

WP23_25: Night-Time Light Remote Sensing for Sustainable Development Goals

1420,252

Basic Information

Full title of the Initiative

Night light of human settlement

Short Title or Acronym

GEO night light

Current category in the 2020-2022 GWP

Community Activity

Proposed category in the 2023-2025 GWP

GEO Initiative

Points of Contact

First Name	Last/Family Name	Email
Xi	Li	lix@whu.edu.cn
Qingling	Zhang	zhangqingling@mail.sysu.edu.cn
Einar	Bjorgo	Einar.BJORG@unitar.org
Sherzod	Rakhmonov	sherzod.rakhmonov@gmail.com
Yi	Jiang	Yijiang@adb.org

Purpose

Objective

Use night light remote sensing to evaluate socioeconomic condition in developing countries where statistics is insufficient

Please provide a short description of the Initiative

Satellite-observed night light images are able to reflect spatiotemporal patterns of socioeconomic dynamics especially for the regions where statistical data is difficult to access. In Central Asia, human settlements with low-density of population are widely distributed due to geography and history. Considering that significant socioeconomic fluctuation is common in this region in the past three decades, evaluating socioeconomic conditions of these human settlements are valuable for both the national governments and international organizations such as Asian Development Bank, while statistical survey in such large area with low density of

population is very costly.

In this project, we aim to use multi-source night light images to evaluate three socioeconomic aspects in this region, including electricity supply, impact of COVID-19 on economy and poverty. Night light images with high resolution from two satellites owned by Wuhan University will help to evaluate the micro aspect, the poverty, while night light images with low resolution from USA's Suomi NPP satellite will serve to evaluate the macro aspects such as impact of COVID-19 on the economy and stability of electricity supply. Based on the developed technique from our ongoing GEO project "Night-time light remote sensing for sustainable development goals" as the Community Activity Project during 2020-2022, time series analysis and socioeconomic parameter estimation methods will be employed to complete this task. The output of this project will be used by governmental departments, such as Ministry of Energy Supply in Uzbekistan, Ministry of Economic development and poverty reduction in Uzbekistan, Ministry of Tourism and international organizations for decision making.

Why is this Initiative needed?

Surveying socioeconomic conditions in human settlements of low population density such as Central Asia is urgently needed for making socioeconomic strategies such as poverty reduction and energy development. However, taking such survey is costly because the residents are scattered in large area, while night light remote sensing data has been proved to be an efficient proxy for socioeconomic variables by a number of distinguished geographers and economists (e.g. William Nordhaus, the Nobel Prize laureate in Economics). Therefore, in this Initiative, the night light remote sensing will be used to survey socioeconomic conditions in the human settlements.

What evidence is there to support this need?

From the reports of the World Bank and IMF, Central Asia has been severely shocked by the COVID-19, which deteriorates existing poor economic conditions in some regions. However, more detailed information is insufficient even for the national governments, which have been proved by our project members from Uzbekistan. Interestingly, night light images have clearly shown that many night light patches have disappeared in 2020 probably due to the COVID-19, indicating that night light remote sensing would help to survey the socioeconomic conditions in Central Asia.

Is this Initiative open to participation by representatives of any GEO Member, Participating Organization, and GEO Associate?

Yes

Are you aware of other projects or initiatives at a global or regional scale (both in GEO and externally) that provide similar products or services?

No

Please identify the most important actual and/or intended outputs (products, services, etc.) produced by the Initiative, along with their intended and/or actual users. This list does not need to be comprehensive but should identify the outputs which are most used and are expected to have the greatest potential impact.

Output	Status	Users	Additional info
Electricity supply map	Regularly updated	Ministry of Energy Supply in Uzbekistan; Ministry of Tourism in Uzbekistan	
Poverty map	Regularly updated	Ministry of Economic development and poverty reduction in Uzbekistan	
Economic recovery map	Regularly updated	Ministry of Economic development and poverty reduction in Uzbekistan	

If needed, please provide additional comments or explanation to accompany the outputs table

- no answer given -

What kinds of decisions are the outputs of this Initiative primarily intended to support?

(1) National and local governments' spatial planning of new power plants for regions lacking of electricity; (2) Spatial planning of aid projects from international organizations (e.g. Asian Development Bank); (3) Improving official tourist handbooks with recommended human settlements for visiting

How will these decisions benefit from the outputs of this Initiative?

(1) Spatial planning of new power plants are based on the detected region with insufficient electricity supply, which can be derived from the electricity supply map; (2) Spatial planning of aid projects are based the detected poverty region, which can be derived from the poverty map; (3) Official tourist handbooks recommended regions for tourists, while electrification rate from the electricity supply map is an important factor for ranking the recommended tourist destination.

What kinds of impacts (for example, reduced loss of life, monetary savings, conservation of biodiversity, etc.) are anticipated as a result of the use of the outputs of this Initiative?

(1) Increased population with stable electricity supply; (2) Reduced poverty population due to optimal international aid; (3) Better reputation of tourism due to improved tourist handbooks

Has this Initiative been asked to provide specific information (for example, reports, data, services) on an ongoing basis to an international convention, organization, or other multilateral body?

No

Technical Synopsis

Please provide a brief description of the methods used by the Initiative to produce its (actual or planned) outputs.

The initiative will mainly include three products (i.e. electricity supply map, poverty map and economic recovery map) as mentioned above, and the methods for generating these products are as follows:

(1) Electricity supply map is derived from night light data of the NPP satellite, because NPP satellite is able to record night light every day at large scale although its spatial resolution is low. Night light dynamic from daily night light in cloud-free weather conditions reflects the stability of electricity supply. Firstly, a human settlement map and time series night light data from NPP satellite will be prepared. Secondly, the impact of Viewing Zenith Angle on the observed night light radiance must be considered, so that radiance-normalization method is used to generate a more stable night light time series. Thirdly, using thresholding on the time series night light radiance, which aims to detect the power outage day, a power outage frequency index is calculated. Finally, combining the power outage frequency index and the average night light brightness, the electricity supply index is generated and thus the electricity supply map is produced.

(2) The poverty map is derived from medium/high resolution night light data acquired from the two nano satellites (i.e. Luojia-1 and Qimingxing-1) owned by Wuhan University. Firstly, a land use map, the night light image and Open Street Map (OSM) are prepared. Secondly, by overlaying the three kinds of data, the mismatch index between the building density and the night light brightness is generated. Thirdly, considering land use types, the poverty intensity map is generated at fine spatial resolution based the mismatch index. Lastly, using spatial statistics, the hotspots of poverty inside cities are detected as a layer of the poverty map, and the poverty map is generated finally.

(3) Economic recovery map is derived from night light data of the NPP satellite. Firstly, long time series of night light images acquired from NPP satellite is prepared. Secondly, a COVID-19 impact index is calculated by comparing night light before and during the COVID-19 era based on Mann-Kendall analysis. Thirdly, the

recovery index is generated based on the pre-COVID-19, COVID-19 and post-COVID-19 eras, by temporal trend analysis of the night light data. Lastly, this recovery index is corrected with econometric model by inputting statistical data.

Appendix:

(1) Luojia-1 satellite, launched at June 2018, has been widely used to map night light data at 130 m resolution (see paper: Li, X., Li, X., Li, D., He, X., Jendryke, M., 2019. A preliminary investigation of Luojia-1 night-time light imagery. Remote Sensing Letters. 10 (6), 526-535).

(2) Qimingxing-1 satellite, launched at February 2022, has shown its powerful capacity to imaging night light at 20 m resolution (see media release in Chinese: <http://rsgis.whu.edu.cn/info/1252/10122.htm>)

If you would like to provide further details on the technical methods, you may upload one or more documents here.

- technique.docx ([link](#))

Are there any significant scientific or technical challenges that need to be resolved by the Initiative during the 2023-2025 period?

No

Does the Initiative expect to complete any key new outputs, improvements to existing outputs, or improvements to the methods of producing outputs, in the 2023-2025 period?

Yes

Please describe these new outputs or improvements.

The current GEO project we host provide general products which are suitable for global scales, and in this new Initiative, we will more focus on Central Asia, so that the algorithm will be updated to be more suitable for Central Asia.

Please identify the key tasks that must be implemented to ensure delivery of these changes, with target dates for completion.

Task	Task description	Expected completion (month/year)
Preparing all data for electricity supply analysis	All data for electricity supply analysis is prepared	July/2023
Producing electricity supply map	The map is produced for Central Asia	December/2023
Preparing all data for poverty analysis	All data for poverty analysis is prepared	July/2023
Producing poverty map	The map is produced for Central Asia	December/2023
Preparing all data for economic analysis	All data for economic analysis is prepared	July/2023
Producing economic recovery map	The map is produced for Central Asia	December/2023
Collaborating with Uzbekistan Government for policy analysis	Providing the produced data for Uzbekistan Government to evaluate its economic policy and make future policy	July/2025

Resources

Have all resources required to implement the Initiative's planned work in the 2023-2025 period been secured?

Please list all financial and non-financial contributions to the Initiative (other than in-kind, voluntary participation by individual contributors) having a value of more than USD 50,000.

Contributing Organization	GEO Status	Type of Resource	Value	Currency
Wuhan University	China	Financial	2000000	RMB
Sun Yat-sen University	China	Financial	500000	RMB
UNITAR	UNITAR - United Nations Institute for Training and Research	Data	200000	USD
Tashkent institute of Irrigation and Agricultural Mechanization Engineers (TIIAME)	Uzbekistan	Secondment	20000	USD
Cadastral Agency	Uzbekistan	Data	60000	USD
Wuhan University	China	Data	1000000	RMB
Asian Development Bank	Multiple countries	Data	5000	USD

Lessons from the 2020-2022 Period

Were all planned activities for the 2020-2022 period implemented as expected?

Yes

Were there any key challenges faced by the Initiative in the 2020-2022 period?

Yes

Please describe.

The international collaboration met challenges due to the COVID-19, so that all the discussions are online.

Were there any impacts or changes to operations due to COVID-19?

Yes

Please describe.

The international collaboration met challenges due to the COVID-19, so that all the discussions are online.

Please describe the key changes proposed for the 2023-2025 period, for example, new projects, new areas of focus, or adjustments to the activity governance.

In the 2023-2025 period, we will focus on Central Asia.

Does the Initiative have outputs (products, services, etc.) available to users now, even if only on a pilot or testing basis?

Yes

Please provide any available information describing this usage (for example, user statistics, results of user testing) and/or feedback from users (for example, user comments, evaluations).

Name: 30 m-scale Annual Global Normalized Difference Urban Index Datasets from 2000 to 2013

Link: <https://www.scidb.cn/en/cstr/31253.11.sciencedb.01625>

The dataset was shared recently, so we are still waiting for user's feedback.

Please provide supporting documentation if available.

- no supporting documents provided -

Do you have evidence of any impacts that have occurred in part as a result of using the outputs of the Initiative (for example, policy decisions taken, behaviour changes by users, risks mitigated)?

Yes

Please provide examples, with evidence where available.

NASA has applied Xi Li's research paper to produce its multi-angular night light product. Please see "User's should be aware that artificial lights derived from VIIRS DNB data show a strong angular effect (Li et al., 2019)... Accordingly, NASA's Black Marble monthly and yearly NTL composites are generated for multiple view angle categories (i.e., near-nadir, off-nadir, and all angles)..." in Page 6 of "Black Marble User Guide Version 1.2".

Please provide supporting documentation if available.

- no supporting documents provided -

Have there been any internal or external reviews or evaluations of the Initiative since 2019?

No

Please indicate any GEO Work Programme activities with which you have ongoing collaboration.

- AOGEO - Asia-Oceania Group on Earth Observations
- EO-IIP - Earth Observation Industrial Innovation Platform for Sustainable Development
- HUMAN-PLANET - GEO Human Planet

Please indicate any additional GEO Work Programme activities with which you would like to establish new collaborations.

- AFRIGEO - African Group on Earth Observations
- EO4DRM - Earth Observations for Disaster Risk Management

Stakeholder Engagement and Capacity Building

Are there specific countries or organizations that your Initiative would like to engage?

Yes

Please list these countries, regions or organizations.

Uzbekistan
Asian Development Bank

What are your plans to engage them?

Tashkent institute of Irrigation and Agricultural Mechanization Engineers (TIAME) and Cadastral Agency in Uzbekistan have strong background on remote sensing applications as well as GIS analysis, and they will collaborate with China and UNITAR by providing local knowledge and data, and they will also responsible for contacting Ministry of Energy Supply, Ministry of Economic development and poverty reduction and Ministry of Tourism in Uzbekistan. Asian Development Bank (ADB) has existing collaboration with Uzbekistan government for affairs including economic reform, economic recovery from COVID-19 and aid projects, and ADB will applied the product of this Initiative on strategy of aid projects.

The initiative will discuss with the users (e.g. governmental ministries of Uzbekistan) to know their need, and make analysis according to it. For example, Ministry of Economic Development and Poverty Reduction would like to know if the investment from the central government has alleviated regional inequality in different regions, and the initiative will analyze the regions which the ministry is focusing on. If the analysis result is negative, the ministry will do more elaborate work, including field work, to investigate the reasons why the investment does not work well.

Does your Initiative engage users in the work of the Initiative (for example, consultation, testing, co-design)?

Yes

Please briefly describe the Initiative's approach to engaging users.

Consultation
The initiative will discuss with the users (e.g. governmental ministries of Uzbekistan) to know their need, and make analysis according to it. For example, Ministry of Economic Development and Poverty Reduction would like to know if the investment from the central government has alleviated regional inequality in different regions, and the initiative will analyze the regions which the ministry is focusing on. If the analysis result is negative, the ministry will do more elaborate work, including field work, to investigate the reasons why the investment does not work well.

Does the Initiative have a user engagement strategy or similar kind of document?

No

Are there categories of users that are not represented at this time, but you would like to engage?

Yes

Please list these user categories or regions.

Governmental ministries of Kazakhstan

What are the plans for further engagement of users in the Initiative?

The users from Kazakhstan will provide their need considering the specific geographic and economic conditions, so that our product and its algorithm will be adjusted to their need.
The initiative will discuss with the users (e.g. governmental ministries of Uzbekistan) to know their need, and make analysis according to it. For example, Ministry of Economic Development and Poverty Reduction would like to know if the investment from the central government has alleviated regional inequality in different regions, and the initiative will analyze the regions which the ministry is focusing on. If the analysis result is

negative, the ministry will do more elaborate work, including field work, to investigate the reasons why the investment does not work well.

Does the Initiative have a documented capacity development strategy?

No

Please describe the approach to capacity development that is being implemented by the Initiative?

Wuhan University, the lead of this Initiative, has used its exiting international training framework to trainees from developing countries. Due to the COVID-19, all the training lectures were online. Until now, there are more than 50 trainees have attended our online training courses for night light remote sensing.

Are there any commercial sector organizations participating in this Initiative?

No

Are there opportunities for commercial sector uptake of the outputs of the Initiative?

No

Are there opportunities for further commercial sector participation in the Initiative?

No

Does the Initiative have a plan for commercial sector engagement?

No

Governance

Please describe the roles of each of the key leadership positions, as well as any team structures involved in day-to-day management.

Wuhan University in China will lead this Initiative with Prof. Xi Li as the lead, and lead persons of Sun Yat-sen University, TIIAME in Uzbekistan, Cadastral Agency in Uzbekistan, UNITAR and ADB are Prof. Qingling Zhang, Dr. Sherzod Rakhmonov, Mr. Sokhib Kamilov, Dr. Einar Bjorgo and Dr. Yi Jiang, respectively. In addition, Wuhan University will employ a full time coordinator to manage this Initiative, and he/she will responsible for contacting different engaged parties. Every month, an online meeting will be hold for communication of this Initiative, and the progress and problems will be discussed during the meeting.

Is there a steering committee or other governance bodies that advise the Initiative but are not involved in day-to-day management?

Yes

Please describe the roles of each body. If there are multiple governance bodies, please describe the relationships among them (such as through a governance structure diagram).

A Steering Committee will be organized, with representatives from participating organizations and end-user department as well independent experts and AOGEO. Because we are still negotiating with end-users (e.g. national ministries of Uzbekistan), the committee will be formed after several months.

- no supporting documents provided -

What methods does the Initiative use to communicate with its participants?

- Email / e-newsletters
- Regular conference calls
- Website
- Regular events

Please describe the key risks that could delay or obstruct the completion of the planned activities and outputs of the Initiative, along with any actions taken to mitigate these risks.

Description of the hazard	Description of the possible impacts	Scale of impact	Likelihood of occurrence	Mitigation measures
Deterioration of COVID-19	Participating organizations and institutes may be closed due to deterioration of COVID-19, and the progress will be slowed.	Moderate	Possible	Work from home and discussion by online meeting

What methods are used by the Initiative to monitor its effectiveness?

- User or beneficiary surveys
- Website statistics

Would the Initiative be interested in assistance from the GEO Secretariat for developing an impact plan?

Yes

How are the results of the monitoring and evaluation activities shared with participants and the wider GEO community?

A project website will be built to share the outcome of this Initiative, and important progress and evaluation results will be directly reported to GEO Secretariat. Our team will also contact other GEO projects to exchange progress.

Are any monitoring or evaluation activities required by funders/contributors?

Yes

Please describe and provide reports if available.

National Remote Sensing Center of China (NRSCC) will evaluate the progress of this Initiative.

- no supporting documents provided -

Participants

Please list the active individual participants in the Initiative

First name	Last name	Email address	Member	Org
Einar	Bjorgo	einar.bjorgo@unitar.org	UNITAR - United Nations Institute for Training and Research	UNITAR - United Nations Institute for Training and Research
Lars	Bromley	lars.bromley@unitar.org	UNITAR - United Nations Institute for Training and Research	UNITAR - United Nations Institute for Training and Research
Yi	Jiang	yijiang@adb.org		ADB - Asian Development Bank
Deren	Li	drli@whu.edu.cn	China	Wuhan University - Wuhan University
Xi	Li	lixli@whu.edu.cn	China	Wuhan University - Wuhan University
Qingling	Zhang	zhangqingling@mail.syu.edu.cn	China	- Sun Yat-sen University
Sherzod	Rakhmonov	sherzod.rakhmonov@gmail.com		
Bakhtiyor	Pulatov	bakhtiyor.pulatoff@gmail.com		
Ilhomjon	Aslanov	ilhomaslanov@gmail.com		
Mukhiddin	Juliev	mukhiddinjuliev@gmail.com		
Sokhib	Kamilov	sohibjonkamilov.sk@gmail.com		
Zixuan	Shao	shaozixuan@whu.edu.cn		
Yuhe	Zhang	2017301750031@whu.edu.cn		
Jinjin	Li	lijinjin21@whu.edu.cn		
Arief	Ramayandi	aramayandi@adb.org		ADB - Asian Development Bank
Katarina	Palmkron	katarina.palmkron@unitar.org		
Luca	Dell'Oro	luca.delloro@unitar.org	UNITAR - United Nations Institute for Training and Research	

Other information

Please provide any other comments or information that was not included in the previous sections, but you would like to appear in the Implementation Plan.

Region for the Initiative

The technique can extend to global regions so that the title of the Initiative is "Night Light of Human Settlement". Considering the exiting connection, this Initiative will take the entire Central Asia as the study region, and we will study on Uzbekistan at first because we have strong collaboration with the two Uzbekistan institutes which will applied the outcome of this Initiative to several ministries of Uzbekistan. In addition, we will invite more Central Asian countries (e.g. Kazakhstan) to join this Initiative.

The data set in this Initiative will be produced for the entire Central Asia, and we will extend national experiences from Uzbekistan to other Central Asian countries after the successful implementation in Uzbekistan. However, in this stage, the collaboration between our side and Uzbekistan is launched recently, many issues are still in negotiation. Therefore, we think our project in the 2023-2025 period should focus on studies and implementation for Uzbekistan

Details of contribution

The funding (e.g. 2, 000,000 RMB) provided by Wuhan University will be partly funded by a National Key R&D Program of China (Grant no. 2019YFE0126800) and partly by a special funding from State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing (LIESMARS), Wuhan University. The funding provided by Sun Yat-sen University will be supported by a National Key R&D Program of China (Grant no. 2017YFB0504204). The data provided by UNITAR is high resolution images based on agreement between UNITAR and some commercial satellite companies which freely provide the images to UNITAR. The secondment supported by Tashkent institute of Irrigation and Agricultural Mechanization Engineers (TIAME) is a part-time staff working for the project for 3 years. The data provided by Cadastral Agency is geographic data, including accurate administrative borders, POI data and human settlement information, which is not open to public but will be open to our project. The data provided by Wuhan University is satellite imagery of Luoja-1 and Qimingxing-1 which are nighttime satellites owned by Wuhan University. The data provided by Asian Development Bank (ADB) is ADB investment data in Central Asia, these detailed data are not open to public but accessible to this Initiative.

Collaboration with UNITAR

Previously, collaboration between Wuhan University and UNITAR mainly focus on development of technology (see: <https://unitar.org/about/news-stories/news/unosat-introduces-ai-its-flood-rapid-mapping-operations-benefit-national-disaster-management>). In the future, this collaboration would focus on regional analysis rather than analysis of some specific disasters or events. Wuhan University, Sun Yat-sun University and UNITAR will collaborate to work on different aspects and events of Uzbekistan. During the collaboration, UNITAR will provide high resolution satellite images for interested regions of Uzbekistan to support the collaboration. Furthermore, UNITAR may work with the universities to provide geospatial technology training course for departments or organizations in Uzbekistan.

- contributors.docx ([link](#))
- mou.docx ([link](#))

Co-Editor Management

List of co-editors for this initiative

- no answer given -