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# USING INTEGRATED GEO AND LEO ORBIT SATELLITE DATA IN ON-GRID SOLAR POWER POTENTIAL SITE SELECTION IN VIETNAM

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# RESEARCH AND APPLICATION OF SPACE TECHNOLOGY IN VIETNAM

The Vietnam government approved the "Strategy for research and application of space technology until 2020“ in 2006, and the “Strategy for the development and application of space science and technology by 2030” in 2021

- *The strategy’s overall goal is to widely apply achievements of space science and technology; improve the country’s scientific and technological capacity, minimize damage from natural disasters and provide diversified services for people; promote the development of all socio-economic aspects*
- *In terms of space science and technology application, Vietnam looks to proactively and opportunely supervise and assist the making of decisions in response to widespread natural and social changes within its territory, while providing a rich diversity of telecom, positioning, navigation, and warning services based on satellite data for its people.*

National Science and Technology Program on Space Technology managed by VAST (2008-2011, 2012-2015, 2016-2020) and by MOST (2021-now)

- Application-oriented basic research related to space science and technology
- Calculation model of solar radiation energy using geostationary satellite data with climate model in Vietnam conditions: The project is led by Nguyen Tien Cong, chaired by Vietnam National Space Center

VAST

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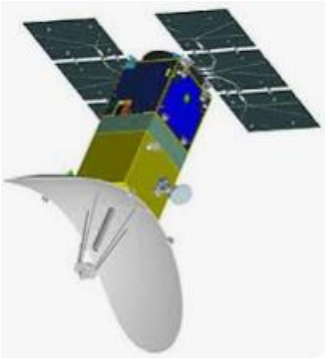
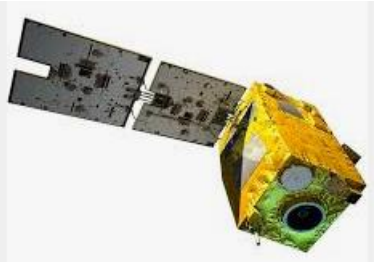


LOTUSAT-1 (2025-)



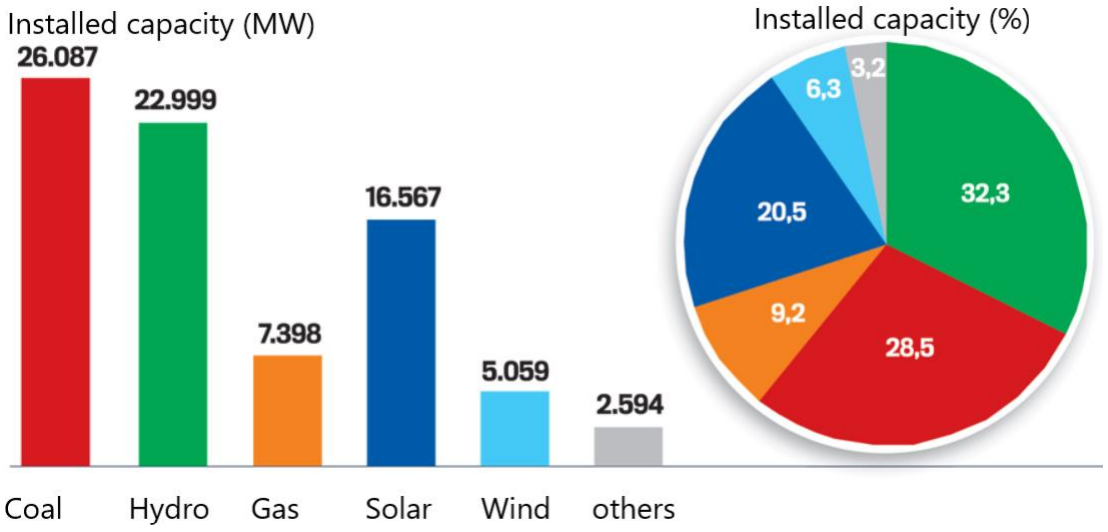
VNREDSAT-1 (2013-NOW)

https://vast.gov.vn/

# SOLAR POWER DEVELOPMENT IN VIETNAM

- The development of solar power system is growing rapidly in Vietnam in recent years by encouragement of the Government in renewable energy. The goal is 50 per cent of public buildings and 50 per cent of households using self-produced and self-consumed rooftop solar power by 2030 (1). The target by 2050 is for the rooftop solar power to reach 39,500 MW.
- Nowadays Vietnamese policymakers are still debating policies and regulations for the development of the rooftop solar power systems for businesses, regarding interests of stakeholders, finance and land use.

- Requirement for accurate data of the solar radiation reaching the surface is important in the successful deployment of solar photovoltaic system. However, measurements of different components of solar resources including direct normal irradiance (DNI) and global horizontal irradiance (GHI) are limited to few stations over whole country.
- Satellite data provides an ability to monitor the surface radiation over large areas at high spatial and temporal resolution as alternatives at low cost.




Until end of 2022, Vietnam power system has installed capacity of 80.704 MW. Solar power is about 16.567 MW, account for about 20,5% (with rooftop solar power is 9.000 MW)
*Source: Vietnam Ministry of Commerce & Industry*

# STUDY AREA & METHODOLOGY

In this research, we integrate GHI (Global Horizon Irradiance) estimated from Himawari-8 that is a Japanese geostationary satellite (GEO satellite) and the land use classified from Landsat-8 and Sentinel (LEO satellites), and other data to select potential site for the 1MWe on-grid solar system development in province of Dak Nong, Vietnam.

## The potential site selection :

**Theoretical Potential solar**

**Mapping:** Partition of Himawari estimated GHI data using K–means algorithm

**Geographical potential**

- **Land use**: type
- **Topography:** slope
- **Natural Hazard:** integrated geological hazards

| criteria | Pro | Con |
|---|---|---|
| slope | <15m | >15m |
| Landuse | Others | Water, cultivation, forest, transportation |
| Geological hazard | low-high | Very high |

Area 6,509.27 km2 (rank 30/63)
Population (2022) 770,600; density 120p/km2; GRDP (billion USD) 1.72 (rank 57/63)

*pepper area is nearly 34,000 hectares, ranking first in the Vietnam; coffee area is more than 141,000 hectares, ranking third in Vietnam (2)*

# Solar radiation estimated from Himawari satellite over Vietnam territory

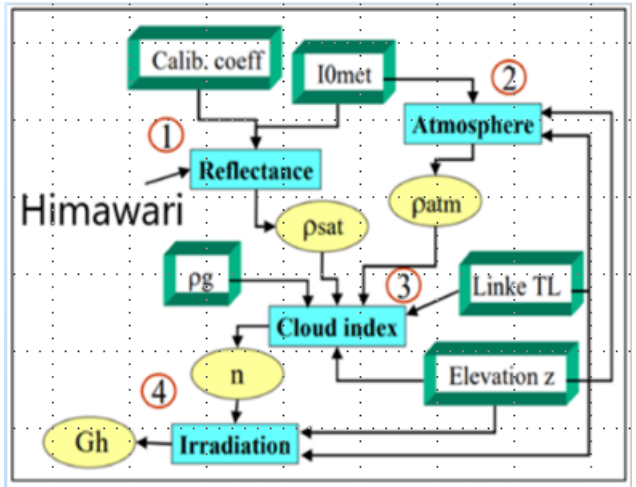
doi:10.15625/2525-2518/58/3A/14230

Observations from Himawari-8 produced imagery covering Asia-Pacific region permitting estimations of Global Horizontal Irradiance (GHI) and Direct Normal Irradiation (DNI) over Viet Nam at 10-minute temporal resolution. This study uses Himawari-8 radiation product (ERSA model) to estimate solar radiation over the Vietnam territory and observations recorded at 5 stations in different regions of Viet Nam to evaluate.

Heliosat-2 model : - ESRA clear- sky model

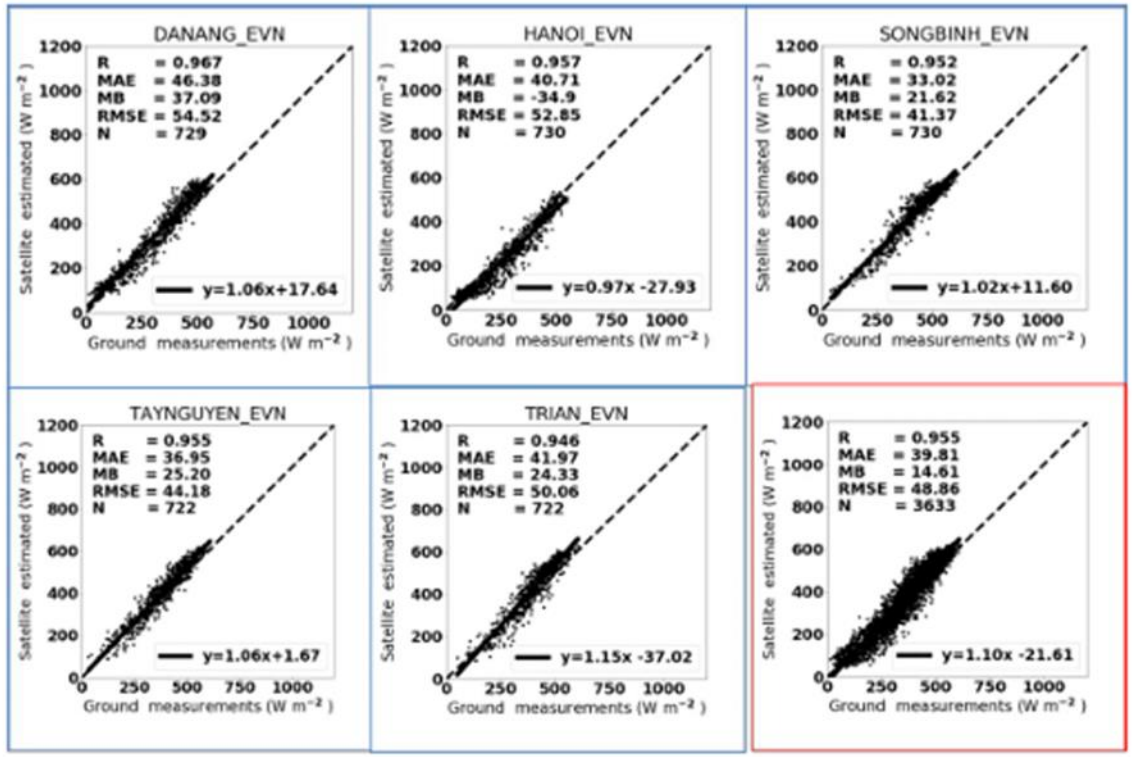
Station Observations: 5 stations by EVN-World bank (10/2017- 2020) and 1 station in Dak Nong by our project (2019-2021)

https://energydata.info/dataset/esmap-solar-measurements-in-vietnam




Work flow of ESRA model

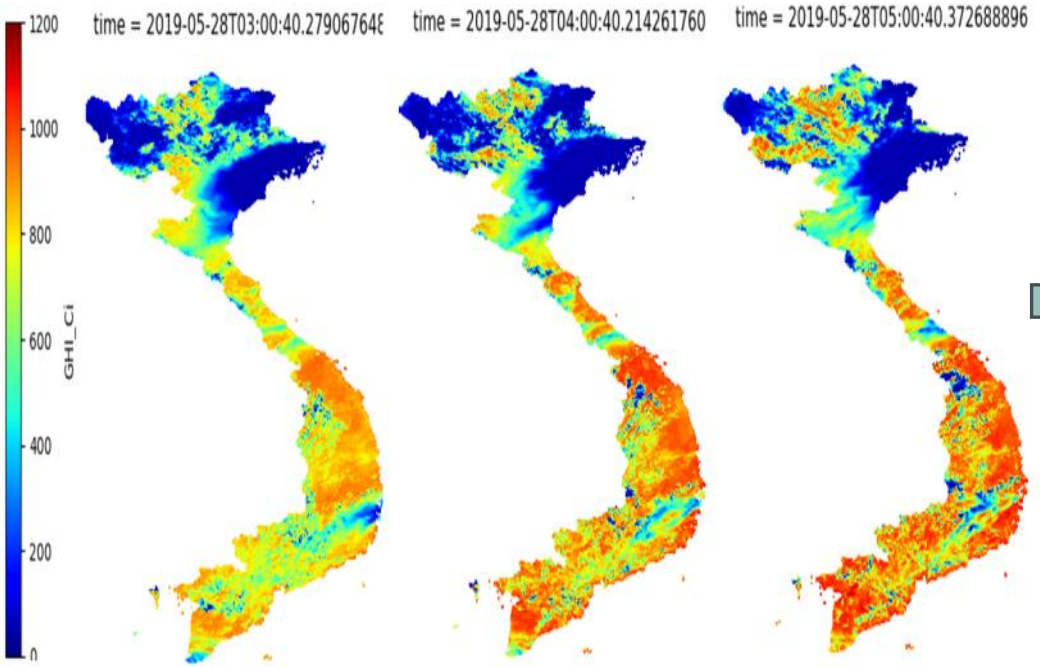
Comparison of daily average radiation estimates using the ESRA model for each station and all stations (red frame)



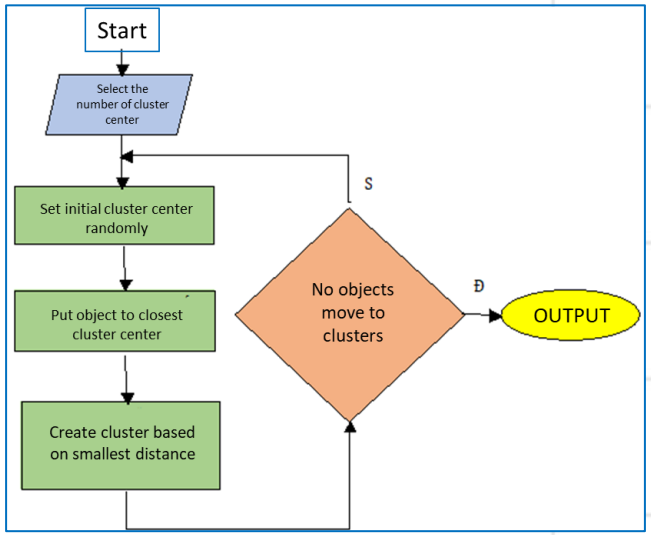
# SATELLITE-BASED REGIONALIZATION OF SOLAR IRRADIATION IN VIETNAM BY K-MEANS CLUSTERING

https://doi.org/10.1175/JAMC-D-20-0070.1

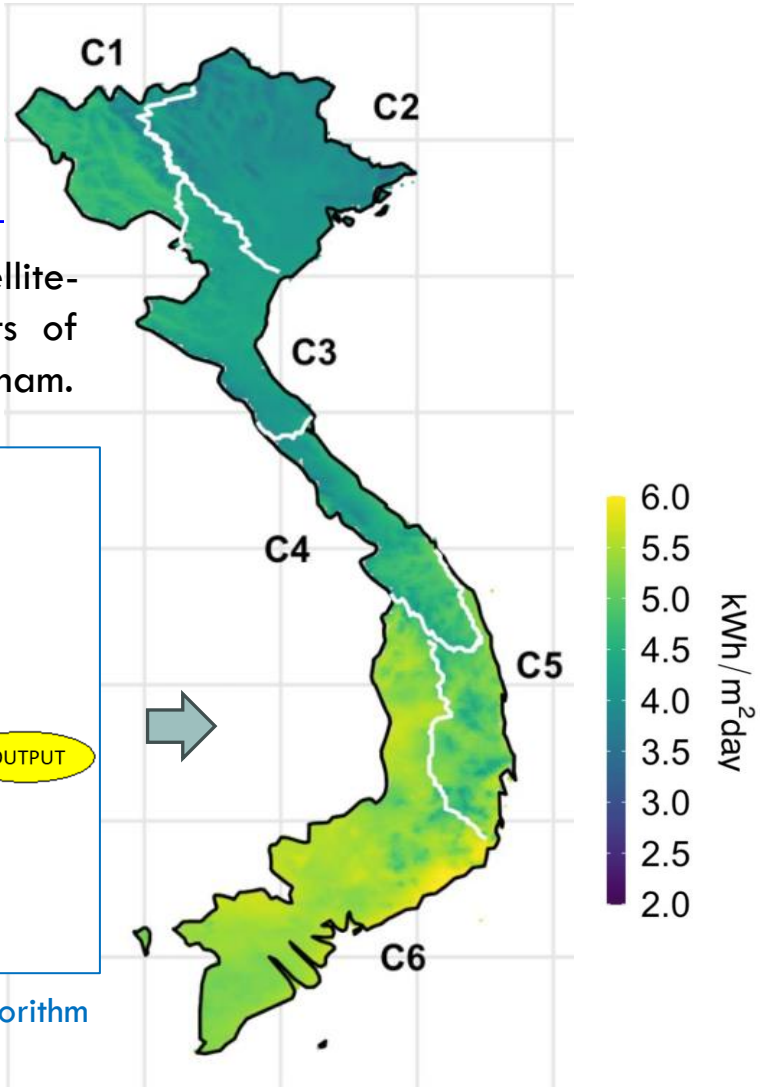
This study focused on regionalization of surface solar irradiation in Vietnam by using 3-year satellite-based daily global horizontal irradiation (GHI) estimates by K-means clustering. The results of illustrated the best 6-cluster groups with a good spatial homogeneity for its regionalization in Vietnam.



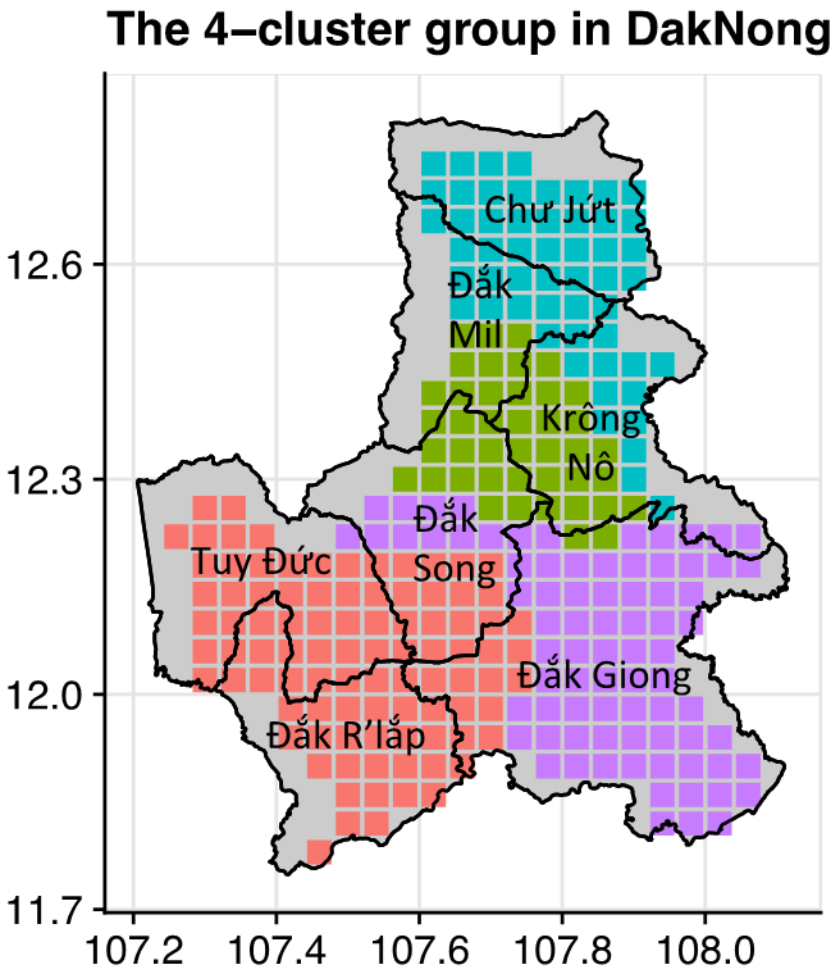

Map of global horizontal irradiation estimates (GHI) from the ERSA model (10-minute data)




Flowchart of k-means clustering algorithm

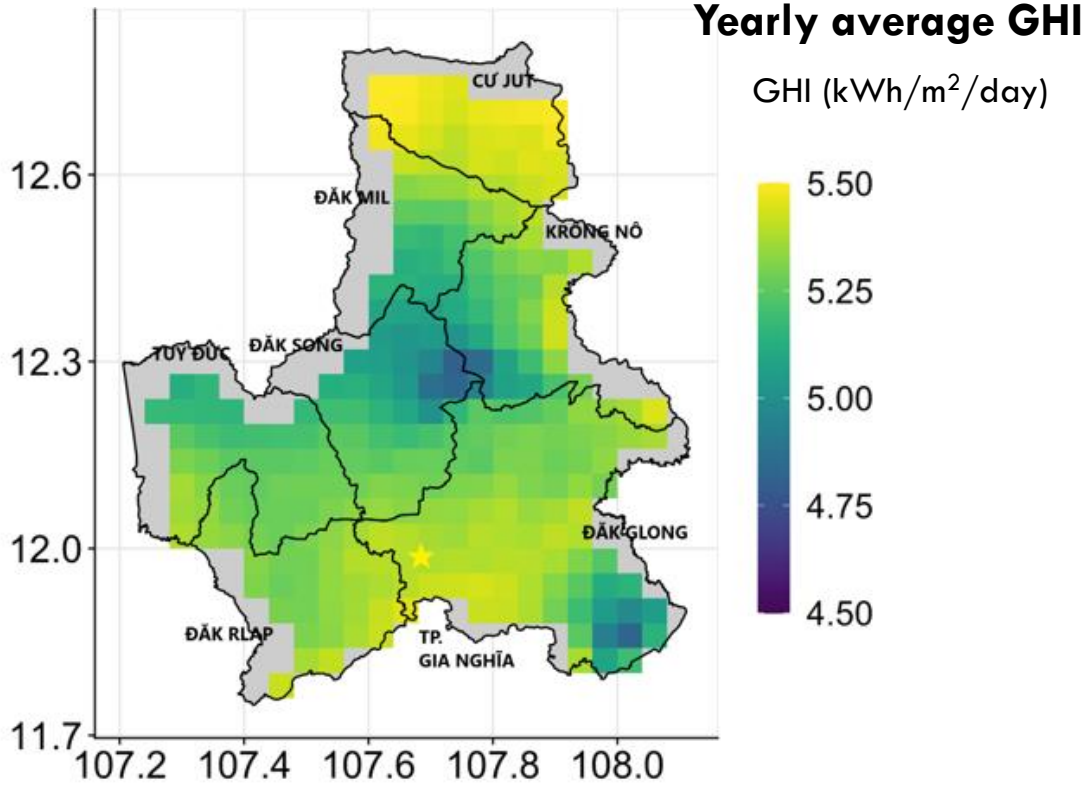



Distribution of the daily-averaged GHI estimated by satellite data and separation of 6 cluster groups









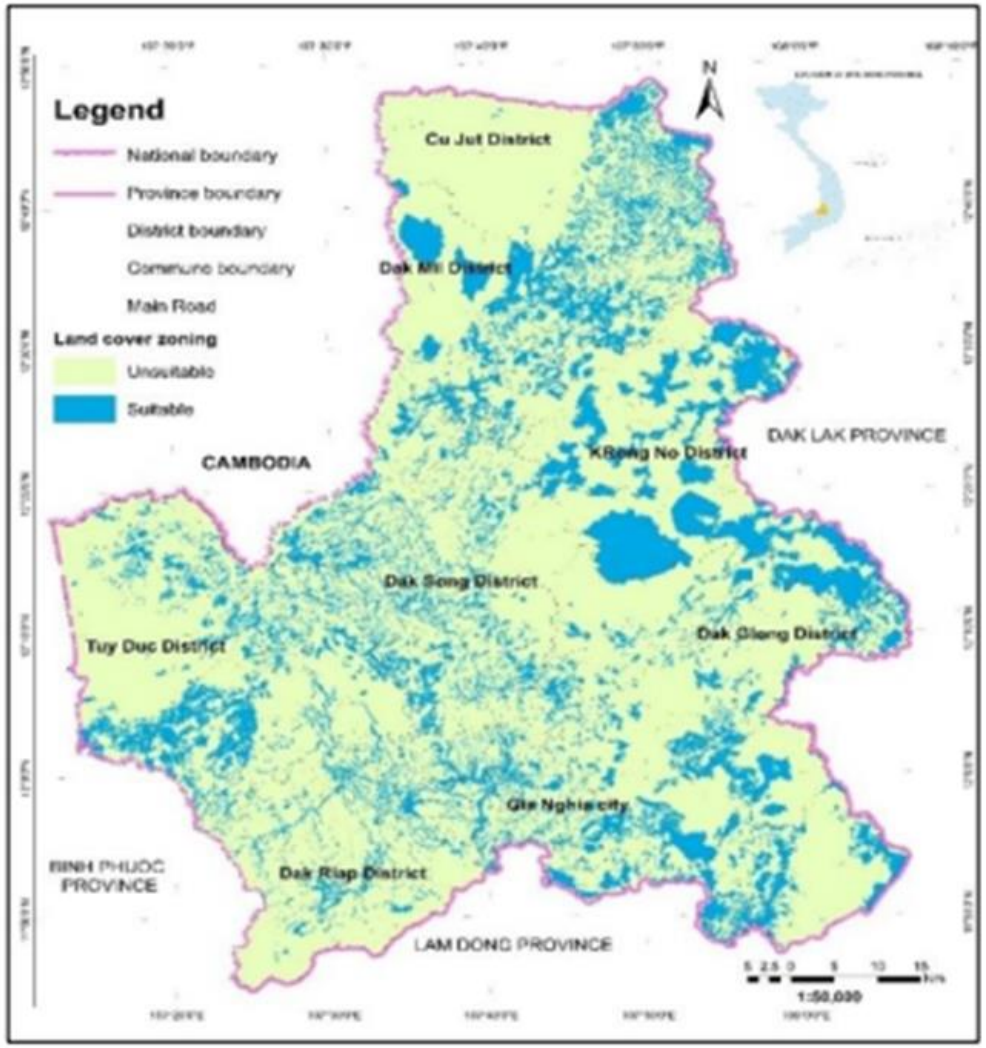

# Mapping Theoretical potential solar for Dak nong province

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | MEAN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cluster-1 | 5.18 | 6.20 | 6.58 | 6.31 | 5.67 | 5.05 | 4.62 | 4.63 | 5.15 | 5.07 | 4.83 | 4.36 | 5.30 |
| Cluster-2 | 4.22 | 5.31 | 6.78 | 6.32 | 5.75 | 5.15 | 5.11 | 5.14 | 5.29 | 4.86 | 3.97 | 3.21 | 5.09 |
| Cluster-3 | 4.64 | 5.67 | 6.96 | 6.57 | 6.08 | 5.37 | 5.43 | 5.44 | 5.59 | 5.07 | 4.29 | 3.60 | 5.39 |
| Cluster-4 | 5.04 | 6.08 | 6.83 | 6.33 | 5.72 | 5.05 | 4.64 | 4.69 | 5.25 | 5.00 | 4.57 | 4.04 | 5.27 |

# Landuse suitability

**Table 2.** Lists of types of Land use suitable for solar power in Dak Nong province.

| Code | Land use type | Area (ha) |
|---|---|---|
| BCS | Unused flat land | 51.05 |
| CAN | Security land | 1,213.09 |
| CDG | Specialized land | 779.88 |
| CQP | Defense land | 2.885.65 |
| DBV | Land for post and telecommunications works | 6.82 |
| DCH | Market land | 33.36 |
| DCK | Land for other public works | 1.55 |
| DCS | Unused hilly land | 18,065.93 |
| DDT | Land with historical and cultural relics | 17.56 |
| DGD | Land for construction of educational and training institutions | 412.92 |
| DNL | Land for energy works | 8,344.65 |
| DRA | Land for landfill, waste treatment | 45.40 |
| DSH | Land for community activities | 49.31 |
| DTS | Land for construction of headquarters of non–business organizations | 31.86 |
| DTT | Land for construction of sports facilities | 83.13 |
| DVH | Land for construction of cultural facilities | 32.39 |
| DXH | Land for construction of social service establishments | 7.39 |
| DYT | Land for construction of medical facilities | 70.64 |
| NHK | Upland land for planting other annual crops | 104,671.3 |
| NKH | Other agricultural land | 108.38 |
| ODT | Land in urban areas | 2,115.60 |
| ODT+CLN | Land in urban areas + Land for perennial crops | 553.30 |
| ONT | Land in countryside | 15,730.46 |
| ONT+CLN | Land in countryside + Land for perennial crops | 2,240.67 |
| ONT+NHK | Land in countryside + Upland land for planting other annual crops | 57.19 |
| PNK | Other non–agricultural land | 235.96 |
| SKC | Land for non–agricultural production facilities | 6.71 |
| SKS | Land used for mineral activities | 385.49 |
| TIN | Land of faith | 0.87 |
| TMD | Commercial and service land | 15.65 |
| TON | Land for religious facilities | 130.51 |
| TSC | Land to build office headquarters | 197.50 |




Landused map of 2014 is updated by using 6 Landsat scenes (2014-2016) & 12 Sentinel-2 scenes (2017-2019) that are classified by pixel-based technique

Landuse suitability area: 158.528,21 ha, 22,9% province area

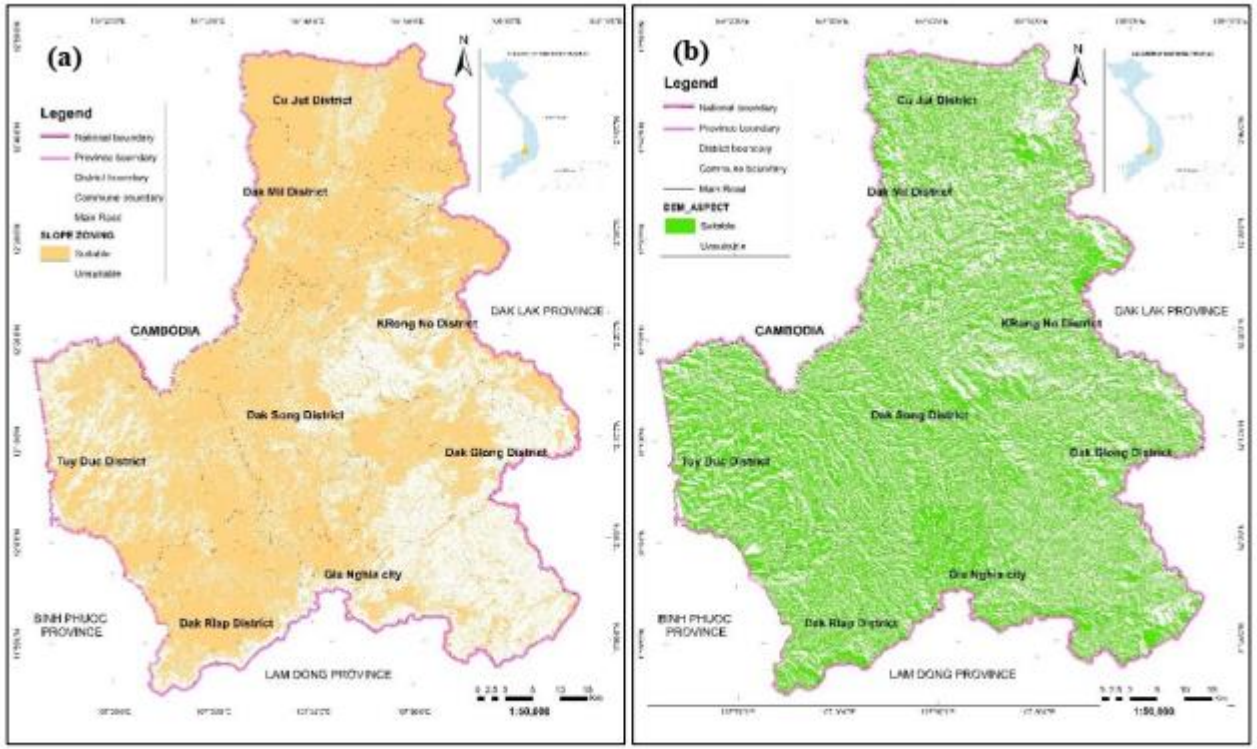
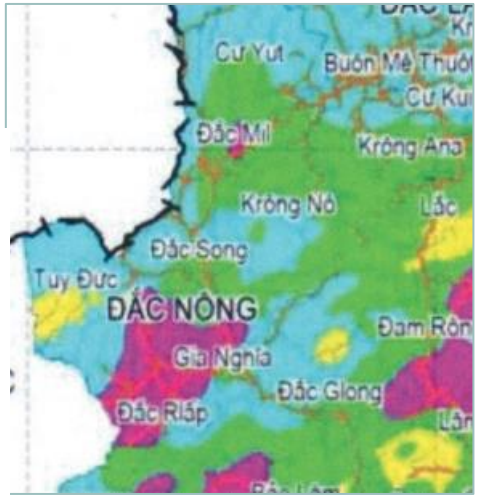
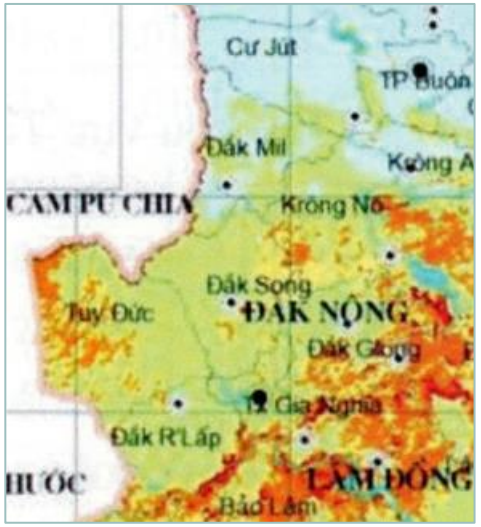


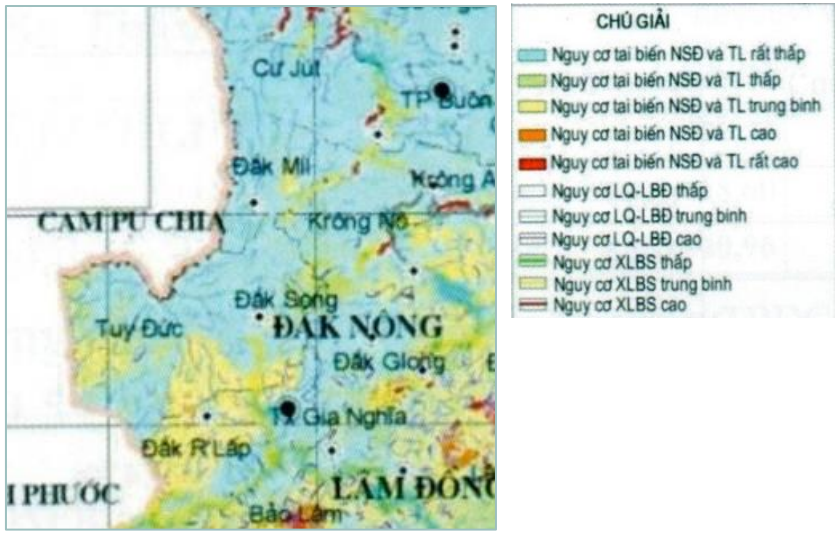

**Figure 7.** (a) Elevation and slope zoning (Orange is the promotion zone and white is the unsuitable zone for Solar PV Development); (b) The Aspect zoning (Green is the promotion zone and white is the unsuitable zone for Solar PV Development.




Subsidence-Cracking risk




Landslide risk

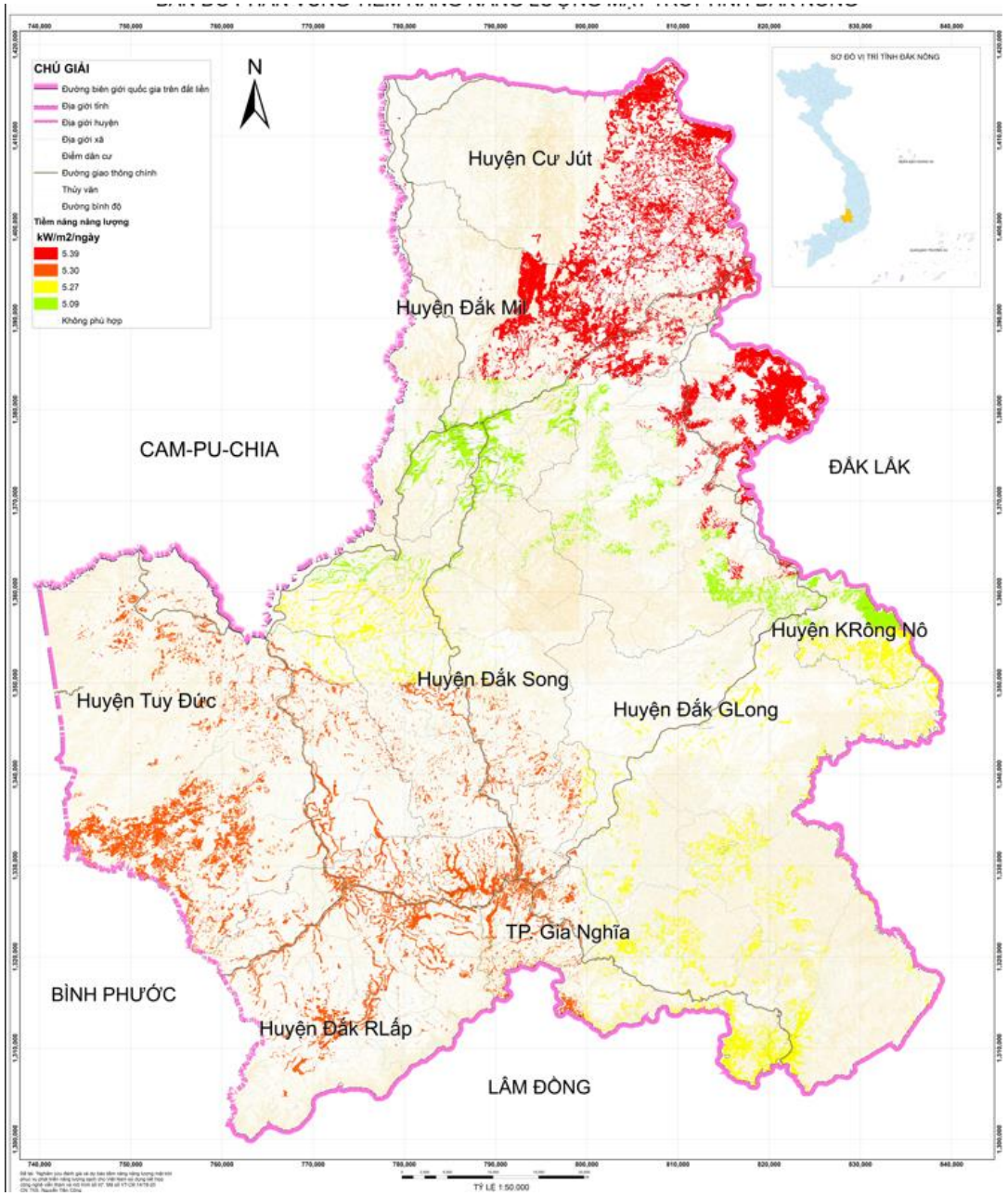


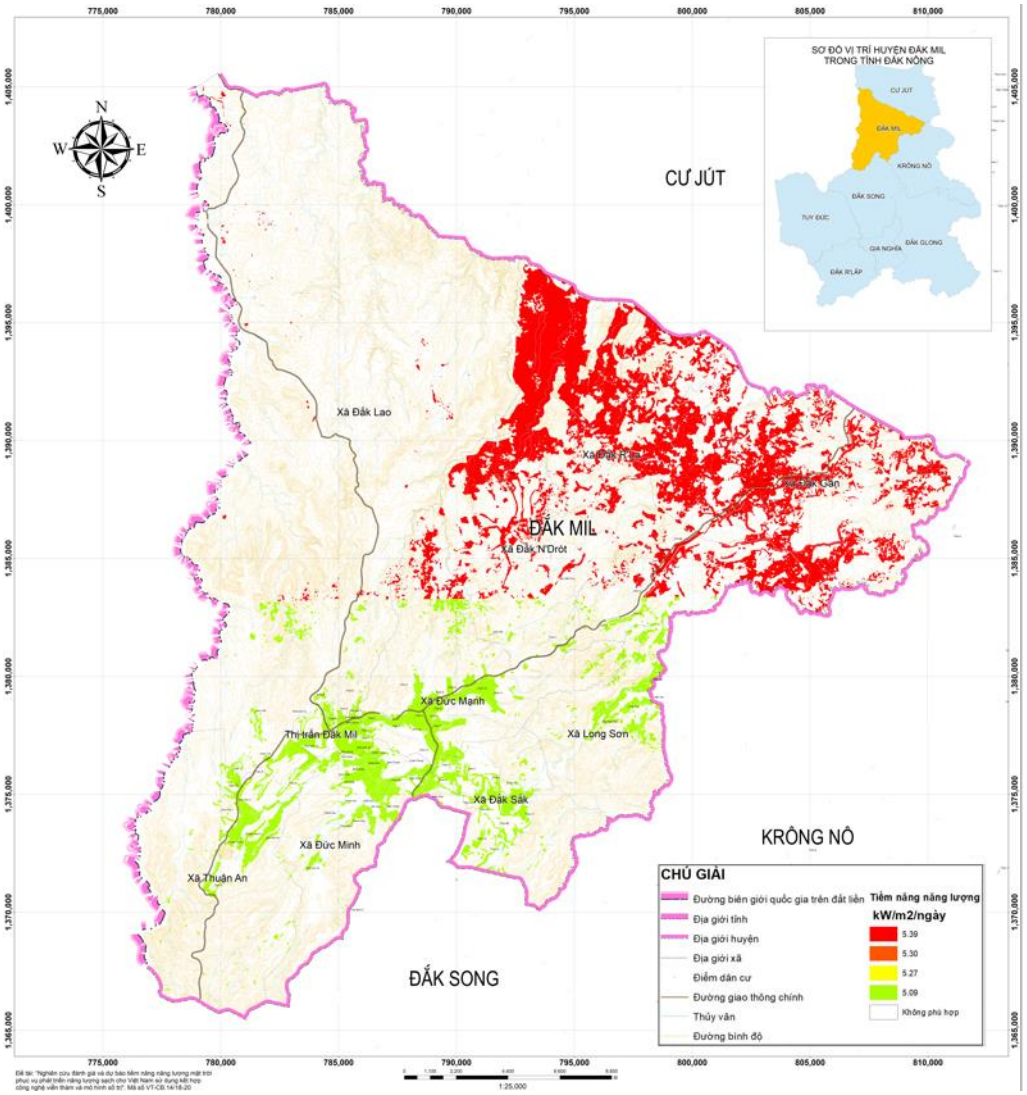

integrated geological hazard

## Topography and Natural Hazard factors

https://doi.org/10.15625/0866-7187/37/2/7370

# RESULTS




About 12 percent of the entire area of Dak Nong province is potential for on-grid under 1MW solar power development.

Red: the most suitable sites
Orange: high suitable site
Yellow: suitable site
Green: less suitable site

# SUMMARY

- The regionalized global horizontal irradiance (GHI) and land suitability are considered as dominant factors in selecting suitable site for solar power development. The regionalized GHI is crucial input data to assess the geographical potential, as well as economically efficient locations for solar power installation.
- The area of pepper and coffee and other cultivation in the study area is so large that place a limit on land for solar power development.
- The study's limitation is shortage of local high-quality solar radiation data. It is difficult to validate our solar estimation model as well as mapping higher spatial resolution in the study area.
- The study's results were transferred to the National Load Dispatch Center where operates the nationwide power system, and put into operation solar power plants. The Center also has need of the forecast of load demand that can be based on daily solar radiation forecast.

# RECOMMENDATION

- This study implements the initiative involving synergistic applications of geostationary orbit (GEO) and Low Earth orbit (LEO) satellites that promoted at the Asia-Pacific Regional Space Agency Forum (APRSAF) 2014 & 2016.
- The integrated usage of GEO and LEO satellites data is essential to assess of solar radiation potential in the development of planning policies and financing schemes for successful PV system deployment in the developing region.
- SHARING DATA is the best possible solution to implement a space application project.