ICLEI Local Governments for Sustainability

100% RENEWABLES CITIES & REGIONS ROADMAP

Supported by:

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IKI INTERNATIONAL CLIMATE INITIATIVE

solutionsgateway Climate, Energy, and Finance Solutions

100% RENEWABLES SOLUTIONS PACKAGE

GIS mapping for local energy planning

This solution is part of a package of solutions meant to guide local and regional governments in implementing a local renewable energy transition by providing guidance on mechanisms, applications or technologies that can help accelerate their climate and energy action.

It was produced as part of the 100% Renewables Cities and Regions Roadmap project, which supports nine cities and regions across Argentina, Indonesia and Kenya to develop bankable renewable energy projects and in-depth local strategy and action plans to achieve one hundred percent renewable energy. The 100% Renewables Cities and Regions Roadmap project is implemented by ICLEI – Local Governments for Sustainability and funded through the International Climate Initiative (IKI), which is implemented by the Federal Ministry for Economic Affairs and Climate Action (BMWK) in close cooperation with the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) and the Federal Foreign Office (AA).

DISCLAIMER

All cities are unique. The Solutions Gateway has been developed as an advanced knowledge catalogue to provide an overview of possible Low Emissions Development Solutions. The Solutions and Packages it contains provide guidance on general conditions, which may not correspond to the existing conditions in your city or jurisdiction. The consultation and use of the Solutions Gateway does not waive the need for the Local Government to assess the feasibility of a Solution or Package in the local context in its city or jurisdiction, prior to implementation. Please note that the impacts, benefits and co-benefits indicated are generally valid but may not materialize in particular circumstances.

ABOUT SOLUTIONS GATEWAY

Solutions Gateway is an online resource platform for Local Governments where they will be able to find possible Low Emissions Development (LED) Solutions for their cities.

In the context of the Solutions Gateway, Solutions are processes, or groups of actions, which Local Governments can implement to deliver climate change mitigation results and enhance local sustainable development. Taking an integrated approach, and focusing on Local Governments usual responsibilities and roles, Solutions include core actions as well as enabling and multiplying actions essential to maximize their effectiveness and efficiency. These include policy, regulatory, governance, capacity building, awareness raising, stakeholder engagement, etc.

ABOUT ICLEI – LOCAL GOVERNMENTS FOR SUSTAINABILITY

ICLEI – Local Governments for Sustainability is a global network working with more than 2,500 local and regional governments committed to sustainable urban development. Active in 125+ countries, ICLEI influences sustainability policy and drives local action for low emission, nature-based, equitable, resilient and circular development. ICLEI’s Members and team of experts work together through peer exchange, partnerships and capacity building to create systemic change for urban sustainability.

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1. INTRODUCTION

Geographical Information System (GIS) Mapping serves as a framework to organize and analyze data, and communicate information using the science of geography. It also reveals deeper insights into data, such as patterns, relationships, and situations, helping users make smarter decisions [1]. Before the introduction of GIS for resource assessment, site suitability was carried out through site surveys, paper maps, and other time-consuming, inefficient, and costly field sampling methods.

For resource assessment purposes, GIS is instrumental in the area of energy planning, both at national, regional, and local levels. GIS is used to quantify how many renewable resources are available in a particular region, as well as the geographical locations within the community's administrative boundary where RE power plants can be located, considering various factors such as environmental, economic, and social constraints. GIS mapping is therefore a type of pre-feasibility study that informs one on what is possible and gives a clear-cut direction on what and where the community should conduct further research studies or field surveys to confirm mapping results.

1.1 RELEVANCE

For renewable energy systems to be truly sustainable and meet other related SDG goals, such as access to clean and affordable energy and other social and economic development-related SDGs, adequate planning and efficient use of resources including land is very important. Today, there are several GIS tools and open-source data available to aid energy planning and inform decision-making. This solution explores the basic approach and use of GIS in community energy planning.

GIS mapping combines all inputs, assumptions, constraints, and requirements from various stakeholder groups to give a graphical or visual representation of the output or result that is easily understandable or translatable to the language of various stakeholder groups. To efficiently harness resources such as wind, solar, hydro, biomass, and Geothermal, GIS serve the purpose to find locations where these resources are most available and exploitable to optimize capital expenditure by finding out where power plants can be constructed either to minimize transport cost or other land or topographic constraints such as distance to the grid, avoiding mountains or water bodies, farms and other determined constraints.

Image source

At the management phase of the energy planning process, GIS mapping could provide a visual representation of the community's facilities for easy access and management. An example of this initiative is the Geoportal of Rwanda, an online platform for data sharing among public, private and non-governmental institutions and the general public. In this geoportal, all energy customers, public and private facilities are represented in the national map for effective management.

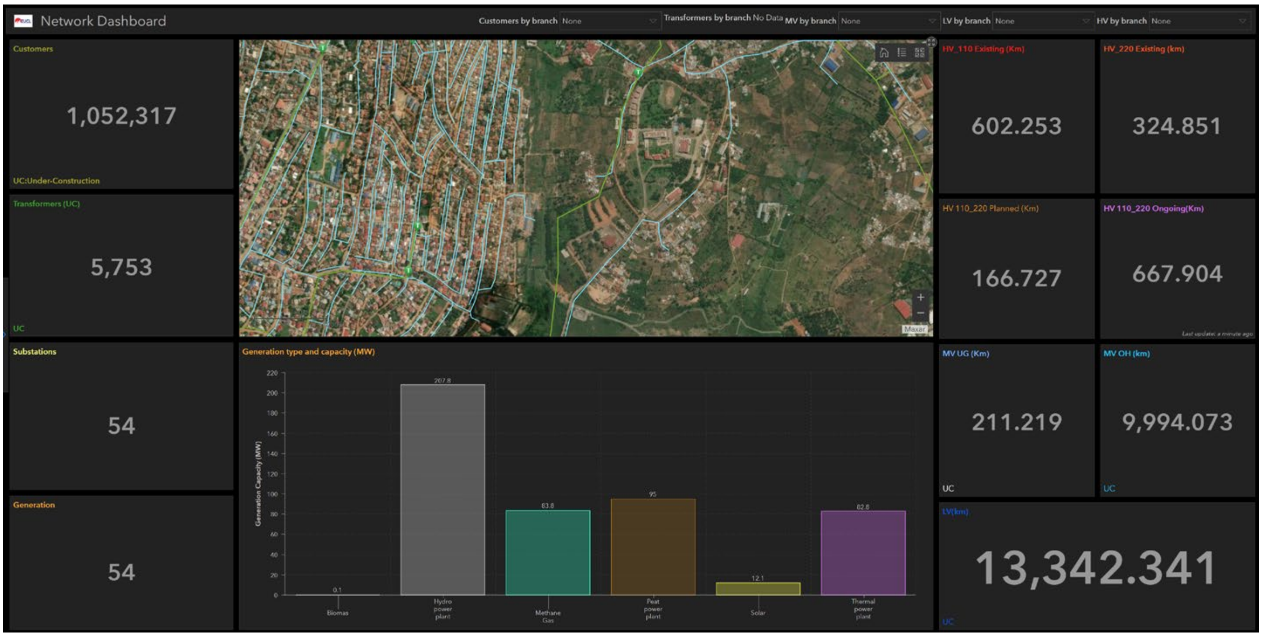


Figure 1: Electricity Dashboard of Rwanda. *Source: Rwanda Energy Group*

1.2 MAIN IMPACTS

- **Renewable Energy resource quantification** is an important step to implement the transition to renewable energy. Understanding the real resource potential of a community is key for it to be able to utilize them efficiently and plan appropriately.
- **Site suitability analysis assessment** provides information on suitable locations for RE generation plants. Renewable energy sources need long-term data trends to analyze which sites are consistently the most suitable. Much of this information is available open-source today.
- GIS also serves as a form of **capacity building** for all stakeholder groups in the community as it provides necessary skills needed for a full understanding of the local environment, the resources, and infrastructure.

1.3 BENEFITS

- **GIS is one of the major tools in energy policy and decision making**—for example, using GIS for creating site maps and cost-benefit analyses
- As a **resource management tool**, for example, a resource or energy management geoportal
- **Cost-saving** is one of the important outcomes of energy planning. GIS mapping reduces the cost allocation for the field survey process, enabling local governments to plan where is most suitable for each community to locate power plants based on criteria such as proximity to public facilities, locations of plants and other facilities, least cost grid planning, and so on. As an example, Sears, a retail company based in the United States, reduced the time

taken by dispatch drivers by 75% after introducing GIS, and saw an overall reduction in operation costs [2]. Task automation is also possible, reducing the need for manpower which can be better directed elsewhere.

- **Effective community decision making**, which relies on scientific data to aid policy formulation and decision-making.
- **Increased efficiency, improved accuracy, and time-saving** as without GIS in energy planning, field surveys are often carried out through random sampling to find out information that can now be obtained from a computer using real and open-source data. GIS mapping has reduced the time needed for community mapping tasks by over 90% concurrently producing very much better results [1].
- **Improved stakeholder engagement**, as the visualization of various needs and expectations as an input constraint provides the assurance and satisfaction to stakeholders that their concerns are being addressed and helps to better reach a consensus.
- **Improved communication** as GIS maps and visualization helps in stakeholder communication through storytelling.

1.4 SUGGESTED INDICATORS FOR MONITORING RESULTS

- Visitors to geoportal site (number of persons)
- Energy projects making use of GIS (number of projects)
- Cost savings before/after use of GIS for energy planning (currency/year)
- Number of officials/staff trained in GIS (number of persons)

1.5 TYPICAL LOCAL GOVERNMENT ROLES

- Policymaker
- Planner
- Investor
- Coordinator
- Operator and service provider
- Education institutions
- General Public

2. INTEGRATED SOLUTION OVERVIEW

	Enabler Actions	Required Actions	Multiplier Actions
Policy	• Defining the scope of what the program wants to achieve, and what role GIS will play	• Creation of policy, rules and procedures with the aim of data centralization, easy accessibility, and streamlining processes	• Awareness campaigns and open source portals could serve as an economic and efficient approach • Multi-sectoral and multi-stakeholder synergies and data-sharing, keeping in mind national level data-sharing policies • Local and regional governments can set policy frameworks within their jurisdiction that support GIS data sharing and capacity building. This could act as a good signal for potential investors • Explore cooperation opportunities and synergies to facilitate the integration of other nexuses such as waste and water systems
Stakeholders and Awareness	• Identify and contact local, state, national and international stakeholders for early engagement, including local businesses, landowners, investors, building owners, tenants, local communities, energy suppliers, technology creators, NGOs, regional and national entities. • Awareness campaign to different stakeholder groups, volunteers, planners, academia to attract expertise and interest	• Encourage community participation and active stakeholder engagement	• An open-source data platform could be a driver and motivation for citizens' participation and capacity development • Engage in local, regional, national, and international initiatives promoting GIS data sharing such as the ESRI conference and OpenStreetMap events • Publish regular reports highlighting important insights obtained from GIS to create interest among various stakeholders

	Enabler Actions	Required Actions	Multiplier Actions
Governance	• Create a geoportal that the local government owns, to facilitate easy data sharing between various sectors • Enhance the utility of the geoportal by aggregating data from different nexuses such as housing, water systems, drainage, electricity, transport etc.	• Delegation of a relevant department to oversee the geoportal or data repository	• Provide technical training, free consulting services, and financing opportunities • Form partnerships with other local governments with similar solutions to share knowledge • Take advantage of online and local communities if dealing with open source data
Capacity Building	• Assess existing GIS capabilities and the need to fill any gaps • Empower the relevant sector in charge of the portal management for the security of the portal against hacks and theft	• Hire GIS data experts to train existing staff on GIS data mapping and management	• Engage the private sector and other interested stakeholders in contributing to the Geoportal, especially local volunteers • Promote the integration of new and more efficient technology and datasets • Promote the development of training-based certification for volunteers using a qualified staff of various sectors • Involve the academic sector for continuous improvement and research into data availability and accuracy
Technical	• Investigate the possibility of integrating energy data, such as generation and distribution with other nexuses such as water systems, GHG emissions, and waste management	• Assessment of existing local institutions and online platforms to determine the best place to host data	• Facilitate open access data sharing and contributions between various stakeholder groups especially private sectors, NGOs, and academia • Create a geoportal for the available data with a plan for continuous improvement and stakeholder participation
Finance		• Engage with potential partners, investors, donors, volunteers, and contributors to expand the scope of the project	• Explore the opportunity to monetize project solutions. An example of a monetized GIS solution is the Migas data repository by the Indonesian Ministry of Energy and Environmental Resources

3. WORKFLOW /PROCESS PHASES

3.1 COMMIT AND MOBILIZE

- Define the role GIS will play in energy system decarbonization and data analysis
- Identify the responsible departments that can contribute and might be interested to participate in consultations.
- Identify the key stakeholders and start an early engagement process by public consultancies and information sessions to gather input

3.2 RESEARCH AND ASSESS

- Find out what type of GIS data is available for analysis and what assumptions can be made
- Gather existing weather-related, environmental and topographic data
- Consult nearby weather stations for relevant data on wind speed, rainfall, geology, and other data that might be useful for analysis and understanding of the local community
- Determine which tool to use for data analysis—examples of useful tools include Python, QGIS, ArcGIS (Python and QGIS are free and open-source)
- Assess the financial resources that the government already has available and look into new possibilities to finance the projects in case some analysis or data gathering will be subcontracted
- Determine through a literature review the threshold to be used for site suitability assessment for various technologies. An example of threshold includes the IEC 61400 wind classification used for suitability mapping of wind parks

3.3 SET BASELINE

- Set a target output or expectation for the use of the GIS tool. For example, the role of GIS in 100% RE roadmap development, sustainable urban planning, and stakeholder management, easy data access between stakeholders
- Use the available data to analyze the natural land cover of the local government to understand how much land is available and the properties of the land cover
- Determine other criteria for suitability based on stakeholder consultation, land rights, and other factors
- In case local maps are not available, local land cover can be obtained by extracting and editing or updating the global land cover maps to align with the local condition
- Set up systems for data creation and a repository. For open-source options, the community can get involved in creating and updating local data from OpenStreetMaps through the use of local and external volunteers, for the local community

3.4 DEVELOP STRATEGY

- Involve relevant stakeholders from the beginning of the project. This includes the project owner or custodian, relevant institutions, non-governmental organizations, data contributors, and volunteers. Organize workshops to establish the goals of the project and the perspectives of all stakeholders.

- Determine the type of suitability analysis to carry out; Boolean[1] or fuzzy[2] logic
- Create an open but secure system to support volunteers. This will also support resilience planning and disaster recovery plans and humanitarian maps. Examples of volunteer platforms include https://tasks.hotosm.org/ and https://missingmaps.org/

3.5 DETAIL AND FINANCE PROJECTS

- Commit adequate resources to the project. This includes infrastructure such as computer systems and databases.

3.6 IMPLEMENT AND MONITOR

- Create a data safety and protection policy. If it does not exist, advocate for one at the appropriate level of government
- Analyze the best strategy to adopt, either subcontracting to a third-party organization or consultant or using local government's own resources and volunteers
- Collect feedback on the functioning of the GIS system to ensure it is performing as per expectations, and incorporate changes where possible

3.7 INTEGRATE AND COLLABORATE

- Connect GIS data with other aspects of the local communities. This includes mapping of energy-related information such as power substations, solar and wind parks, street lights, green buildings in the community, lakes, and so on
- Connect with cities developing similar projects and sources for external volunteers
- Create a system to make data available for private institutions and investors, keeping in mind data protection concerns
- Collaborate horizontally and vertically with other levels of government to enhance the ability to implement action and process plans

3.8 REVIEW AND UPSCALE

- Document the direct and indirect benefits of GIS mapping and data availability for decision-making both for policymakers, NGOs, and private institutions
- Document in financial terms the impact of GIS mapping and its direct and indirect contribution to other sectors
- Assess the implementation of the overall strategy and specific actions to ensure the city stays on track with the defined goals
- Make the most of the lessons learned that emerge from the evaluation of the strategy to accelerate progress in a targeted way to overcome barriers
- Consider incorporating GIS and other informatics skill development into the local and national educational curriculum

1 Boolean Logic: method based on binary law of zero and one, otherwise interpreted as No and Yes or On and Off. zero and one are assigned to data classes based on subjective suitability criteria of whether the data class is suitable or not suitable

2 Fuzzy Logic is a flexible approach that produces maps with a range of suitability classes by assigning weights to data class instead of 0 and 1

3.9 ADVOCATE AND INSPIRE

- Create a system to share the results and benefits perceived by implementing GIS mapping and keeping GIS data archive for the local government
- Create a platform to share best practices to give guidance to the involved stakeholders, to contribute to data access and availability for other local projects
- Continue to collaborate with other local governments in sharing data or creating a more comprehensive database
- Advocate at the national and international level for the use of tools such as GIS for improved resource assessment and energy planning processes

4. REALITY-CHECK

GIS Mapping is important for cities and local governments with the growing concern of data and information access, renewable energy planning, sustainable urban development, energy planning, stakeholder management, and asset or facility management. For many countries, especially in the Global South, data to support informed decision-making are currently not available. This can affect implementation and lead to difficulties in realizing projects due to land access issues etc. With GIS, assets, infrastructure, facilities, land, renewable resources such as wind, solar, biomass, and hydro can all be mapped to a detailed level and visual information made available to the general public.

As a standalone project, or in connection with other projects, GIS is relevant for the following:

- For resource assessment when developing climate and energy action plans
- Sustainable urban planning and development
- Providing a visual and geographic data repository for informed policy, economic, financial, and investment decisions
- Improved stakeholder understanding and management
- Location and facility maps and incorporation of different sectors into one holistic community map

4.1 REQUIRED PRE-CONDITIONS

- Policy framework to support data access, open-source system data sharing, and data safety
- Financial tools and support for related projects and capacity development
- Closing the local knowledge gap and capacity development if the project will be locally managed

4.2 SUCCESS FACTORS

- **Integration** of GIS data with other local government projects such for data collection and archiving purposes
- **Local stakeholder engagement** needs to begin early and requires transparency and information sharing
- A **long-term focus** on the potential direct and indirect benefits of the solution
- **Soliciting external support** when necessary, including in local capacity building
- **Identify existing local capacity and resources** such as academic institutions, agencies, NGOs, and ministries and liaising with them
- **Ensure system flexibility** to allow improvements over time, as innovations and new technology are expected
- **Assess all the financial resources available and income possibilities** to support project development and improvement

4.3 FOLLOW-UP NEEDED AND/OR RECOMMENDED

- Continue to foster relationships with key stakeholder groups by using different channels: meetings, customer services, educational activities in schools, public hearings, etc.
- Continue to update data and incorporate improved data collection and management methods

4.4 BARRIERS

TECHNICAL BARRIERS

- Lack of suitable information technology infrastructure and data collection abilities, which can be addressed through seeking external support
- Capacity and knowledge gap in the area GIS data management, which can be addressed through liaising with experts
- Inadequate local data and lack of suitable global data for analysis in a specific area of interest, which can be addressed by collaborating with various data and reporting initiatives

FINANCIAL BARRIERS

- Inadequate upfront cost allocation to the institution in charge which can be managed through finding alternate sources of funding or developing a business model

INSTITUTIONAL AND POLITICAL BARRIERS

- Local governments prioritizing more tangible development outcomes. By increasing awareness and exchange on the benefits of GIS, this barrier can be addressed.
- Insufficient multi-level governance coordination
- Lack of policy support for data collection, storage and privacy

AWARENESS BARRIERS

- Inability to communicate the relevance of the project to potential stakeholders

4.5 RISKS

TECHNICAL RISK

Projection errors, wrong or invalid data, wrong coordinate system, data loss from resampling. Technical risks may have a direct impact on the accuracy of the result. Effect of risk includes wrong geopositioning, overestimation, and underestimation. Such risks are inherent but can be mitigated with information management and improving data collection and synthesis.

FINANCIAL RISK

Lack of suitable financial support for project implementation. For example, financial resources needed for data acquisition, field visits and capacity development.

5. CLIMATE CHANGE MITIGATION POTENTIAL

GIS is one of the planning tools for roadmap creation for achieving strategic objectives such as climate change mitigation targets, carbon neutrality targets, energy transition targets, and other strategic objectives. The use of GIS mapping for resource assessment and roadmap development contributes to the decarbonization of the energy system and climate change mitigation. Other contributions of GIS mapping include the efficient use of land and other resources and monitoring adaptation strategies.

6. NATIONAL – SUBNATIONAL INTEGRATION IN THE CONTEXT OF THIS SOLUTION

6.1 BENEFITS TO LOCAL GOVERNMENT

- National support for GIS and building capacities can help with more efficient local policy-making and planning
- GIS mapping helps in geographical administrative boundary demarcation and avoidance of conflicts between neighboring local governments and communities

6.2 BENEFITS TO OTHER LEVELS OF GOVERNMENT

- Higher renewable energy use across a diverse mix of technologies can help improve energy security
- Local action can help trial new solutions, and scaling this up can help in achieving national level goals
- Greater technological innovation can boost the green economy and lead to economic development

7. CASE STUDY

GIS FOR WIND RESULT ASSESSMENT FOR WEST NUSA TENGGARA PROVINCE

GIS was used to assess renewable resource potential in West Nusa Tenggara and to identify the spatial distribution of RE potential based on GIS Information

Data Input

- Wind speed map [4]
- Map of global land use [9];
- Map of the administrative boundary of West Nusa Tenggara [3]
- Digital Elevation Model map [5];
- Map of the protected area[8];
- Population density map; [5]
- Map of the road network in West Nusa Tenggara [6];
- Map of the electricity grid [6];
- Map of the airports in West Nusa Tenggara [6]

Methodology

The boolean methodology employed involved the classification of data, including whether they were suitable or not, and combining them. The combination method is based on the binary law of zero and one, otherwise interpreted as No and Yes or On and Off. With the Boolean method, zero and one are assigned to data classes based on subjective suitability criteria of whether the data class is suitable or not suitable.

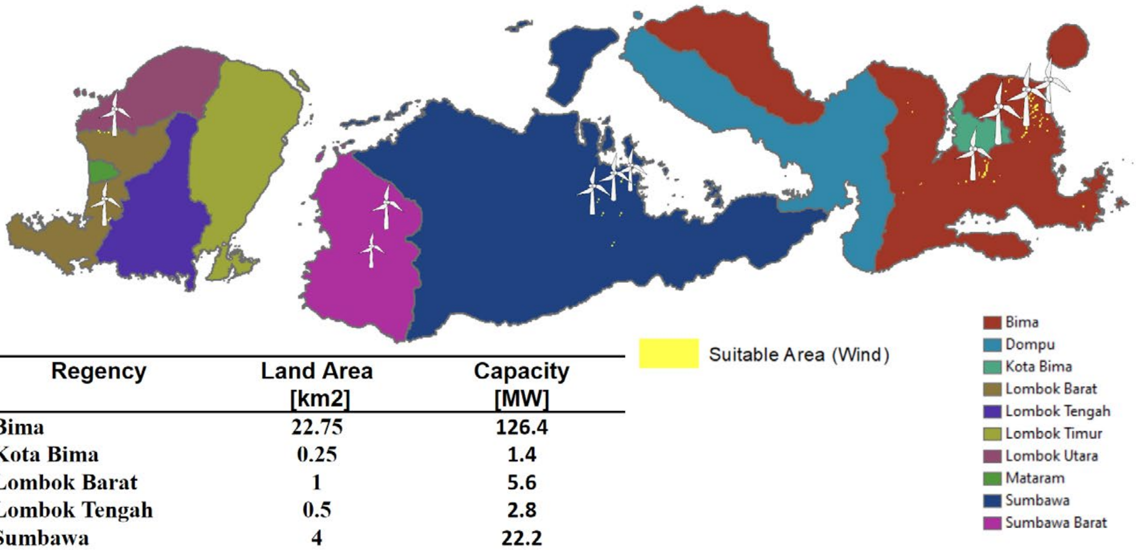
Every data class regarded as not suitable is assigned a value of zero while suitable data classes are assigned the value of one. Thereafter, all reclassified layers are combined by simply multiplying them. The output layer is a binary data class formed from the intersection of all the input true values and input false values. That means that, if both input values are true, the output takes the value of 1 and if the input values are false or a combination of true and false, the output value has a value of 0 (false).

Data criteria:

- Wind speed: >= 6m/s at 50 m height (IEC 61400 Threshold)
- Population density: Population <1000 people per km^2
- Slope: Terrain with 15 degrees or less x ≤15°
- Globe cover: Excluded flooded areas, forest, water bodies, and built-up areas; others including farms are considered suitable
- Electricity Grid: Proximity to transmission lines [250 m safety distance and <50 km]
- Protected Areas: Avoided protected area with 300 m buffer
- Road Network: Avoided road with 250 m safety distance, and not farther than 50 km from the road network
- Airports: Farther than 2 km from airports
- Others: Avoided Mines, Canals, and Lakes

Output

The result shows that the province has about 29.25 km^2 land area available for wind park construction, mostly situated in one of the municipalities called Bima as shown in the figure below.



S/N	Regency	Land Area [km2]	Capacity [MW]
1	Bima	22.75	126.4
2	Kota Bima	0.25	1.4
3	Lombok Barat	1	5.6
4	Lombok Tengah	0.5	2.8
5	Sumbawa	4	22.2
6	Sumbawa Barat	0.75	4.16
	Total	29.25	162.5

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