Global Development Assistance

Clean Energy

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List of Abbreviations

ADB	Asian Development Bank
BREB	Bangladesh Rural Electrification Board
CE	Clean Energy
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German-Aerospace-Center)
EDMP	Electricity Distribution Modernization Program
EO	Earth Observation
ESA	European Space Agency
ESMAP	Energy Sector Management Assistance Program
FITNAH	Flow over Irregular Terrain with Natural and Anthropogenic Heat sources
GDA	Global Development Assistance
GDA AID	GDA Agile EO Information Development
GDP	Gross Domestic Product
GIS	Geographic Information System
HQ100	100-year flood
HR	High resolution
IFI	International Financial Institution
MPEMR	Ministry of Power, Energy, and Mineral Resources
PV	Photovoltaic
SDG	Sustainable Development Goal
VHR	Very high resolution
WB	World Bank
WBG	World Bank Group

What does ESA's Global Development Assistance (GDA) Activity on Clean Energy do?

Access to energy is one of the essential preconditions for poverty reduction (Sustainable Development Goal 1) and one of the main goals of International Financial Institutions (IFIs) like the World Bank (WB) and Asian Development Bank (ADB). Energy enables investment, innovation and new industries that are drivers of new jobs, inclusive growth and shared prosperity for people and entire economies. The IFIs facilitate clean energy investment in developing countries via clean energy projects. Lending operations to their Client States are commonly accompanied by technical assistance activities. Programmatic approaches are often applied to transfer knowledge across national and regional authorities. EO and related applications can support this process by providing independent information about the state of the environment and man-made infrastructure, resulting in more detailed insights for the considered regions.

The GDA AID Clean Energy Activity aims to deliver value-adding products and services to assist the IFIs teams involved in the framework of their current operation and their strategic goals over the coming years. Our geospatial solutions are developed to promote and play its role in facilitating a sustainable energy supply with the targeted use of clean energy.

The objective of the GDA AID Clean Energy activities is linked to IFI initiatives; interacting with and supporting the project teams by providing a more comprehensive, partly multidisciplinary view onto the challenges the bank teams have. The higher granularity of EO information, reached by providing national scale to hyper localised information and linking it to potential and/or existing infrastructure, results in the potential to enhance decision-making processes.

For further context please see: https://gda.esa.int/thematic-areas/

What topics of Clean Energy are in focus?

Renewable energy resource mapping

Detailed and long-term statistics are providing the baseline for resource mapping suitable to characterise and quantify e.g., solar irradiance, wind speed and direction, runoff due to snow cover, geothermal anomalies, and biomass crops. These are only some sources to provide the baseline for the selection of sites and technologies and dimensioning of the potential energy infrastructure.

Localised knowledge on renewable energy resources, specifically their range, steadiness, and extrema, is a fundamental knowledge for building a sustainable implementation of such green resources in suitable dimensions. The use cases of renewable energy resource mapping aim to draw a more comprehensive picture of the exploitable sources considering geospatial conditions.

Energy demand characterisation

Identifying the people's needs and their potential development is essential for efficient and sustainable infrastructure planning. EO is used for mapping settlements, emphasising those containing critical or public infrastructure and commercial activities likely to require higher and rapidly growing demand. By providing an environmental inventory it also identifies potential sources of high demand, such as irrigation areas, smallholder industry and other indicators of high electricity consumption and economic activity.

EO Services can enable IFI teams to provide present and future demand estimation in significantly higher granularity and thus provide valuable input for the entire use case implementation chain: from planning to implementation and monitoring the related impact.

Infrastructure site selection

The information on potential energy resources is linked to the local environment and existing infrastructure. An adequate understanding of the renewable resource availability from national down to local scale is crucial, e.g., identification of solar potential on a country level, considering the specific environmental conditions and its location, down to very high-resolution roof top estimations. The freely available Copernicus Satellite data with high spatial and temporal resolution feeds into this high-level site assessment. Using scalable EO based technology provides valuable site recommendations which are reviewed considering the general effort necessary for use case implementation itself (e.g., proximity to consumers, infrastructure) relevant for deployment of least-cost solutions and for preparing a suitable transmission infrastructure.

Creating inventories of existing energy infrastructure by mapping features such as high-voltage lines

Existing infrastructure, even high-voltage lines, is often coarsely known. An inventory as well as monitoring the electrification progress gets supported by a combination of high- and very-high resolution imagery. Besides identifying the visible infrastructure using EO imagery (high- to low-voltage lines), downstream geospatial modelling supports understanding the most-likely existing and non-existing energy related infrastructure and networks.

Managing energy production operations

Available and/or forecasted biomass, as well as available solid fuel in the form of waste accumulated at managed waste sites, needs to be quantified to set-up beneficial and sustainable energy production operations, aiming to supplement rather than conflicting with food production. Here specific emphasis is put on exploiting EO information of higher resolution (in time and level of detail) to understand and consider significant variations, potentially caused by extreme weather events, while still being able to satisfy the energy demand.

Assessing energy infrastructure vulnerability to climate change and natural disasters

Understanding the exposure of infrastructure assets towards environmental threads and human interactions is a key element in the conceptualisation of planning, maintenance, and repair measures. The necessary effort needs to be adequately dimensioned and distributed. Seasonal variations and natural disasters have an impact on the energy infrastructure, in worst cases leading to major economic damage and are thus a highly considerable factor.

Describing the asset surroundings is performed on the national level, and then gets decomposed to hyper-localised information, providing the baseline for asset-/ project-specific risk assessments. Single power pylons or line segments get addressed by multiple hazard criteria such as exposure to flooding, erosion, drought, landslide, critical land-cover change, earthquake, fire and other. This spatial resolution has often not been considered to this extent by the IFI teams and offers a great advantage in terms of the equitable distribution of financial resources. EO technologies combine long term records with most recent environmental developments, specifically relevant due to the inevitable increase of extrema linked to the ongoing climate change, providing a comprehensive picture supporting the decision-making processes.

For further context please see: https://gda.esa.int/thematic-area/clean-energy/

Who runs the GDA Clean Energy Thematic Activity?

The GDA Clean Energy Thematic Activity is run by a consortium of six European companies with an energy and/or EO background and is led by **IABG Germany**.

IABG	(DE)
VIDA	(DE)
RSS	(DE)
GMV	(PT)
GEO-NET	(DE)
TTA	(ES)

Priorities of GDA Clean Energy

- Supporting the International Financial Institutions (IFIs) initiatives in augmenting globally distributed national and regional development efforts.
- Increasing granularity and reliability: geospatial information is currently often linked to administrative units. The extraction of information at high-quality levels is required. The adoption and/or adaptation of state-of-the-art EO-based methods, as well as the exploitation of openly accessible information from various data sources, is one of the key elements.
- Providing adaptive and flexible EO solutions, leveraging agile methodologies to raise awareness, address emerging needs and situational developments effectively.
- Preparation and presentation for different players and needs: stakeholders are representing the IFIs as well as their national contacts and partners who require comprehensive and fit-for-purpose solutions and information.
- Developments and services are benefitting from pre-existing data and information, gathered in former and ongoing international initiatives and projects. Making those available and implementing them accordingly is a baseline element of providing highly transferable solutions at an acceptable effort.

Use case examples

Vulnerability Assessment of Energy Infrastructure - Bangladesh

Users: The World Bank, Bangladesh Rural Electrification Board (BREB), Power Cell (Technical Agency of the Ministry of Power, Energy, and Mineral Resources (MPEMR)

Geographic Region: South Asia

Country: Bangladesh

Description: Bangladesh is amongst the most vulnerable countries to the adverse impacts of climate change. The country is situated in a deltaic region, humid climate and is highly exposed to floods, landslides, storm surges and other extreme weather events. Due to the exposure to various risks, local authorities are taking steps to mitigate the resulting impacts. Whereas its focus is first laid on protecting the local population, the maintenance and protection of the energy infrastructure network is equally important. Within GDA – Clean Energy exposure assessment, and further downstream vulnerability analysis, gets addressed to prevent temporal power shortages having a direct impact on the economy. Knowing and understanding the current situation, recent and latest tendencies, as well as projecting severe scenarios, will help understanding and quantifying potential impact on the assets and support sustainable and efficient counter measures adequately.

The WB is supporting Bangladesh with a USD 500 million Program-for-Results operation. The implementing agencies are the Bangladesh Rural Electrification Board (BREB) and Power Cell, which is the technical agency of the Ministry of Power, Energy, and Mineral Resources (MPEMR). The operation is called Electricity Distribution Modernization Program (EDMP) and has as its objective to increase the delivery, reliability and efficiency of electricity supply and strengthen institutional capacity and readiness for its sustainable transformation. The support from GDA will enable characterisation of climate risks in areas of interest for the national power system and will advance the implementation of an indicator (and disbursement of funds) relating to Bangladesh's development and adoption of guidelines to address extreme weather, disaster, and climate risk in the electricity network. While BREB focuses on the distribution system, the use case will support Power Cell's planning across the entire power system [link].

The national assessment and analysis of selected environmental and human-made threats to Bangladesh is performed as a Use Case within the framework of the GDA – Clean Energy project and provides the ground for a tailored monitoring from national to local level, looking at single power pylons and characterising their geospatial information.

The analyses are benefiting from globally available data, such as on climate and weather, their variation, and extrema, combined with most recent tailored services developed locally. Since many of the open sources have been recorded for decades now, they are highly valuable for multiple applications. Modelling exposure of energy infrastructure to seasonal and irregular periodic events gets tailored by applying data of the European Copernicus satellites and other sources, extending common approaches with most up-to-date investigations.

The flood exposure calculation allows a classification of energy distribution assets in Bangladesh on national and regional level. It also highlights transmission line segments severely prone to flooding and helps identifying regions where maintenance and monitoring of the assets require higher attention.

Product sample:

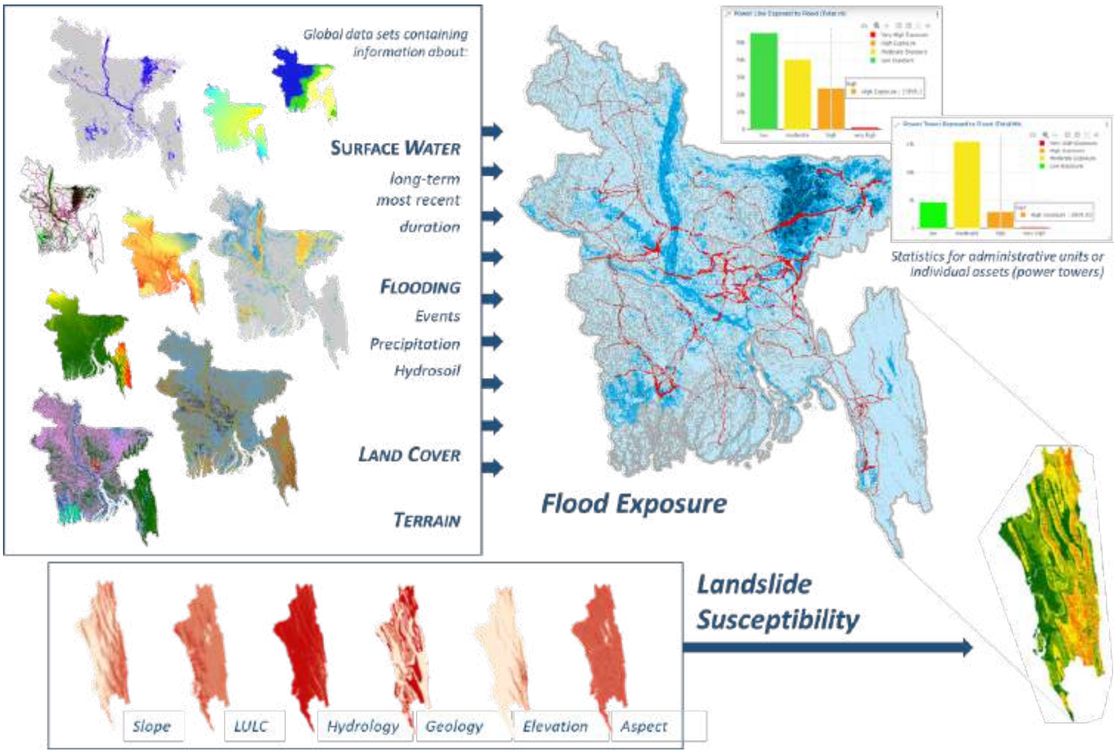

Figure 1: Sketch of selected data for analyses of flood exposure, landslide susceptibility and addressing other thematic aspects.

The landslide analysis is mainly performed in the northeast region of Bangladesh, and the Chattogram region in the southeast of the country. The analysis considered multi-parameter datasets relevant for surface stability besides the relief itself, such as geology and land cover information, and aims to classify the power assets and evaluate them based on their exposure to the landslide hazard.

Vulnerability Assessment of Energy Infrastructure-Niger

Users: The World Bank, National Representatives

Geographic Region: Western and Central Africa

Country: Niger

Description: Niger, bordering Mali, and Burkina Faso, is in the heart of the Sahel Zone. Despite being large in extent, most of the people live in the southern belt, highly exposed to climatic extrema and thus vulnerable to weather extrema and climate change. Its economy is dominated by agriculture accounting for 40% of its GDP, leaving more than 40 % of the population (10mio) living in extreme poverty (2021).
The WB is putting emphasis on supporting the development of several sectors like energy and extractive industries [link] to work against the economic and political challenges the country is facing. Insecure political situations often prevent or reduce international activities related to environmental monitoring. Little is known about the challenges related to extreme weather events and its impact on the people and their economic situation. Energy infrastructure is prone to severe flooding, extreme winds, and heat waves, happening more often than in recent years.

The WB is providing loans for electrification projects, including installation of main power lines, as well as transmission to single households. This use case in Niger provides a medium scale modelling of flash floods using open-source information, which makes the applied models generic and transferable to other countries.

Product sample:

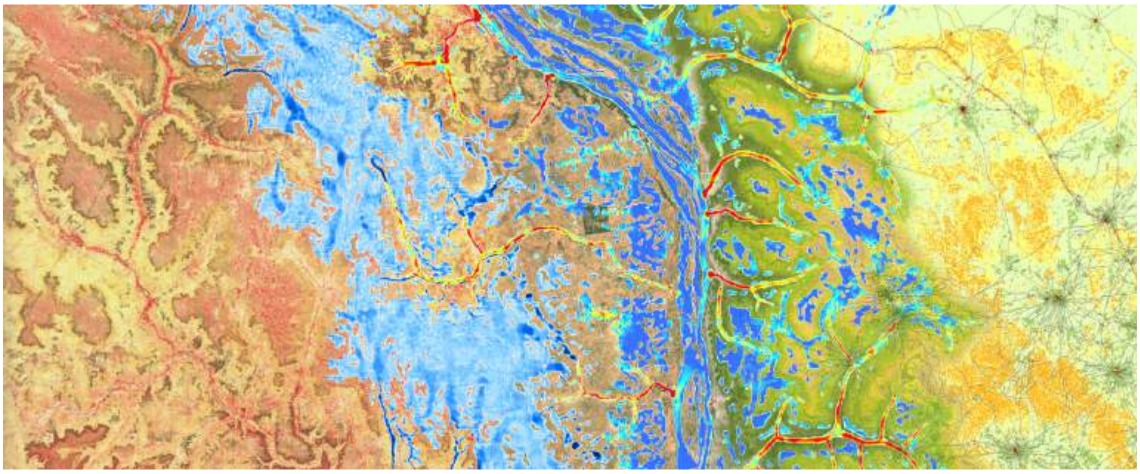

Figure 2: Niamey and surroundings. Shown: Sentinel 2 data, output for the hydro-modelling analysis (water depth and hazard) in correlation with land use land cover and infrastructure

A detailed hydro-modelling has been performed focusing on the Western Grid of Niger, being selected as a highly prioritised region. In this analysis, the water extent for an extreme rainfall scenario (HQ100), was modelled and the runoff velocities were calculated and translated into hazard classes. This information is then linked to existing and planned energy infrastructure of different construction levels, ready to be considered for infrastructure planning.

Agriculture Demand Assessment-Madagascar

Users: The World Bank, Supra-national Team

Geographic Region: Southeast Africa

Country: Madagascar

Description: The WB has provided financial and advisory support to many governments, especially in Sub-Saharan Africa. The Energy Sector Management Assistance Program (ESMAP) aims to achieve universal energy access by 2030 according to SDG 7, and simultaneously supports the clean energy sector by addressing two major pillars: national electrification planning, with a particular focus on decentralised solutions such as mini grids, as well as encouraging solar home systems to reach remote communities. [link, link]

Product sample:

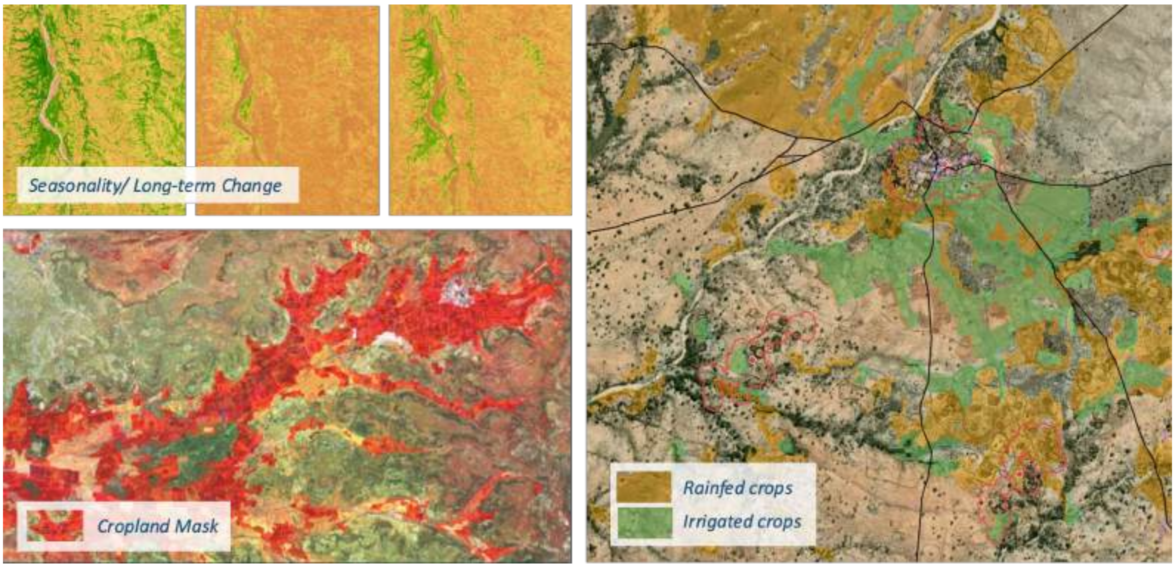

Figure 3: Satellite analysis on vegetation intensity (seasonal), cropland mask and classification of agricultural management classes to support demand assessments.

A central foundation is energy demand assessment on the national scale and at settlement level. In this regard, the World Bank is using geospatial analysis already, especially for national least-cost electrification planning (e.g., Global Electrification Platform). Until now, energy demand is derived from household consumption with building footprints (size) being assigned average demands. However, significant consumption comes from "productive use of energy", which includes agricultural, commercial, and industrial sectors. [link]. For agricultural demand, there is a significant gap in geodata with sufficient spatial, temporal, and thematic detail. The most commonly used dataset MapSPAM provides information on crop types, yield, and cropping practices, but only on a regional scale with limited spatial accuracy, especially in complex agricultural system that are common in Sub-Saharan Africa, and it is not regularly updated (units approximately 10x10km).

This use case connects at this point by providing analytic approaches using most recent EO data and techniques, with the overall aim of mapping, monitoring, and quantifying agricultural demands on settlement level and national scales. The high spatial and temporal resolution of the Sentinel 2 optical satellite imagery (10m, 5 days re-visit time, open source) is well suitable to facilitate this effort and is new to the related WB activities. The use case scenario follows an incremental approach, starting with cropland mapping in smaller test regions (completed as of now), and expanding this thematically and/or geographically based on feedback and assessed requirements. The selected target country is Madagascar due to related World Bank activities, whereas a generic and scalable method shall be developed which can be applied across any geographic context.

Renewable Energy Resources-Armenia (Wind Atlas)

Users: Asian Development Bank, National Representatives for Renewable Energy Resources-Armenia (Wind Atlas)

Geographic Region: West Asia

Country: Armenia

Description: Over the past three decades, Armenia has made great progress in providing electricity to its almost 3 million inhabitants. However, the country relies mainly on imported oil and gas to meet its energy demands, and the majority of its Soviet-era power infrastructure requires maintenance (link).

The Asian Development Bank (ADB) has supported Armenia since 2005 through various programmes and in several sectors. In addition to its support in transport, public finance, school safety, water supply and urban development, it has been consistently playing a key role in strengthening Armenia's energy sector, from generation to transmission and distribution (link). The ADB is collaborating closely with the country to assist in the development of its renewable energy capabilities and expanding access to reliable, affordable, and sustainable energy.

In this context, the GDA Clean Energy thematic activity supports with this use case the wind energy sector and is delivering a feasibility analysis of candidate wind power projects and a robust utility-scale project investment pipeline. The development of a wind atlas for the country of Armenia aims to determine regions with the highest potential for wind energy development, and thus supports stakeholders in making suitable decisions on mobilising capital to develop Armenia's indigenous energy resources, thereby reducing reliance on imported fuels, and delivering lower-cost power generation.

Product sample:

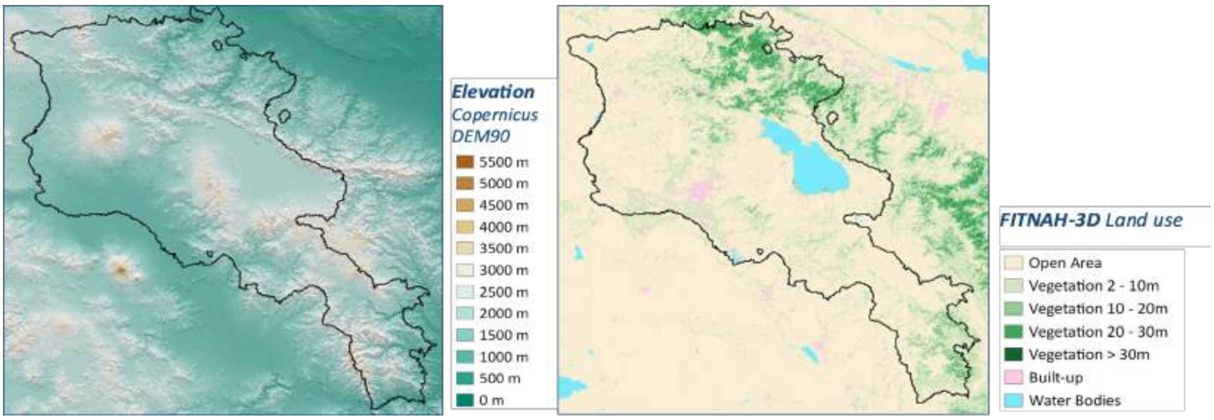

Figure 4: Input data (terrain height and land-use/canopy height using FITHNAH-3D) for modelling the wind atlas of Armenia.

The solution includes information about terrain height, land-use classes, and canopy heights, as well as other geospatial indicators to gain the best possible input data for modelling of the wind resource.

Electrification Monitoring & Poverty Reduction-Cameroon

Users: The World Bank

Geographic Region: Central Africa

Country: Cameroon

Description: Electricity is crucial for poverty alleviation, economic growth, and improved living standards. Measuring the spatial distribution of people with electricity access is therefore an important social and economic indicator. There is no universally adopted definition of what 'access to electricity' means. However, most definitions are aligned to the delivery of electricity, safe cooking facilities and a required minimum level of consumption.

The cities, villages and other urban agglomerations of Cameroon and their development over the recent decades was assessed with coarse resolution nightlight data of similar time periods, to identify the progress of electrification on a national level, and at the same time detailed data down to housing level. The result of the use case is applicable to any national GIS analysis, aiming to quantify the impact of measures adopted for poverty reduction. The long-term impact of electrification in the region and its communities, is to be reviewed by assessing its impact onto social and economic activities.

The night light analysis can be seen as one of the key tools to measure the access to electrification at comparably low costs.

Product sample:

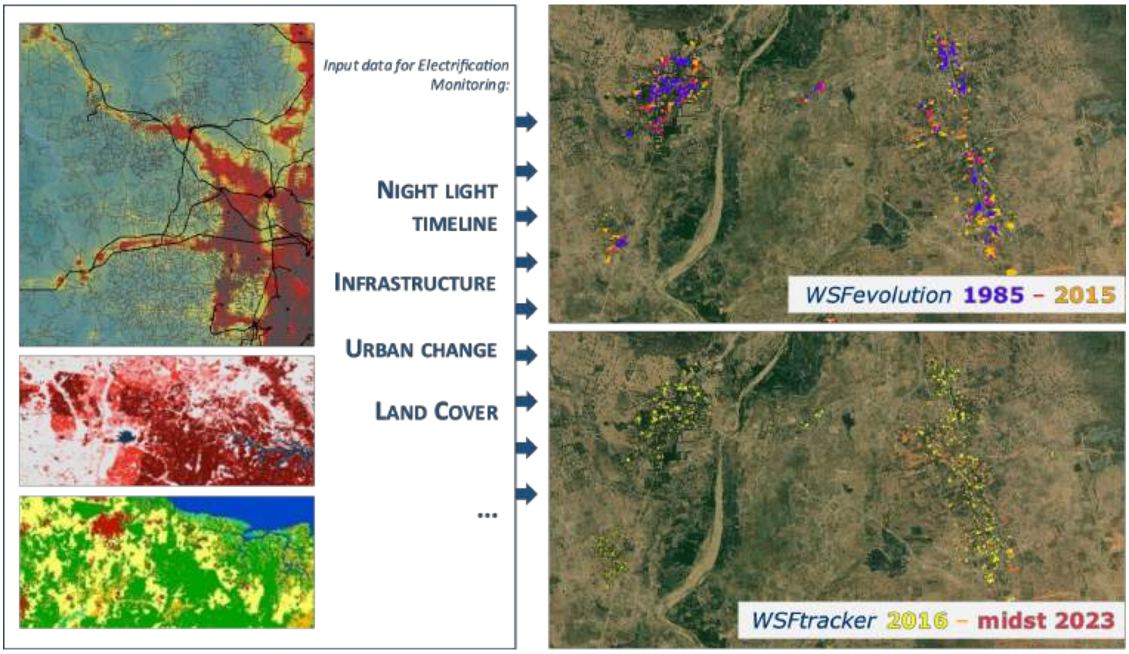

Figure 5: Sketch of input data for electrification monitoring as input for the poverty reduction analysis, linked to World Settlement Footprint (© DLR).

Renewable Energy Resources-Armenia (national analysis to PV-Rooftop)

Users: The World Bank

Geographic Region: Western Asia

Country: Armenia

Description: Armenia has made considerable efforts towards supporting the energy sector, with a focus on developing renewable and sustainable energy. In this sense, on May 11, 2018, Armenia has launched the first large-scale solar power plant in the history of the country (link).

Considering that The WB is committed to encourage harnessing the opportunity for low-cost and clean solar power, it is involved in providing support to create the baseline knowledge necessary for these activities. For this purpose, GDA-Clean Energy provides detailed information from national to local level:

Specific combinations of terrain and climatic conditions may result in exceptional high or low probability of cloud cover in some regions. Freely available Sentinel data can support sketching multi-annual to seasonal cloud density on the national level. The same data sources are relevant for generating a national solar potential data set, linked to land use and land cover or other geodata.

More detailed investigations address analyses on solar rooftop potential, especially considered for public sector investments, which is according to the IFI itself expected to be one of the most important clean energy investment programmes of the World Bank.

Product sample:

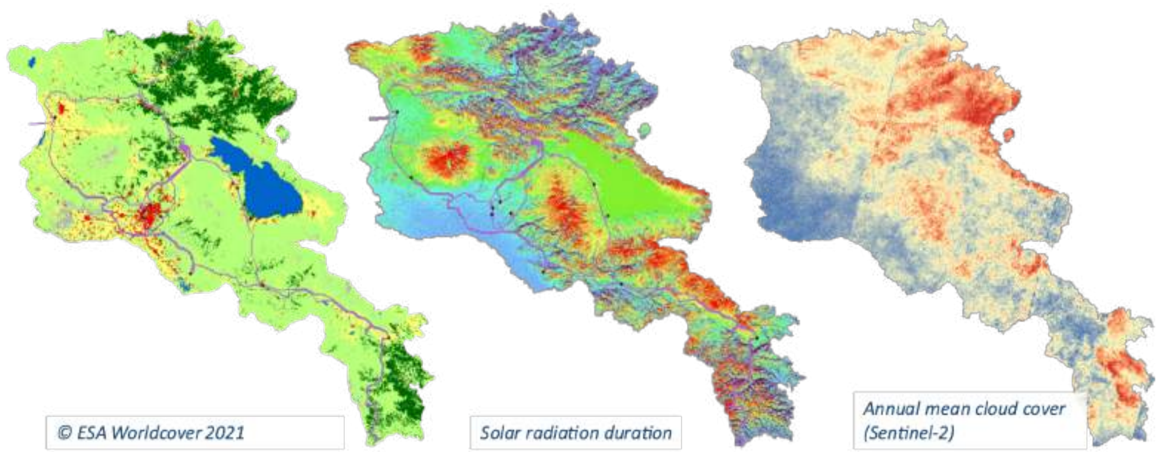

Figure 6: Land use land cover and energy assets (purple); solar radiation duration and annual mean cloud cover from Sentinel-2

The use case implements a roof-top analysis of the cities of Kapan and Syunik, south of the Artsvanik Reservoir. For this analysis commercial stereo and tri-stereo data sets were compared to present how a better initial data selection can increase accuracy and provide information beyond average roof top characterisation.

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