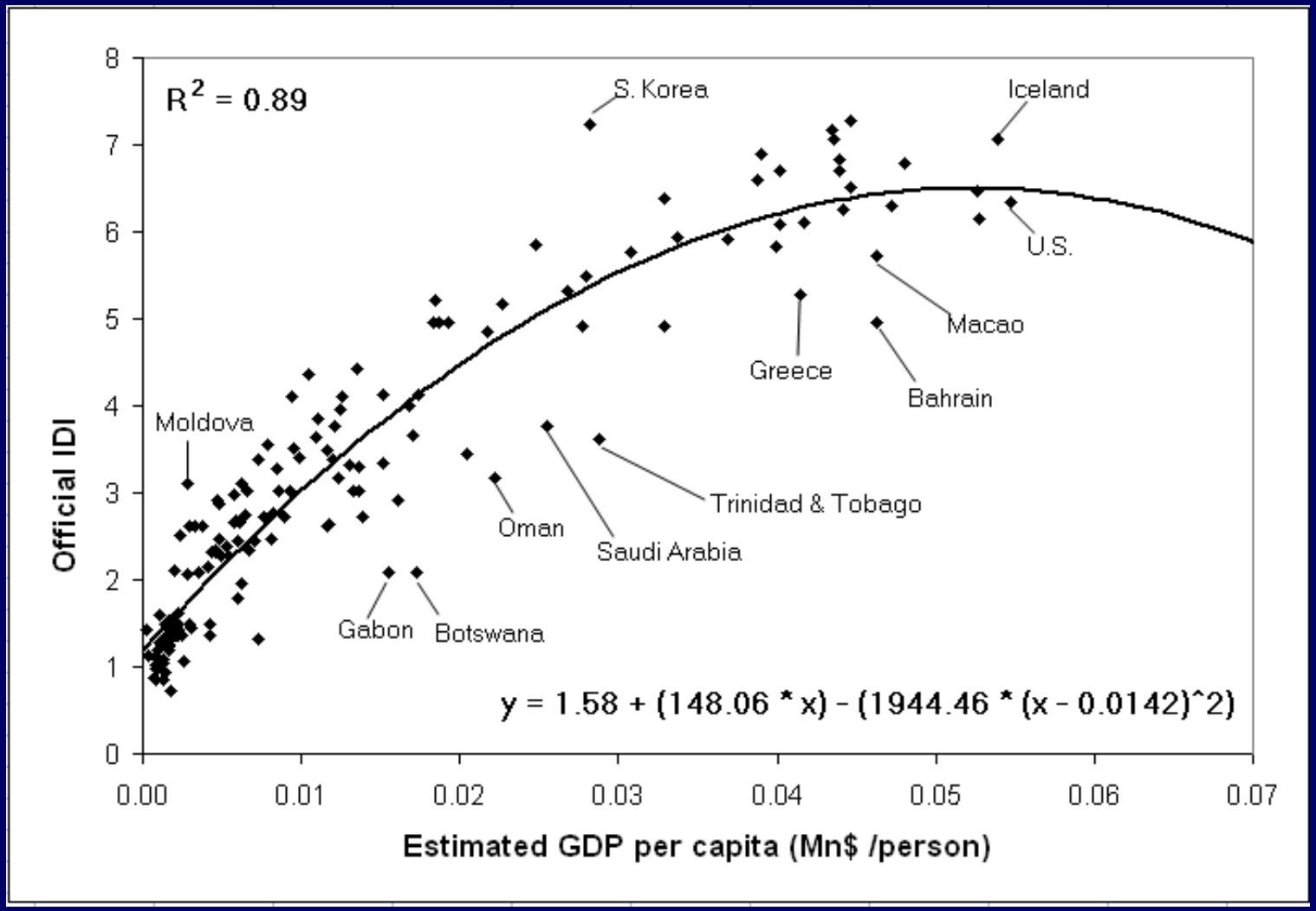
Aggregated estimated GDP per capita of countries



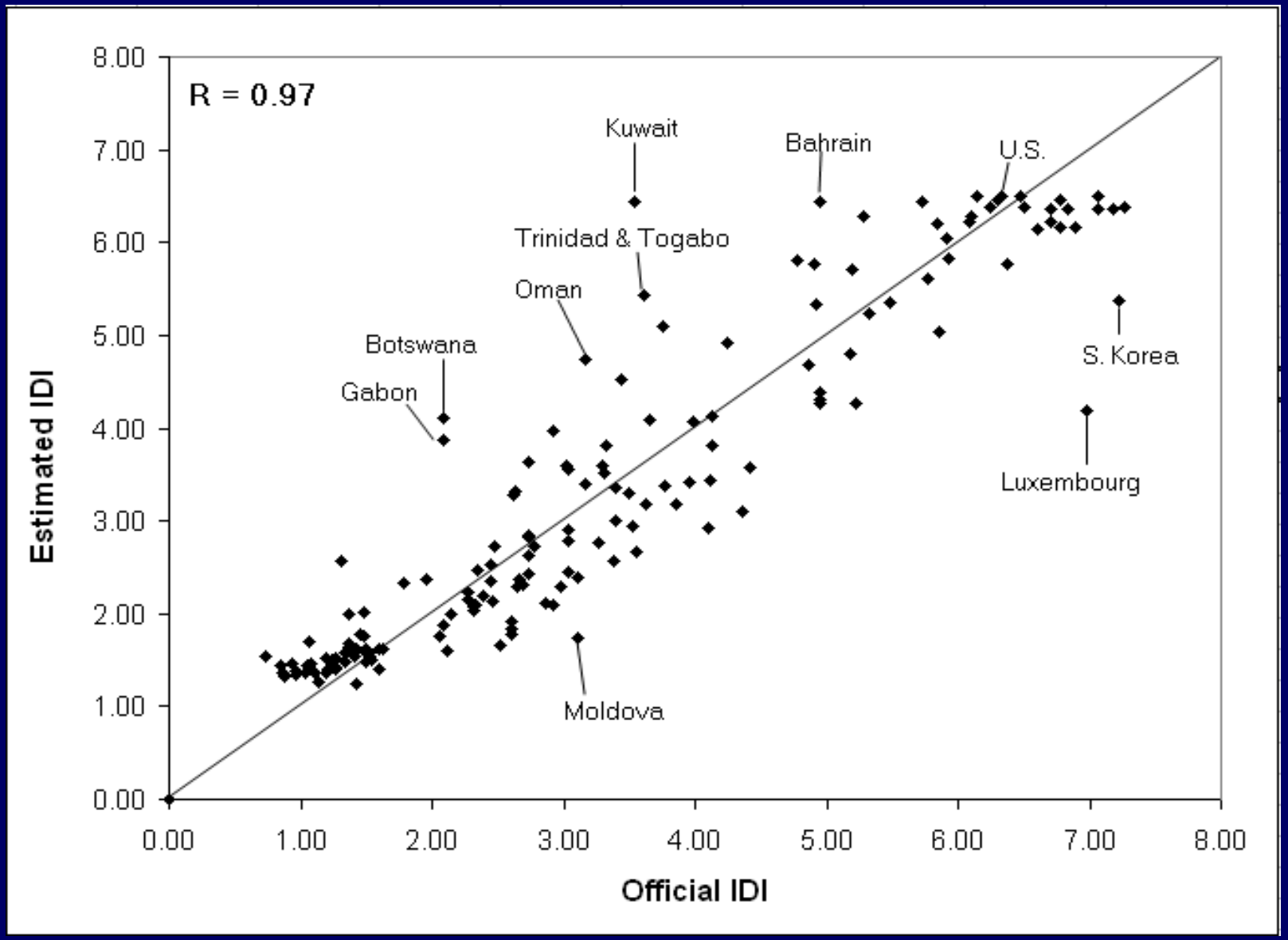


South-east Asian countries

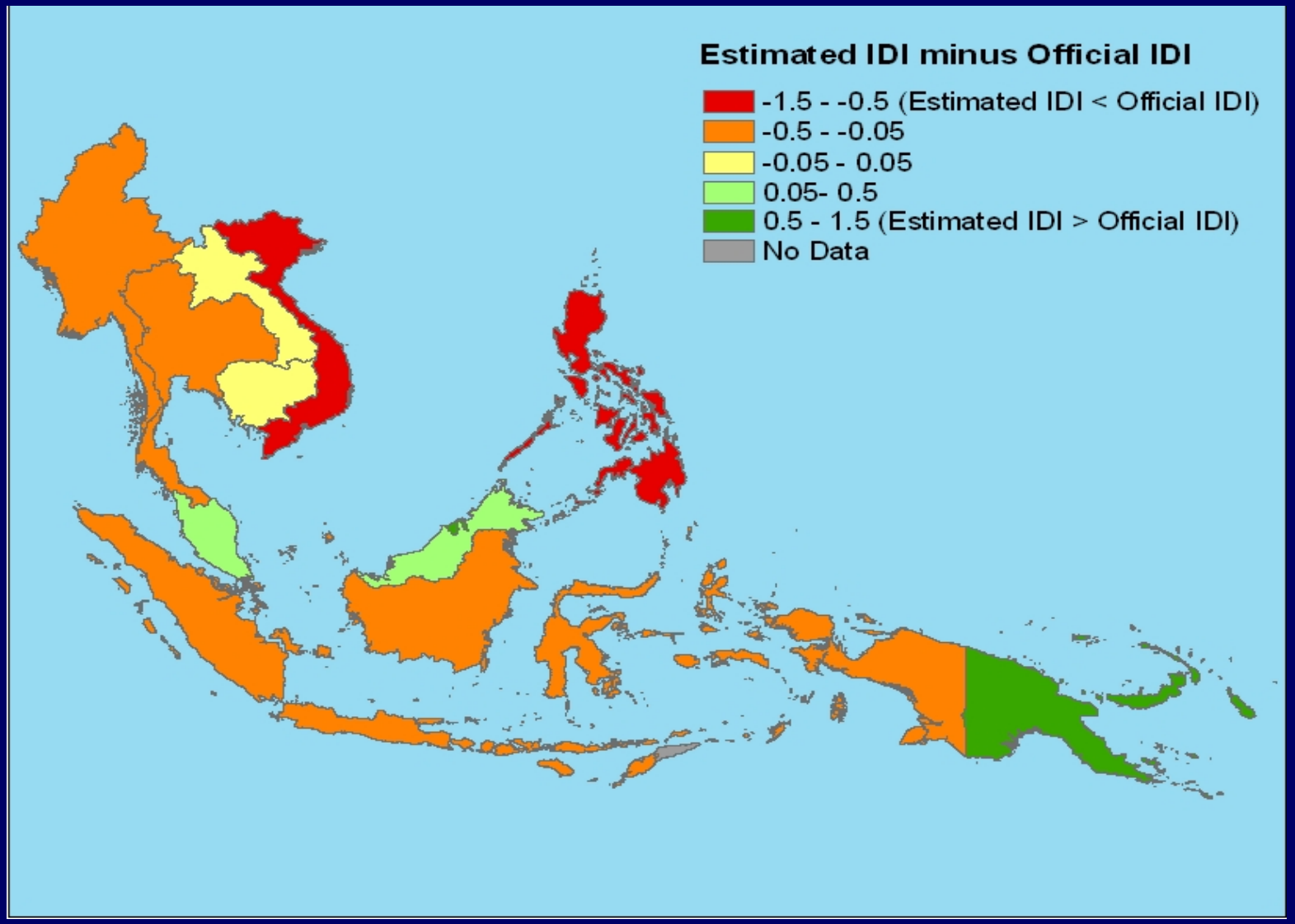
Second degree polynomial regression analysis to estimate IDI index



Official versus estimated IDI of all countries of the world

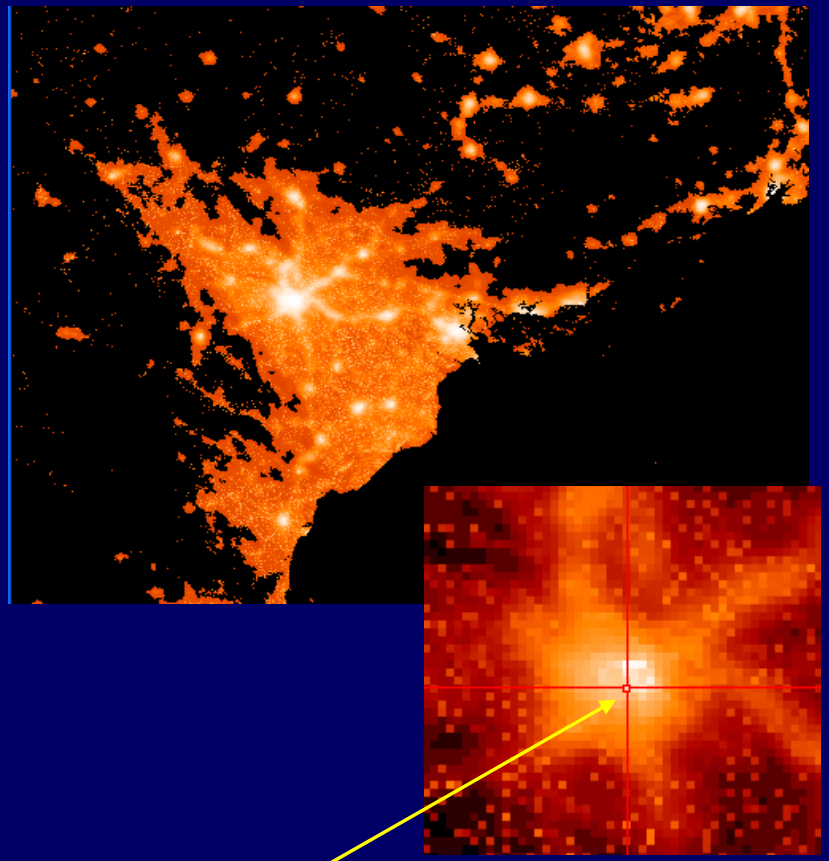


Difference map of estimated IDI and official IDI of the South-east Asian countries

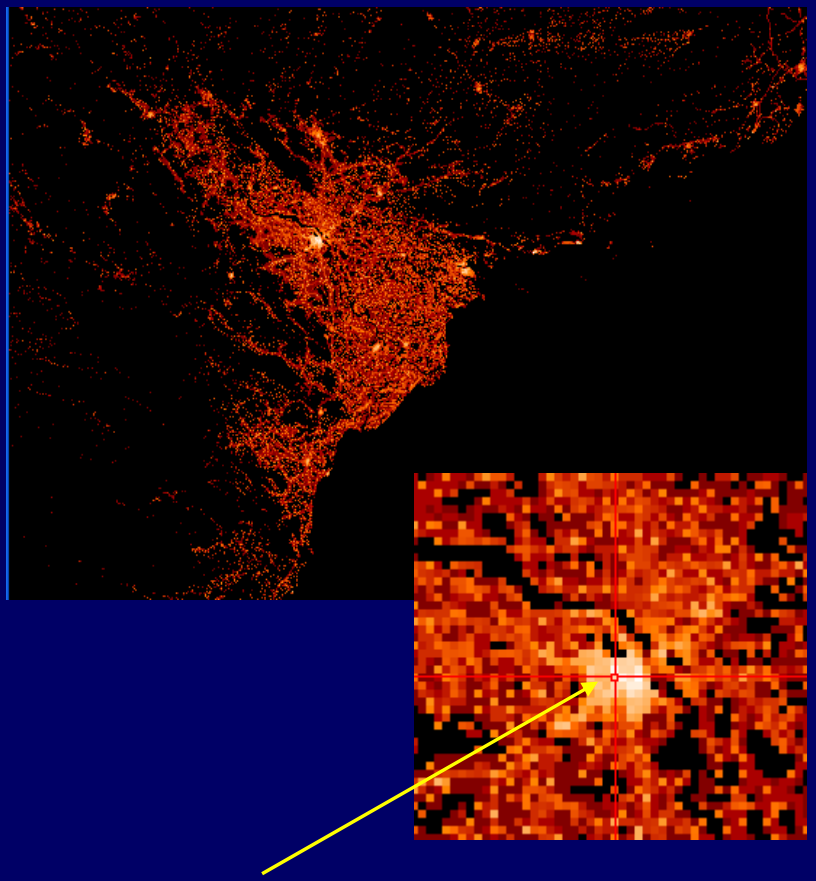


Why a disaggregated IDI map at 30 arc-second resolution could not be produced?

Example showing Hanoi



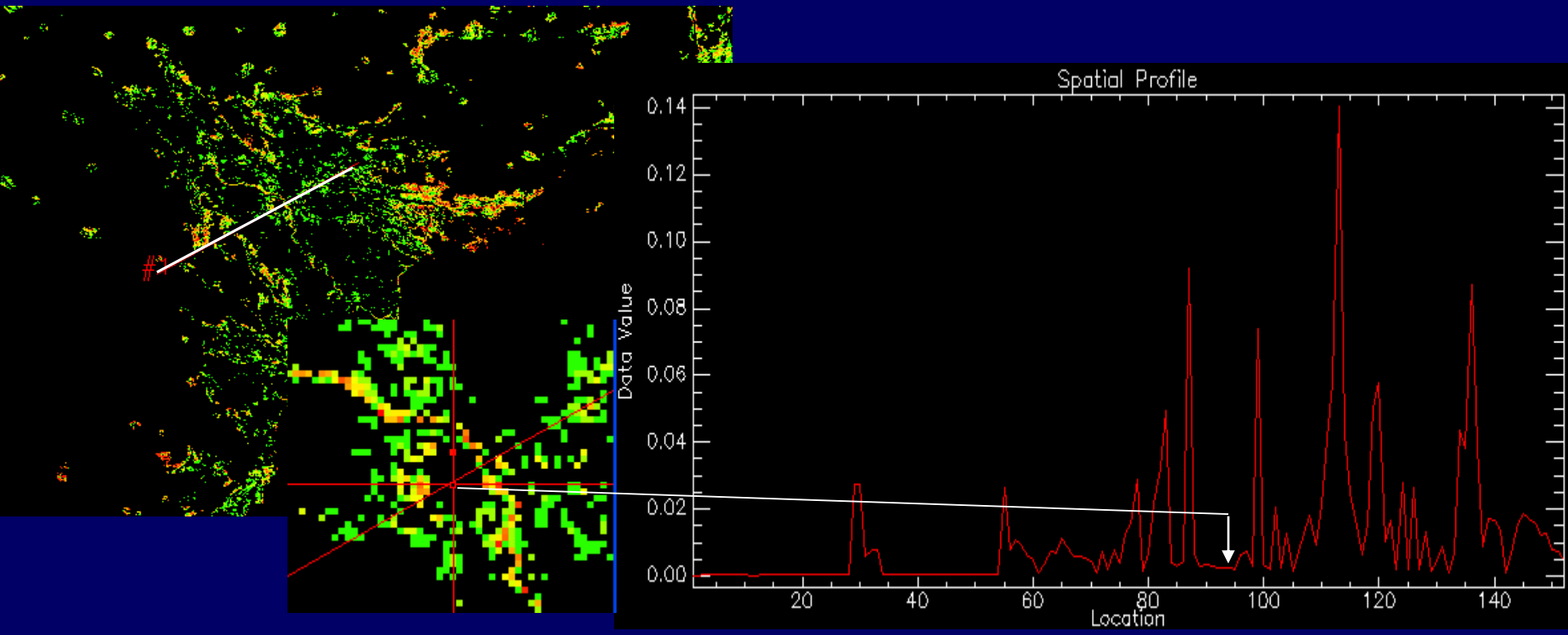
In this 30 arc-second pixel of the estimated GDP grid , value of GDP in millions per km^2 = 82



In this 30 arc-second pixel of the population grid , population number = 33149

Why a disaggregated IDI map at 30 arc-second resolution could not be produced?

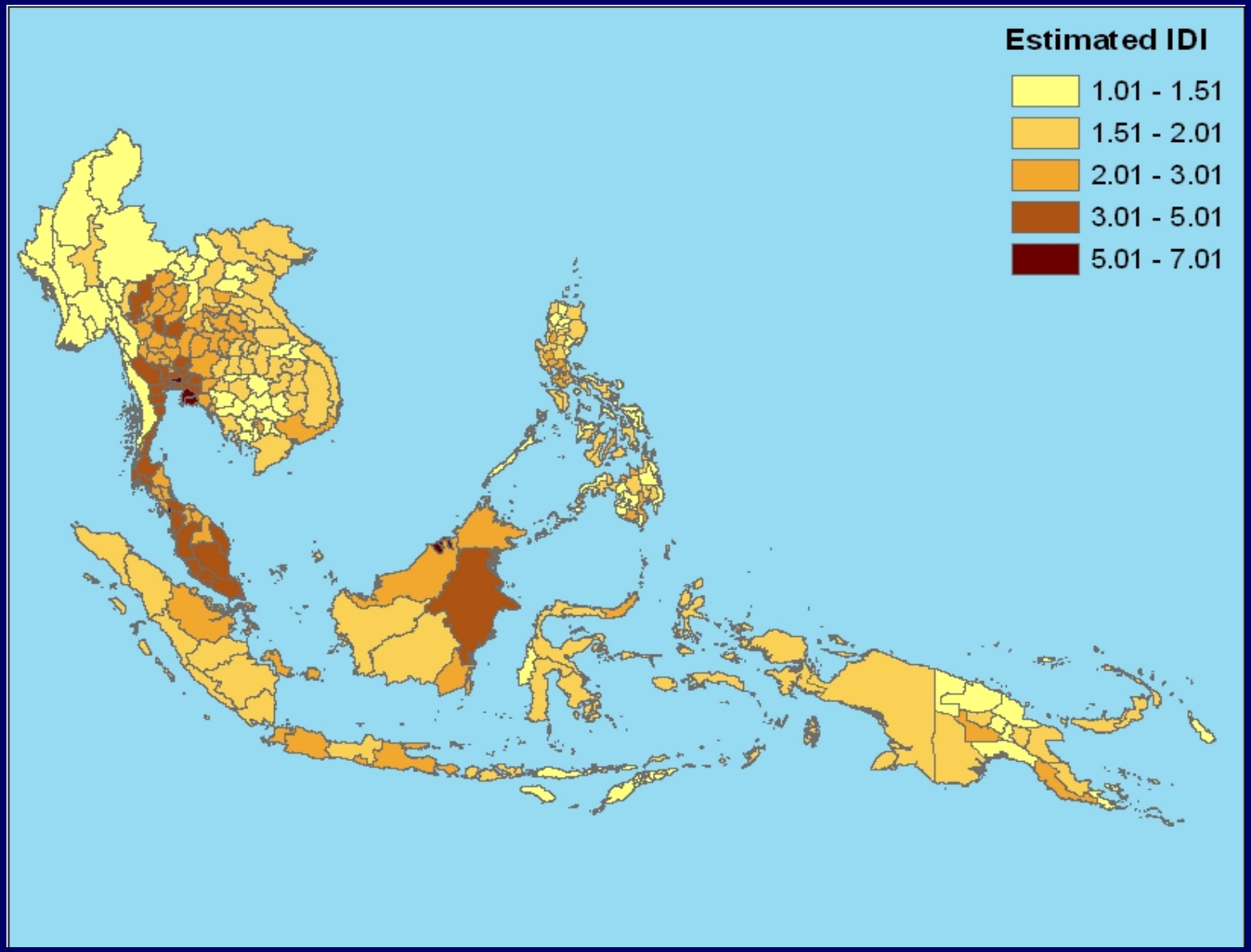
Example showing Hanoi



Dividing estimated GDP by population for the 30 arc-second pixel gives a value of .0024 GDP (millions) /capita for that pixel

The graph of the transect shows that at the 30 arc-second pixel level –low values are obtained for estimated GDP/capita in the city centers and higher values just outside the city centers, no relation could be established with IDI

Estimation of IDI of the South-east Asian countries at the state level



Discussion and Future considerations

- Global coverage of nighttime lights data available daily and are composited annually, thus frequent updates possible
- With the intercalibration of the DMSP lights it may be possible to extend the gridded GDP series to past years and also make future predictions
- Similarly, IDI can could be estimated for past and future years
- Although a 30 arc-second IDI map could not be created, the state level map showed that we can estimate IDI at subnational resolution
- Will attempt at estimating IDI at the county level or estimate IDI by aggregating the nighttime image and LandScan population grid to higher resolutions (2 km^2 or 4 km^2, etc.)



Thank You!