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Negative Emissions on South East Asia: Renewable Energy Optimization with BECCS for Indonesia

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science for global insight

Tropical Futures Initiative

BCEF2016 Bali Clean Energy Forum

BeWhere

G4M

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P. Yowargana, P. Patrizio, S. Leduc, S. Mesfun, G. Kindermann, S. Fuss, and many more…

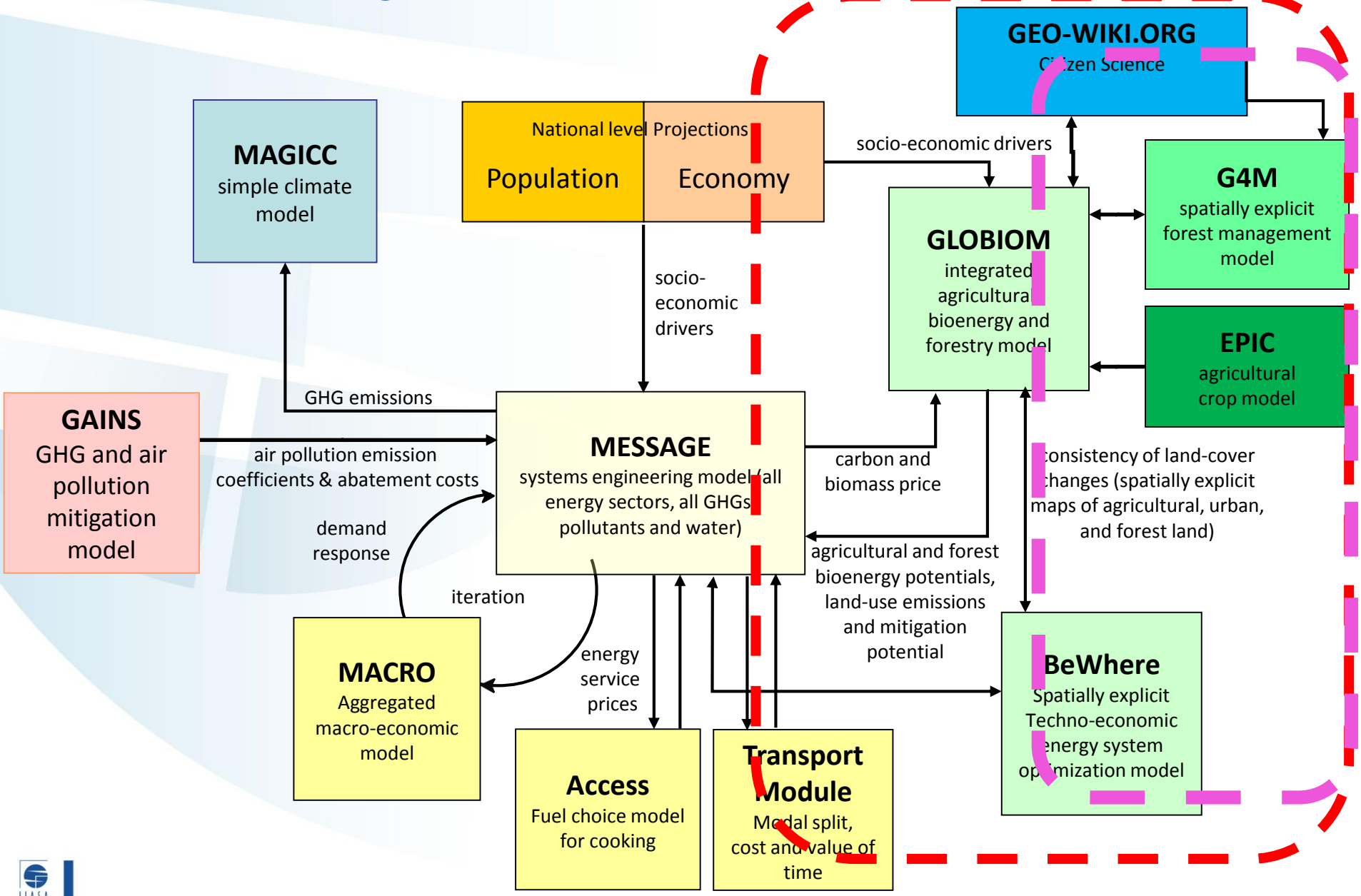
Co2 Summit III: Pathways to Carbon Capture, Utilization, and Storage Deployment

22-26 May 2017, Cetraro, Calabria, Italy

MODELING BACKGROUND
&
THE LAND-BASED CHALLENGE




IIASA Integrated Assessment Framework



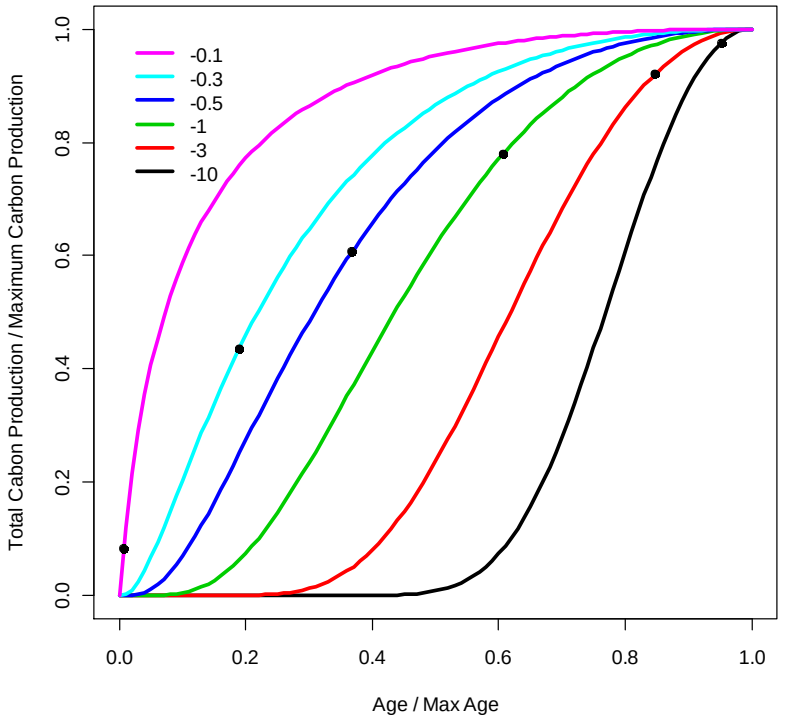
THE GLOBAL FOREST MODEL G4M



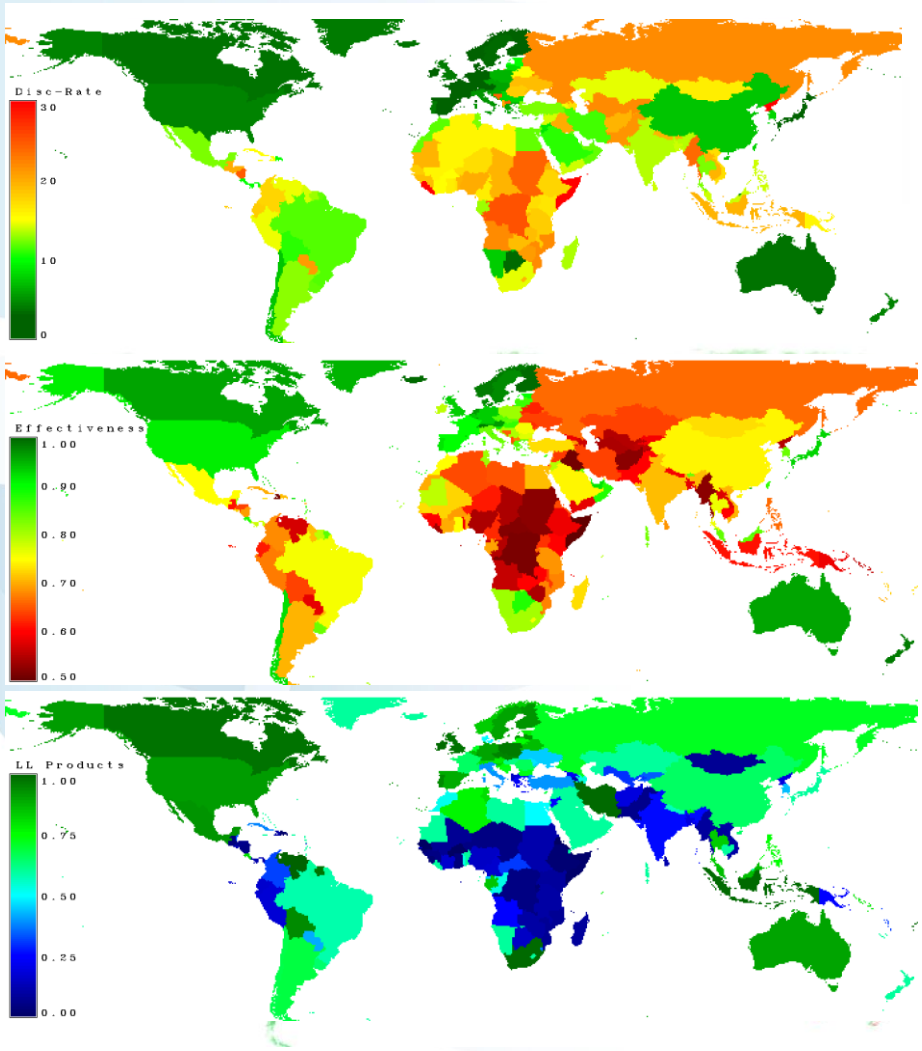

Biophysical forest model G4M

G4M

- Forest parameters from G4M
  - Provides annual harvestable wood (for sawn wood and other wood)
  - Afforestation/Deforestation (NPV)
  - Forest management (rot/spec)
  - Forest Carbon stock
    - Downscaling FAO country level information on above ground carbon in forests (FRA 2005) to 30 min grid (Kinderman et al., 2008)
  - Harvesting costs
  - Forest area change
  - Spatially explicit



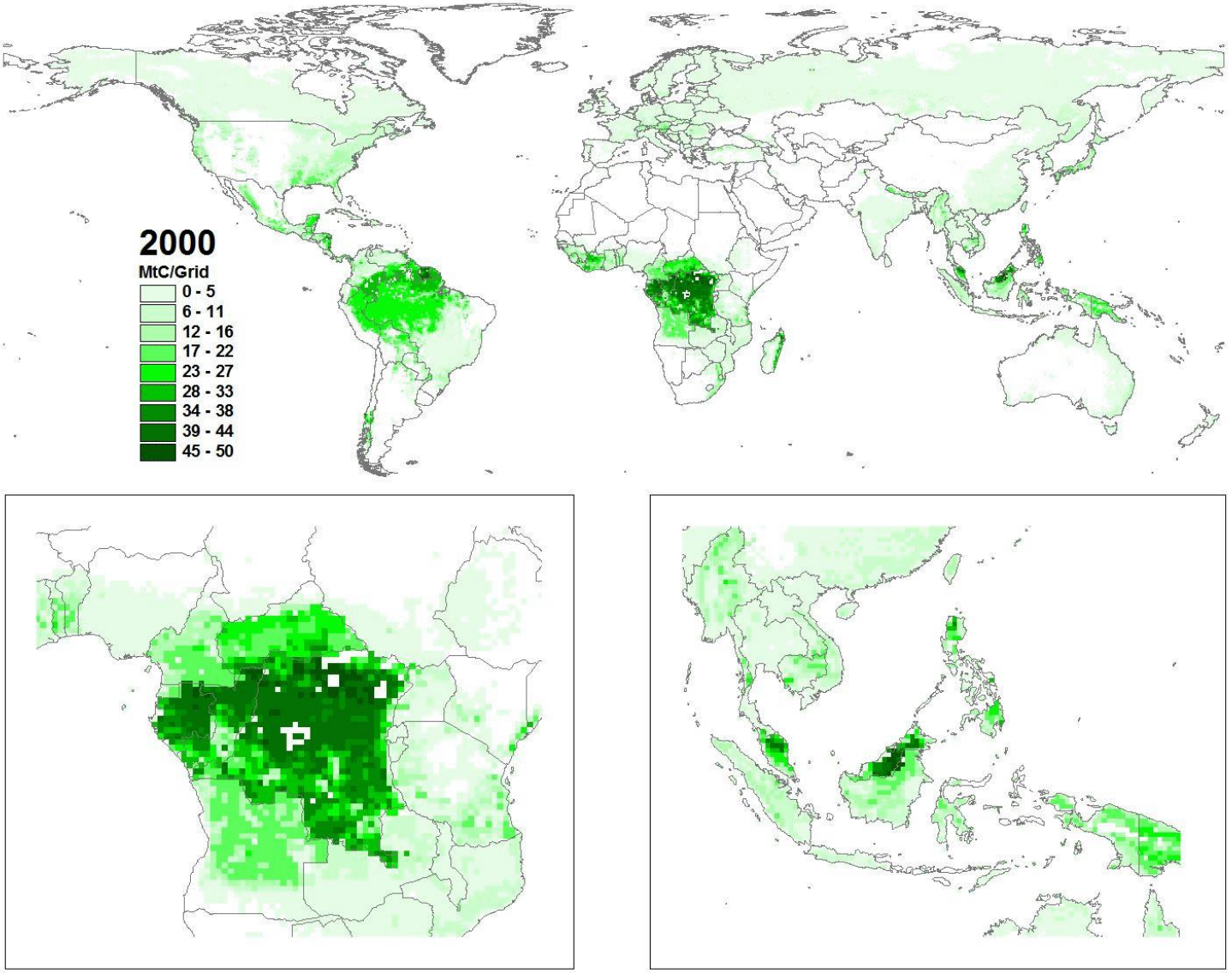
Input Data Sets for the Global Forestry Model (G4M)



- NPP
- Population Density
- Land cover
- Agricultural suitability
- Forest Biomass
- Price level
- Discount rate
- Corruption
- Product use

Source: Kindermann (2010)

Forest Area Development (2000 – 2035)

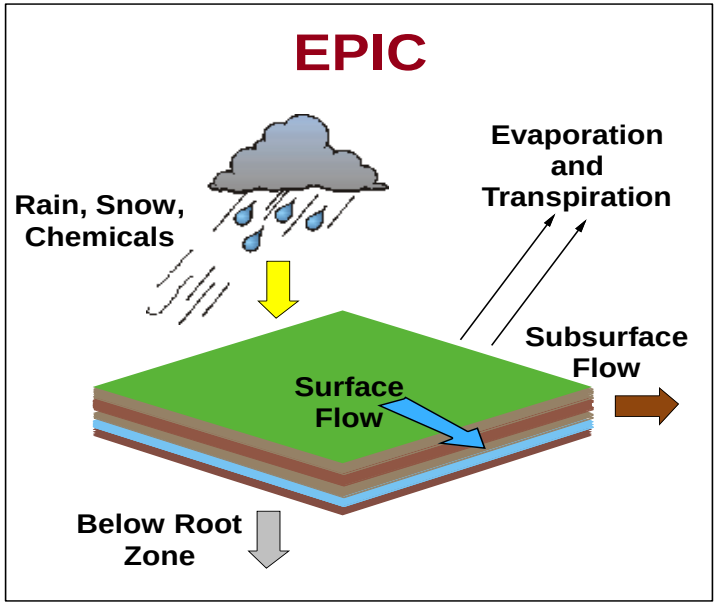


Source: IIASA, G4M

THE GLOBAL AGRICULTURE MODEL EPIC

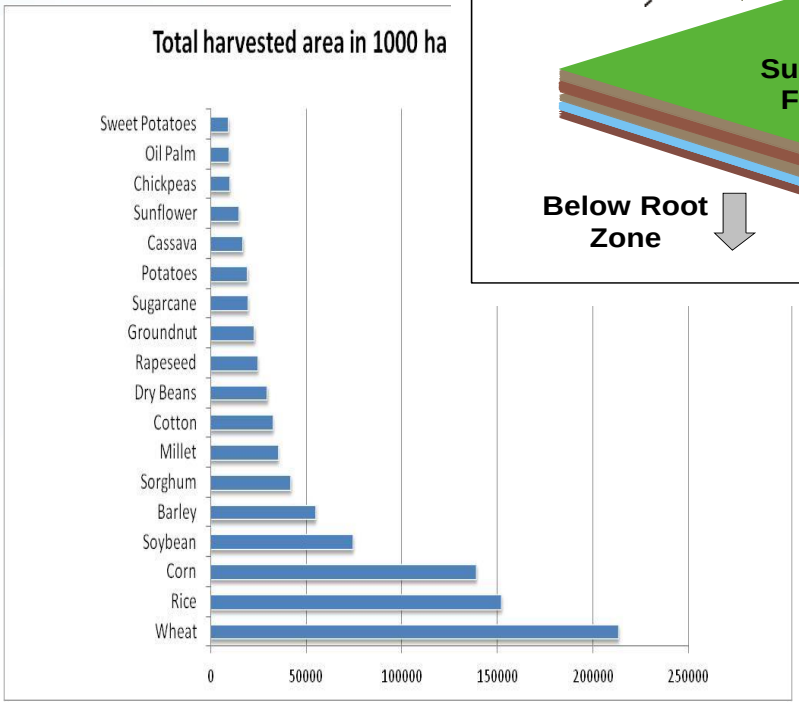



Cropland - EPIC



Processes

- Weather
- Hydrology
- Erosion
- Carbon sequestration
- Crop growth
- Crop rotations
- Fertilization
- Tillage
- Irrigation
- Drainage
- Pesticide
- Grazing
- Manure



Major outputs:

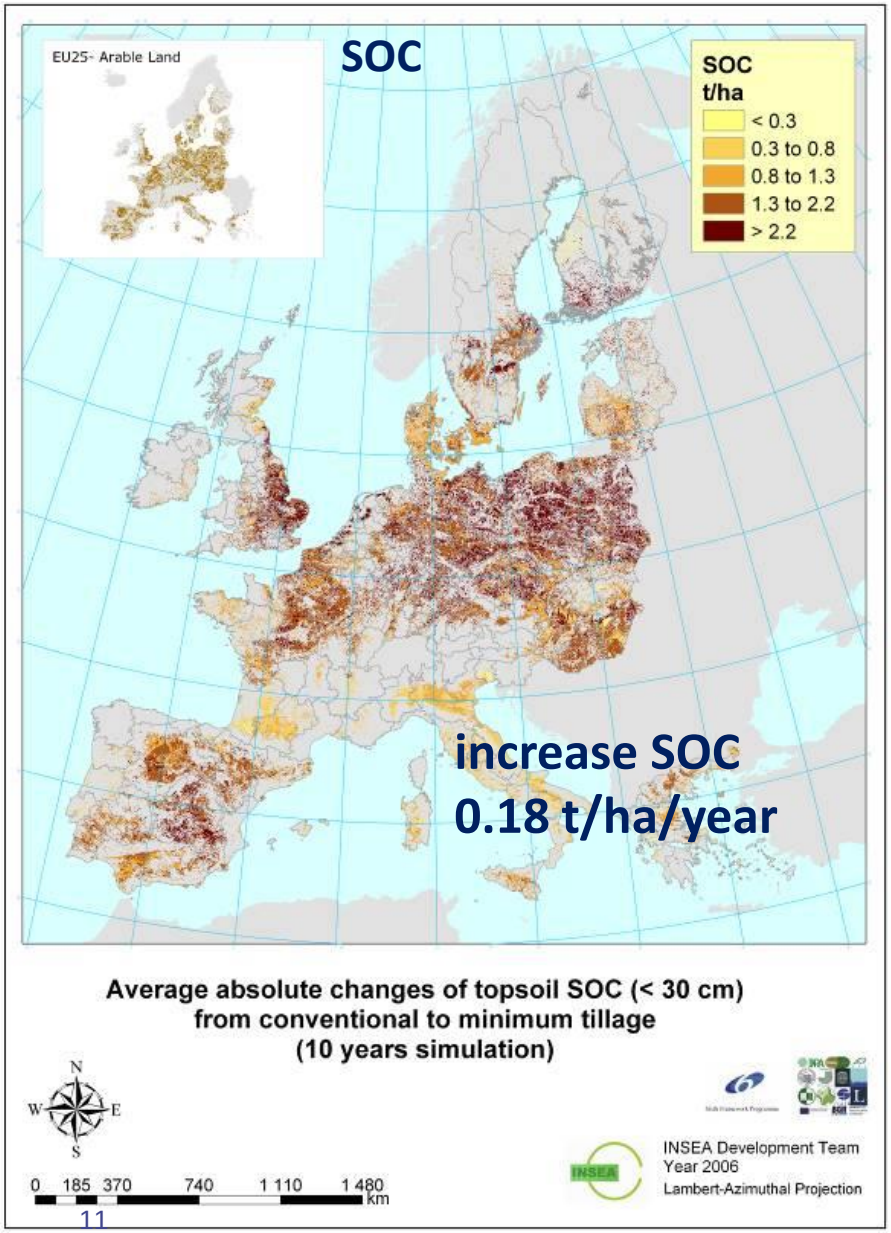
Crop yields, Environmental effects (e.g. soil carbon,)

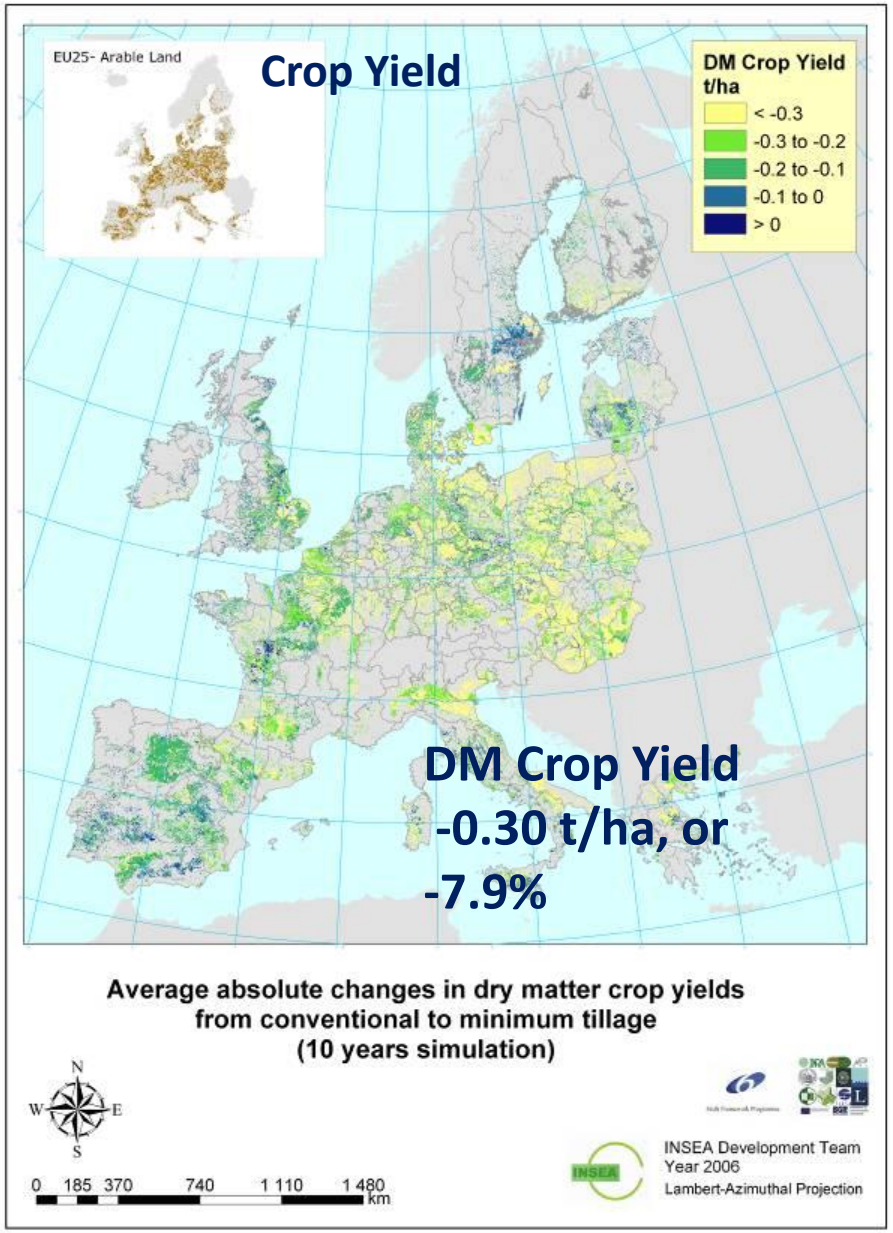
20 crops (>75% of harvested area)

4 management systems: High input, Low input, Irrigated, Subsistence

Source: Schmid (2008)

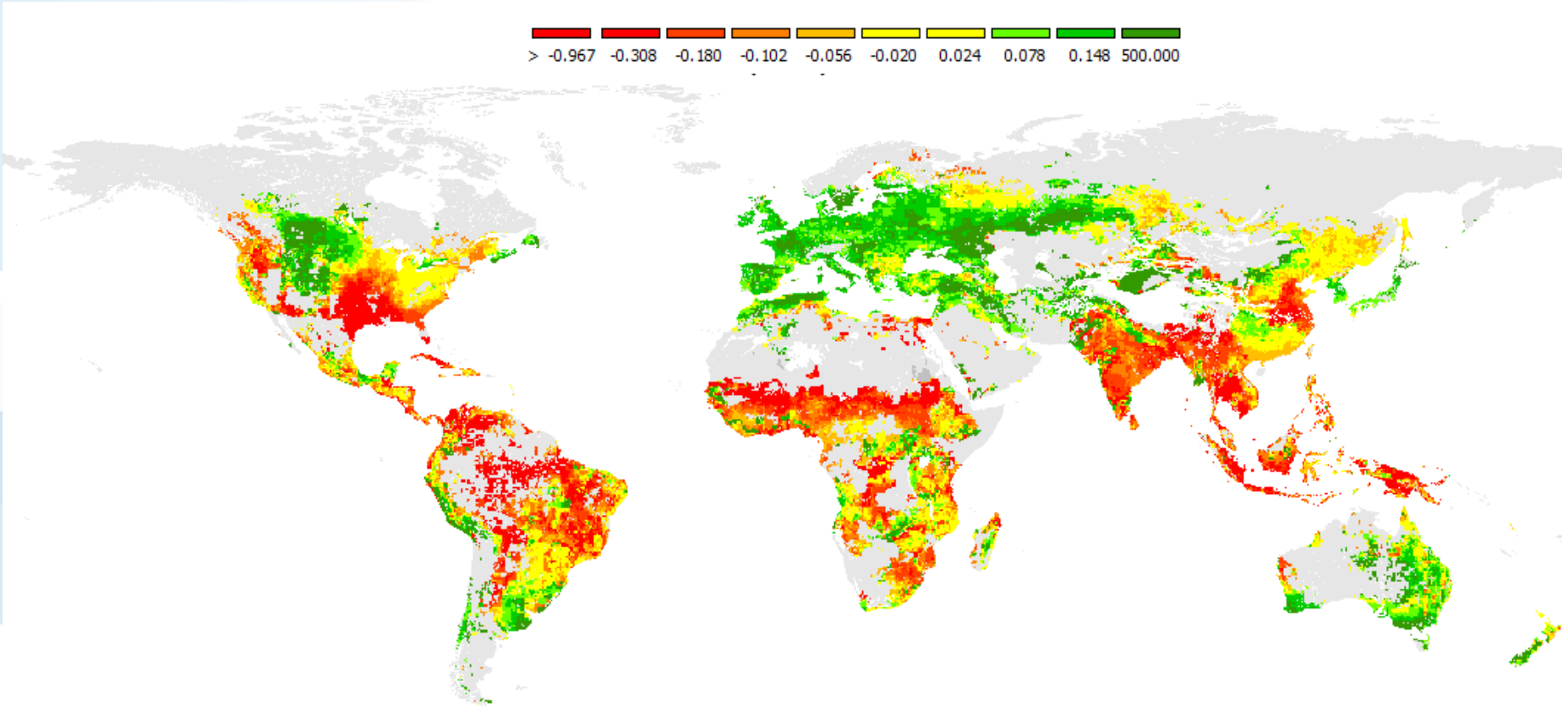
EPIC – Management Change (conventional → minimum tillage)





Source: INSEA, Schmid (2006)

EPIC - Relative Difference in Means (2050/2100) in Wheat Yields

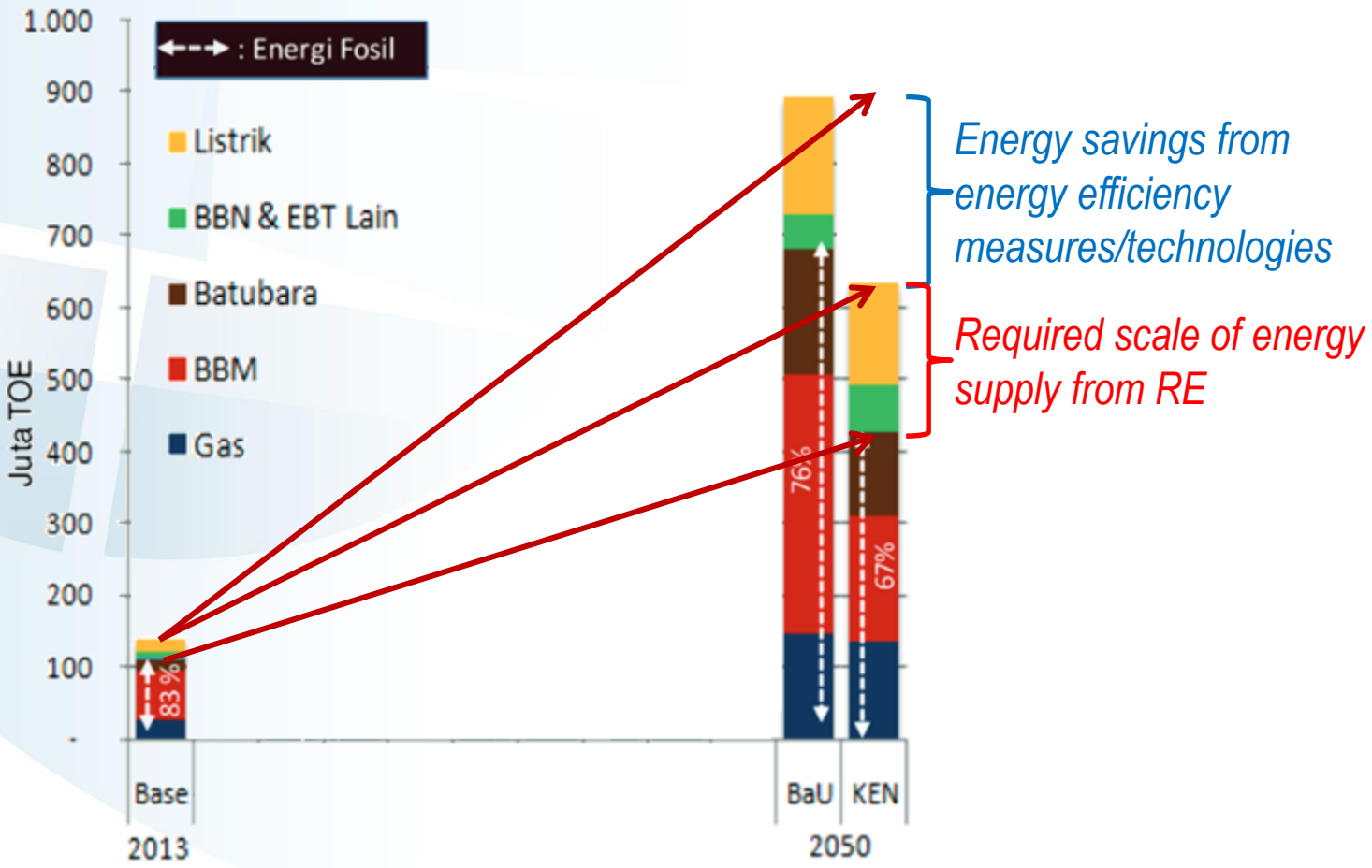


Source: Data: Tyndall, Afi Scenario, simulation model: EPIC

THE SITUATION IN INDONESIA




Why Indonesia?
Long term targets: how do we get there?



Source: IIASA-BCEF, 2016

THE MODELING APPROACH




The BeWhere Umbrella

Source: IIASA-BeWhere, 2016

BeWhere Model

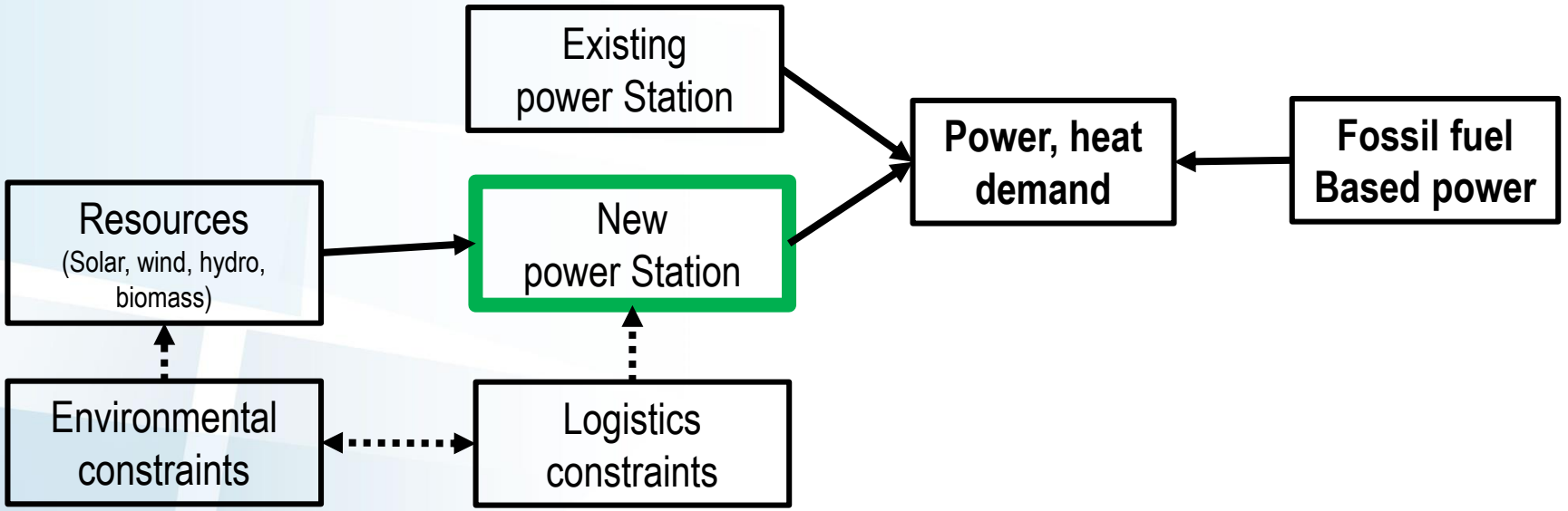
- Techno-economical model, geographic explicit
- Mixed integer linear program (GAMS)
- Spatially explicit - 0.2˚ to 0.5˚grid cell
- Static - periodic basis (fluctuation of demand over the period)
- Minimize the total cost of the whole supply chain for the region's welfare

*min [Cost + Emissions * (Carbon Tax)]*

- Does not maximize the profit of a plant

Source: IIASA-BeWhere, 2016

Modeling new (RE-) power plants



Optimize **location**, **capacity** and **technology** of renewable power generation sites

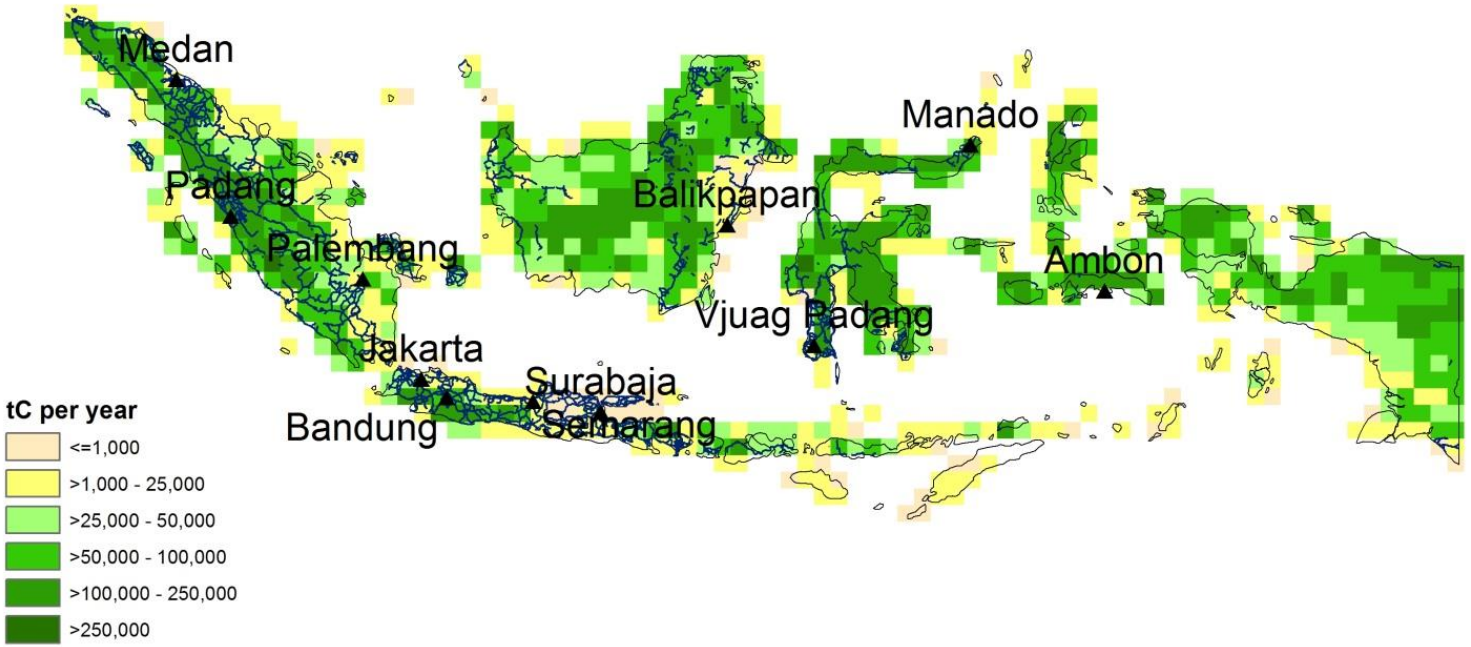
Source: IIASA-BeWhere, 2016

BOTTOM-UP MODELING
E.G. FOREST-BASED BECCS

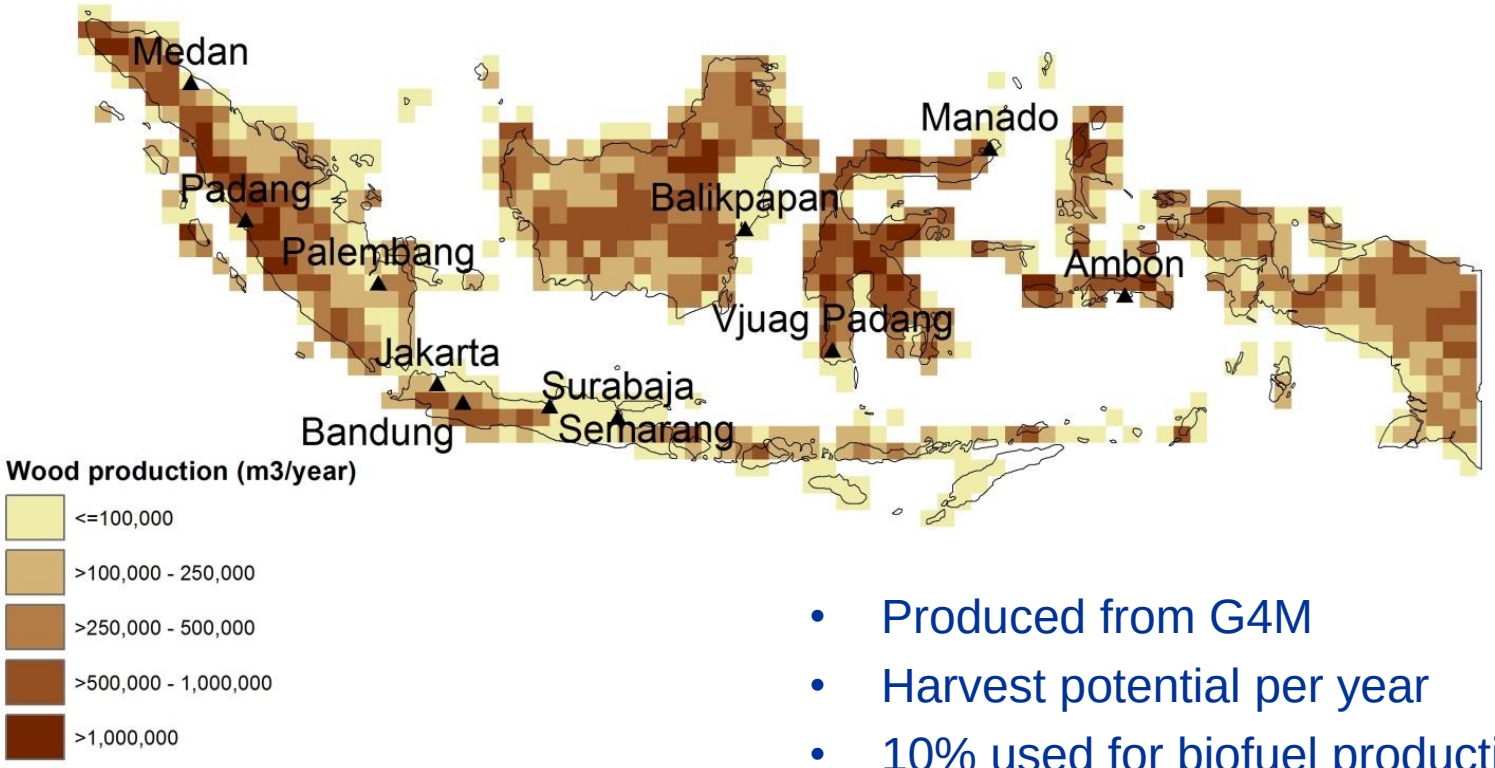



BECCS in Indonesia

Forest Biomass



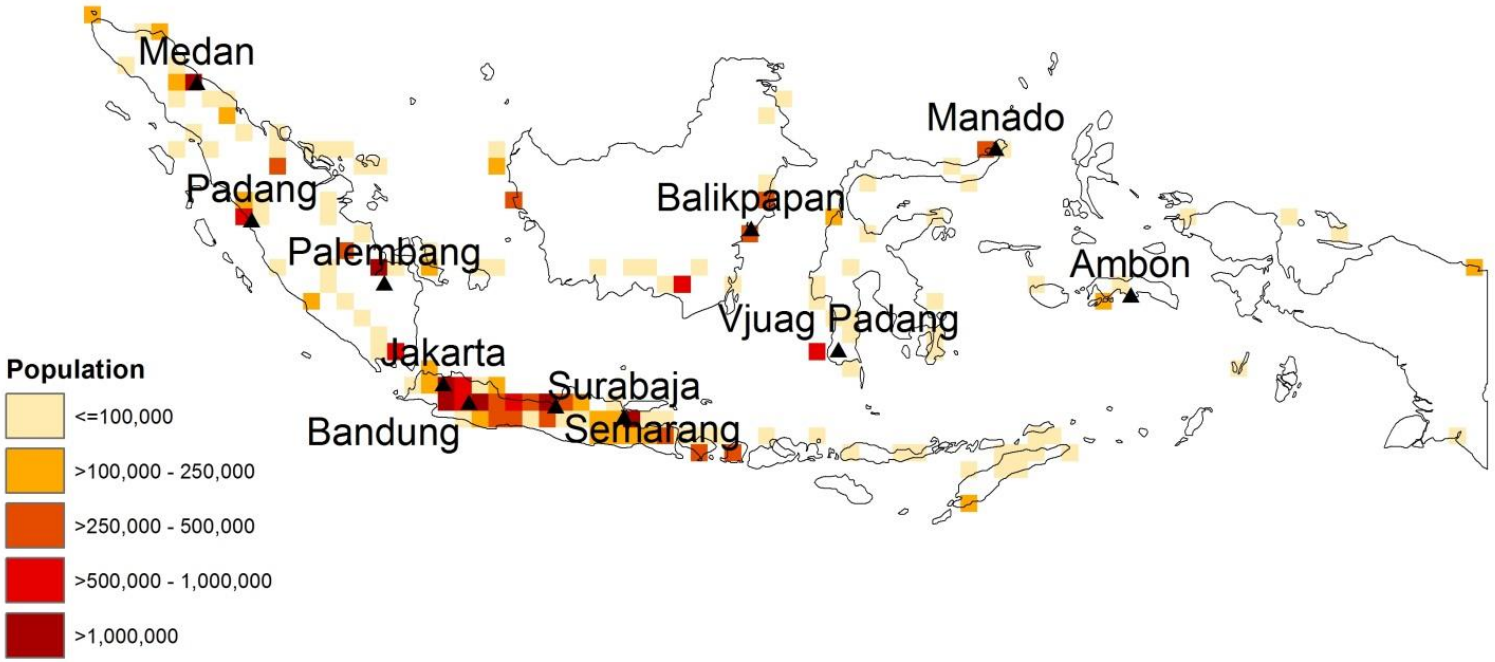
Managed Forest



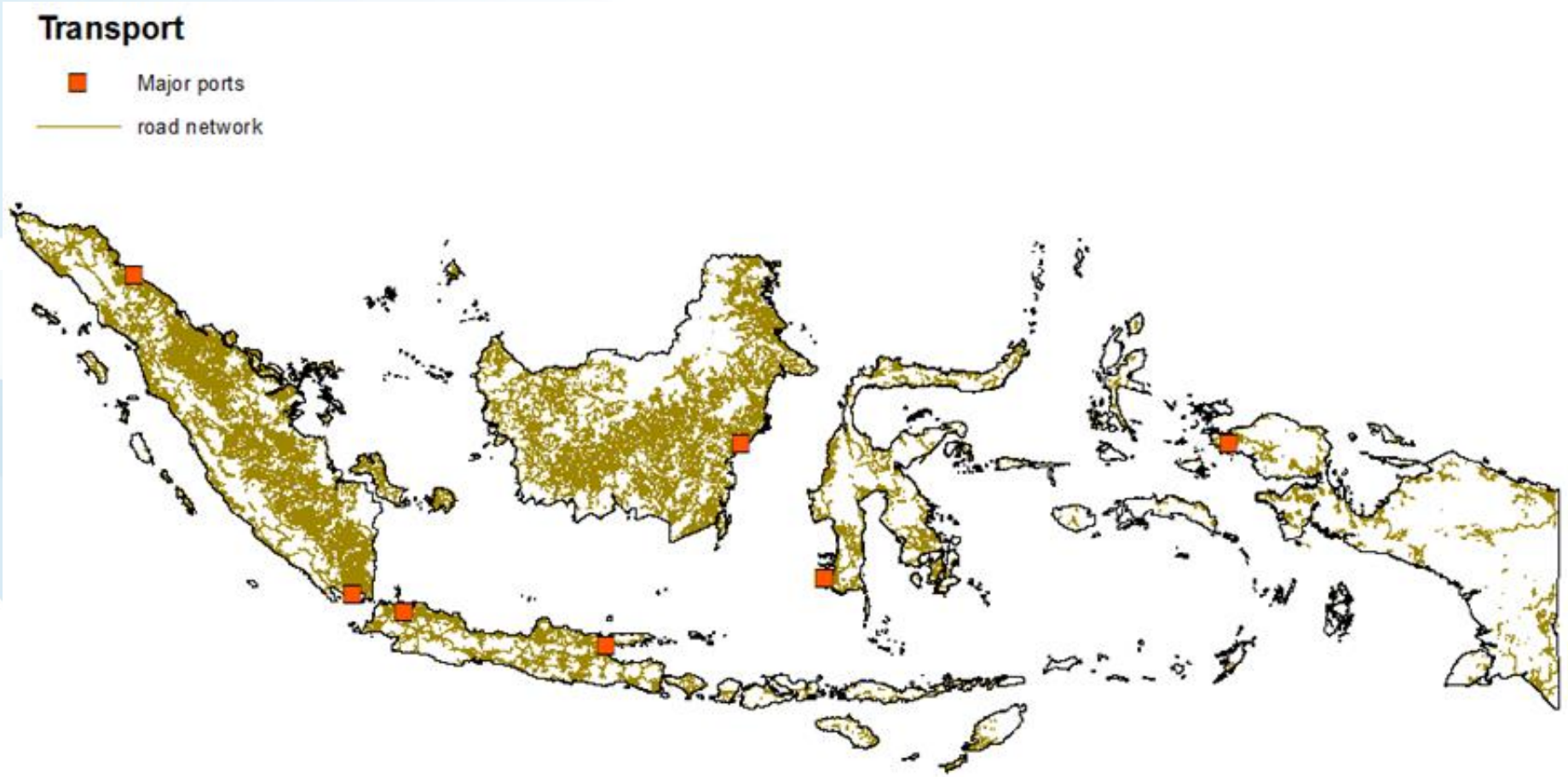
- Produced from G4M
- Harvest potential per year
- 10% used for biofuel production

Protected Areas

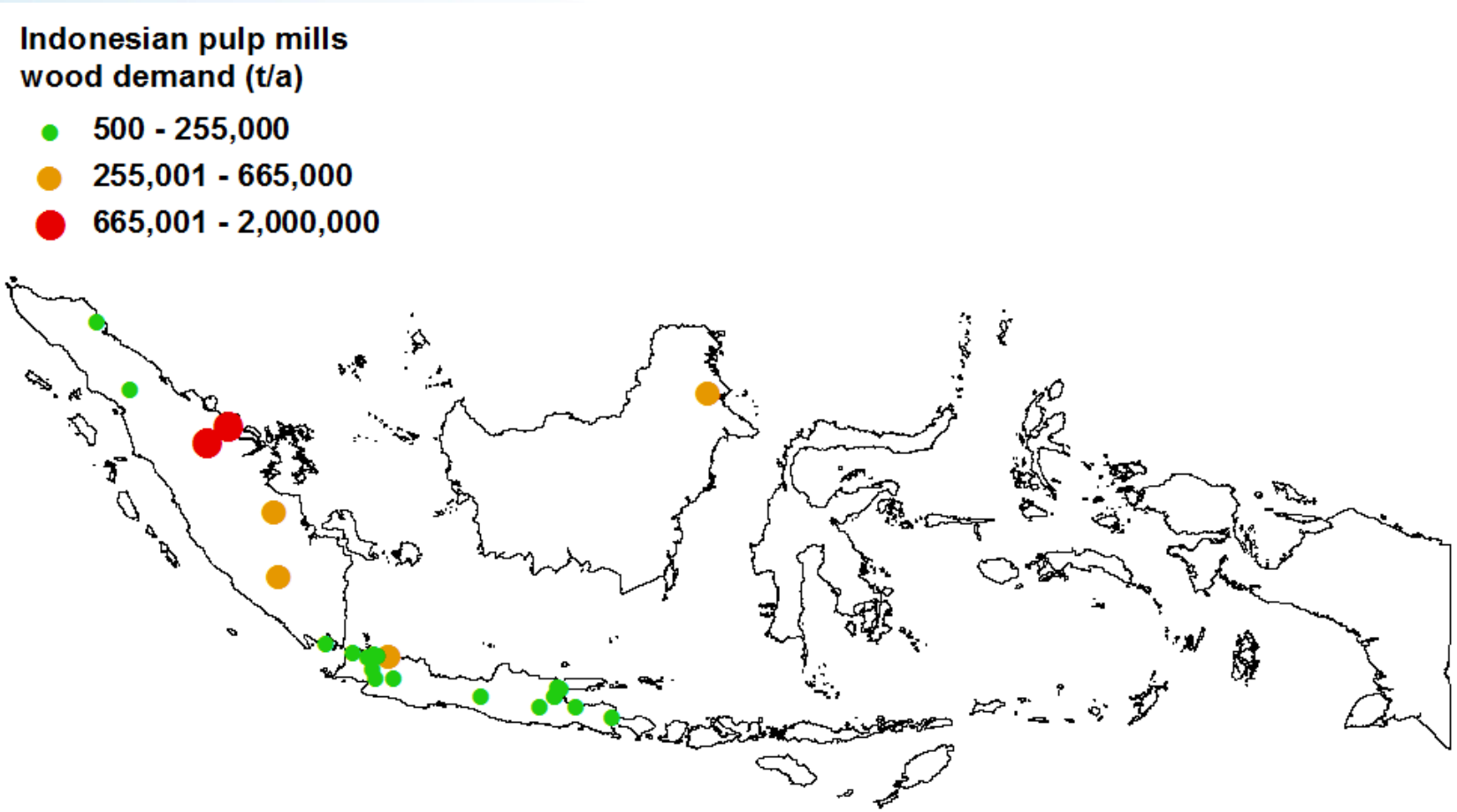
Population


Medan
Padang
Palembang
Jakarta
Bandung
Surabaja
Semarang
Balikpapan
Manado
Vjuag Padang
Ambon
Population
<=100,000
>100,000 - 250,000
>250,000 - 500,000
>500,000 - 1,000,000
>1,000,000

Transport

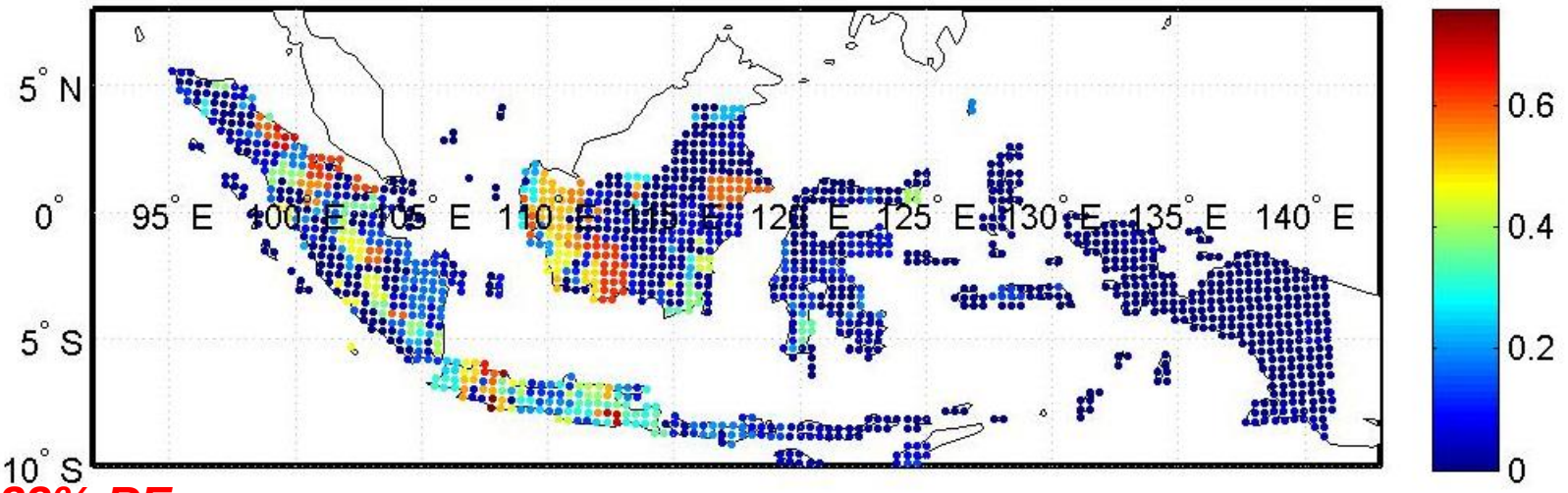


Pulp & Paper Mills



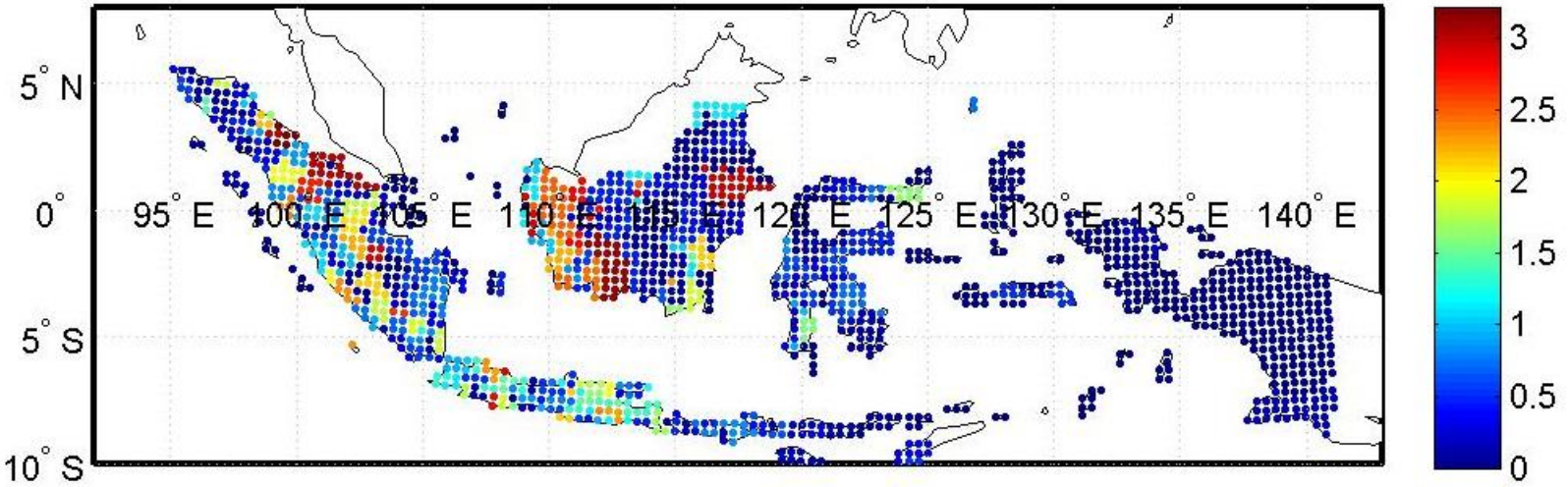
Implication for Biomass Harvesting Intensity

Least cost



MWe

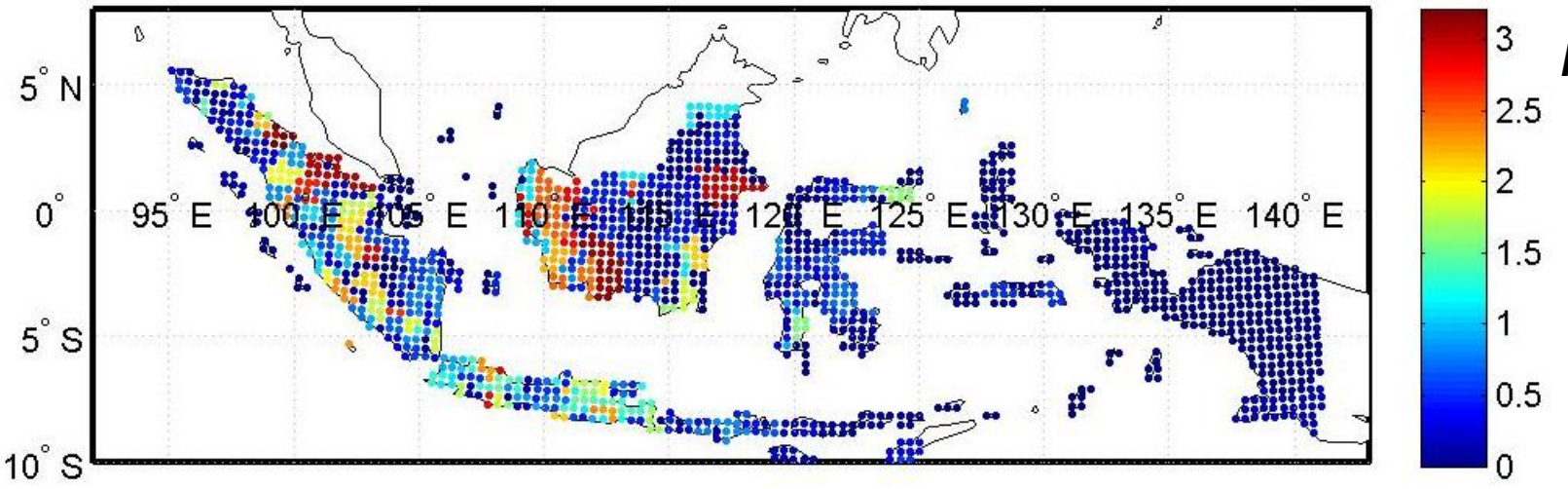
23% RE



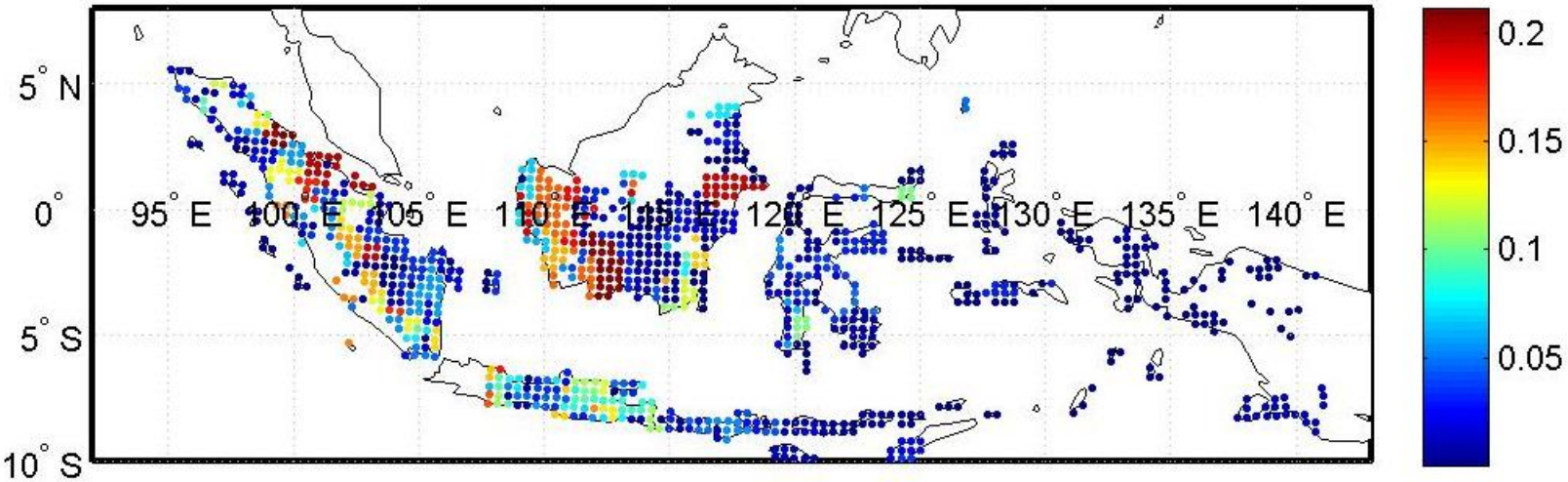
Source: IIASA-BCEF, 2016

Being more sustainable

23% RE



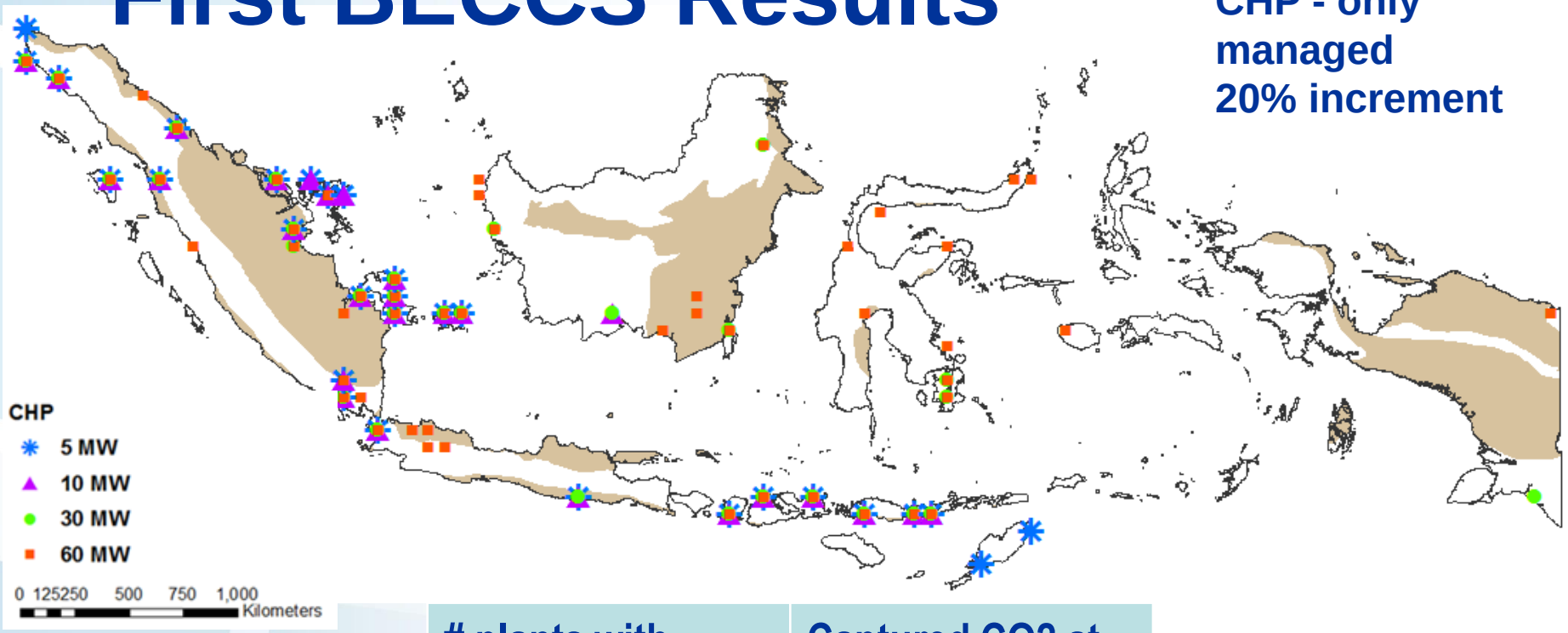
Excluding primary forest



Source: IIASA-BCEF, 2016

First BECCS Results

CHP - only managed 20% increment



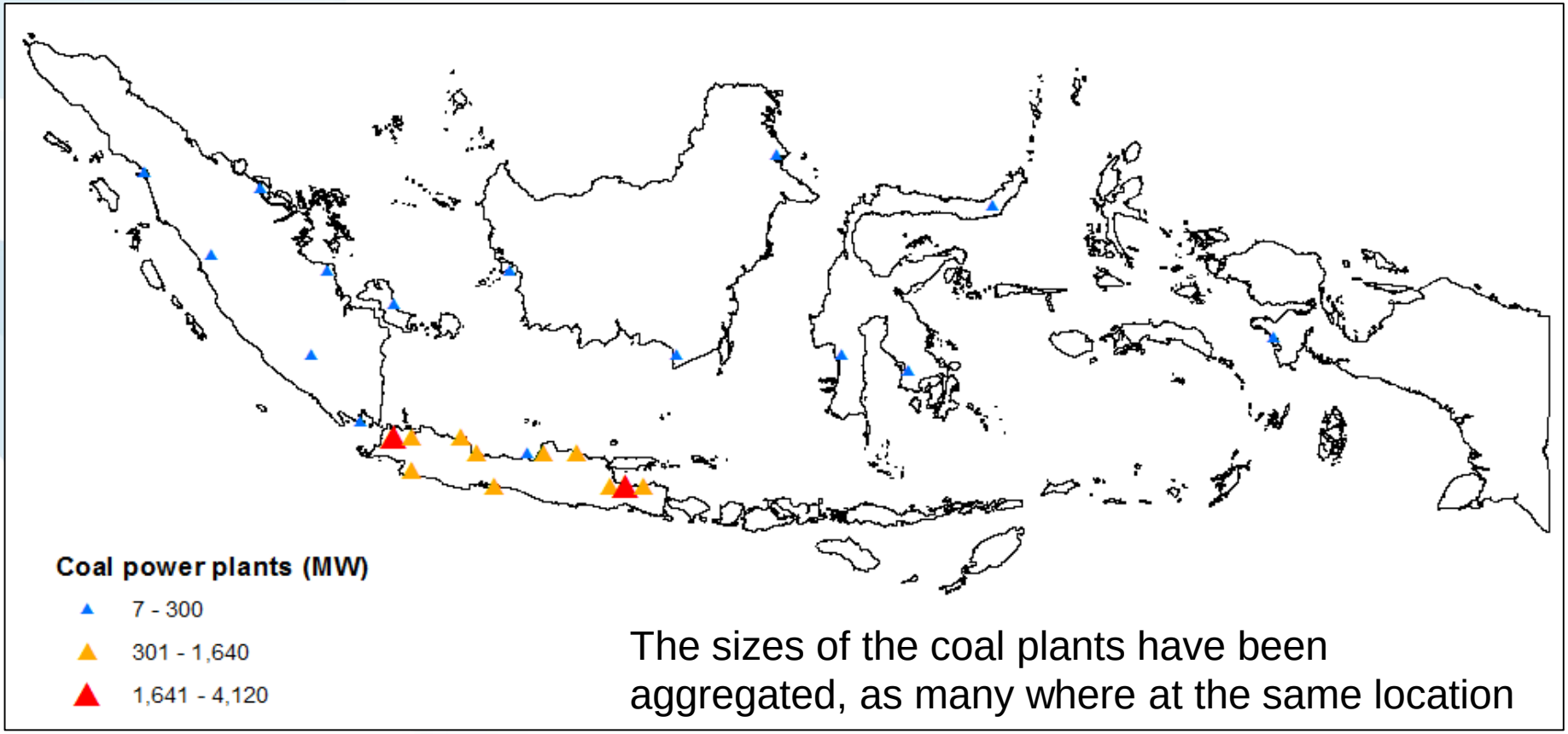
# plants with suitable storage access	Captured CO2 at 80% capture efficiency
1,185 MW	**2.5 Mt CO2/yr**

Resulting amounts could be substantially higher if allowing for bundling, taking into account other feedstocks (only managed forest used now) and adding other technologies (relatively low cooling demand now).

BIOMASS CO-FIRING AS A KICK-OFF OPPORTUNITY

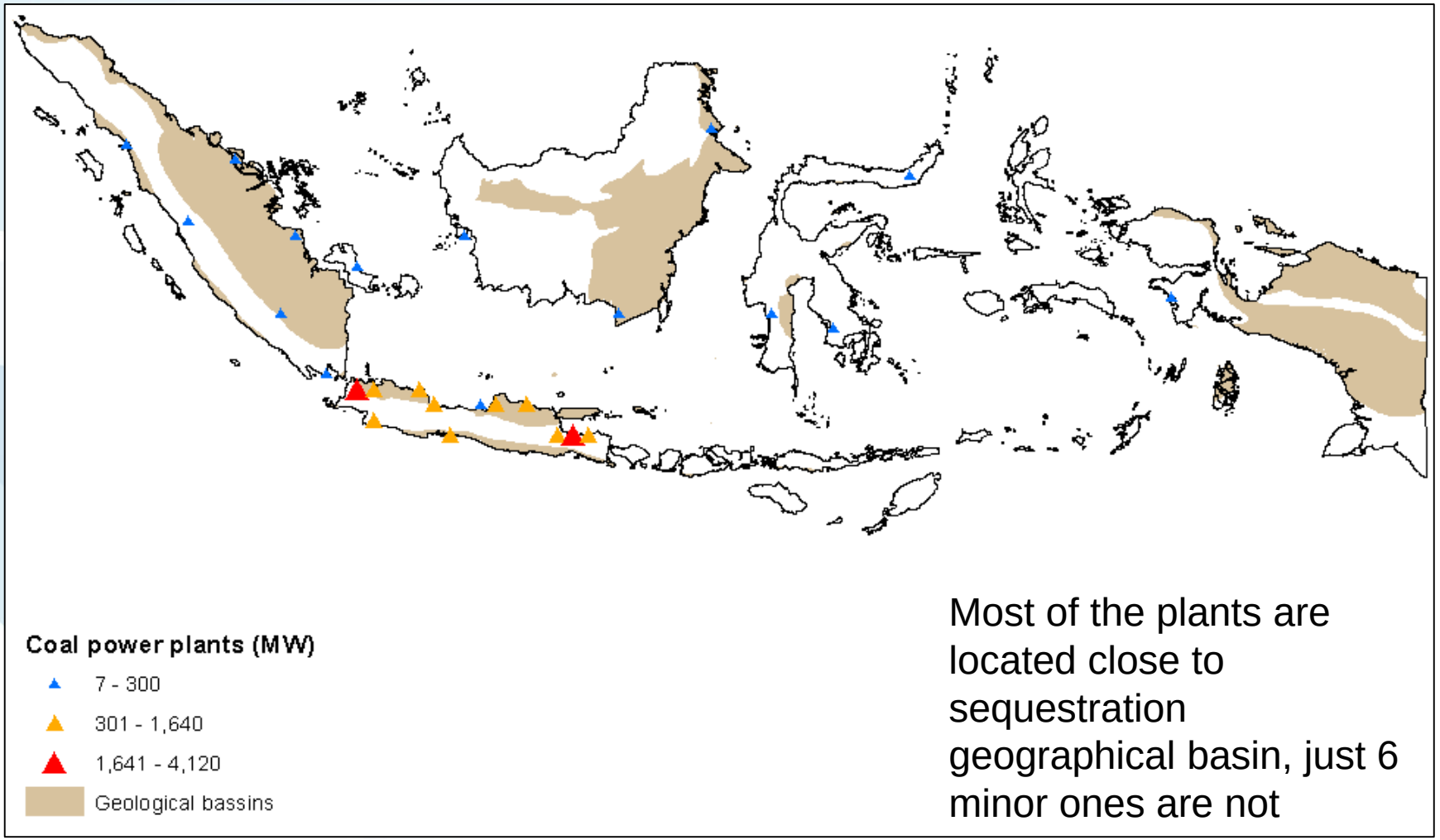



Coal plants



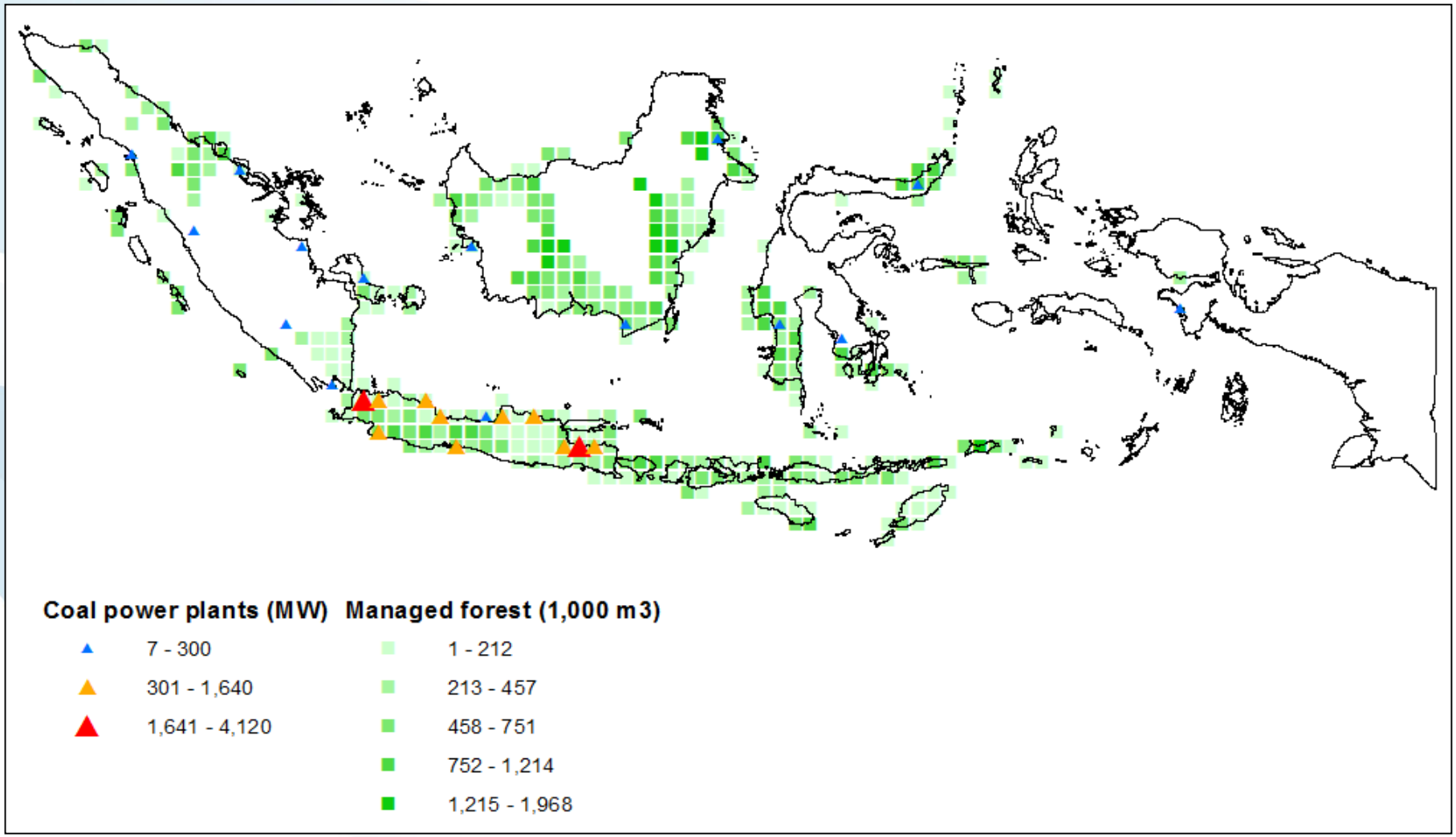
The sizes of the coal plants have been aggregated, as many where at the same location

Coal plants and geographical basins



Most of the plants are located close to sequestration geographical basin, just 6 minor ones are not

50% co-firing / managed forest



First Results on Co-Firing with Biomass

Scenarios	Coal plants CO2 emissions [Mt CO2]	Biomass Co-Firing CO2 emissions [Mt CO2]	Saved emissions [Mt CO2]	Substituted emissions [Mt CO2]	Total system emissions [Mt CO2]	Emissions captured through fossil CCS [Mt CO2]	Negative emissions through BECCS [Mt CO2]	Total System emission ballance [Mt CO2]
No Co-Firing	294	0	0	0	294	294	0	**0**
20% Co-Firing	236	20	38	58	256	236	20	**- 20**
50% Co-Firing	148	51	103	154	199	148	51	**-51**

With BE/CCS

Conclusions

- This is work in progress
- First real bottom-up methodology for Indonesia
- Better data in → more detailed/reliable results
- More technologies to be included (consistent methodology)
- More social and environmental safeguards to be considered
- Should serve as a first approximation for planning (policy making), impact assessment and investment
- Detailed on-the-ground planning by engineering companies
- Methodology can be expanded to the wider region SEA

→ **more realistic potentials for sustainable biomass feedstock**

POSSIBLE STEPS AHEAD
E.G. COMBINATION WITH RESTORATION



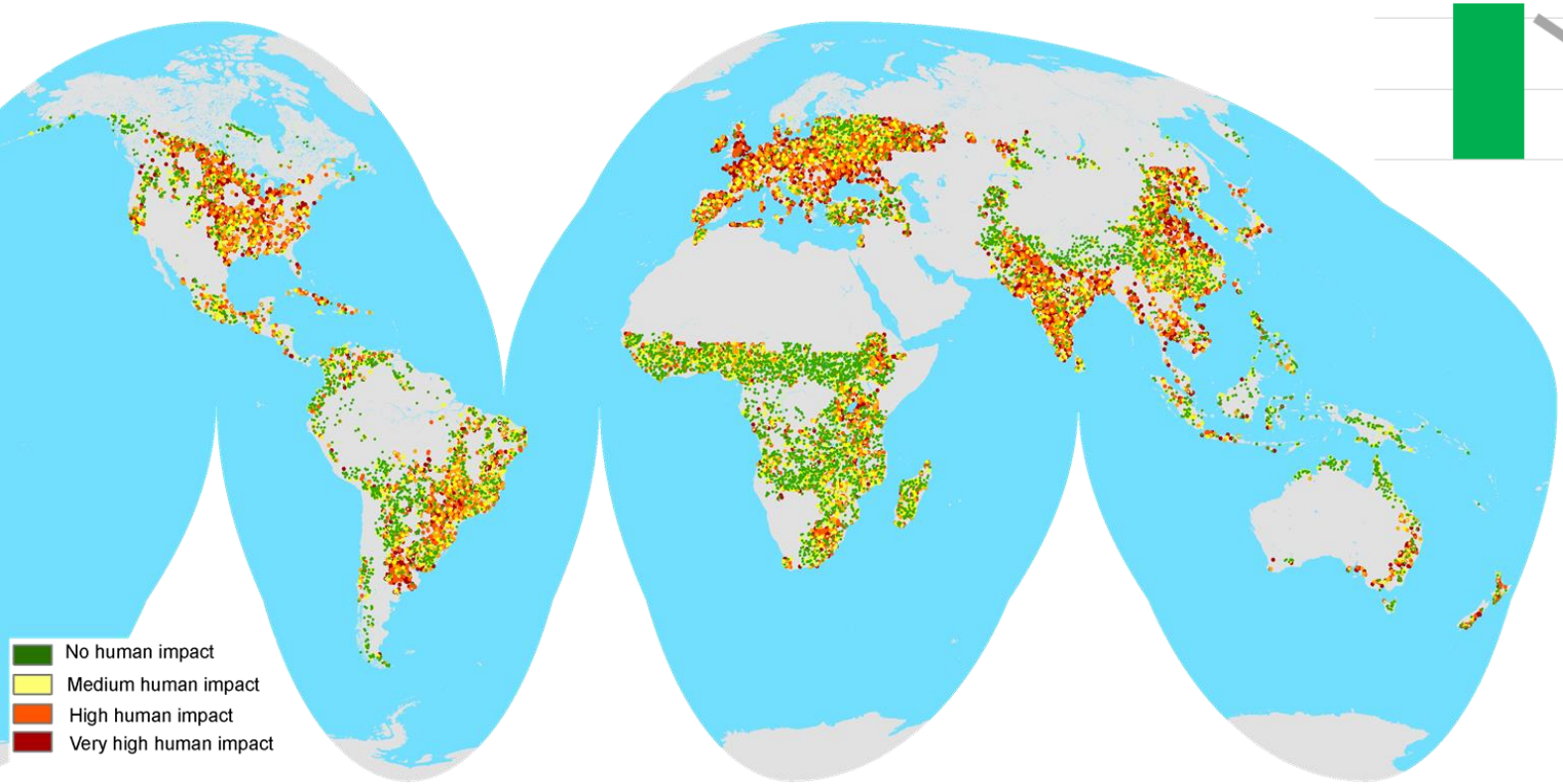

Bonn Challenge targets: 150 million hectares of deforested and degraded land by 2020, and additional 200 million hectares by 2030

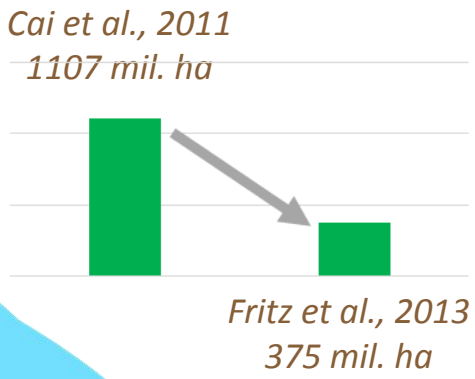
"Global estimates of degraded area vary from less than 1 billion ha to over 6 billion ha, with equally wide disagreement in their spatial distribution."
(Gibbs and Salmon, 2015)

How do we assess large scale FLR potential?

Realistically ambitious and operational to ensure environmental and social benefits?

REALISTIC ESTIMATES OF LAND AVAILABILITY USING CROWDSOURCING





Fritz et al, 2013, Environmental Science and technology

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