Ecowrex2 viewer

Demonstration of tools and functionality

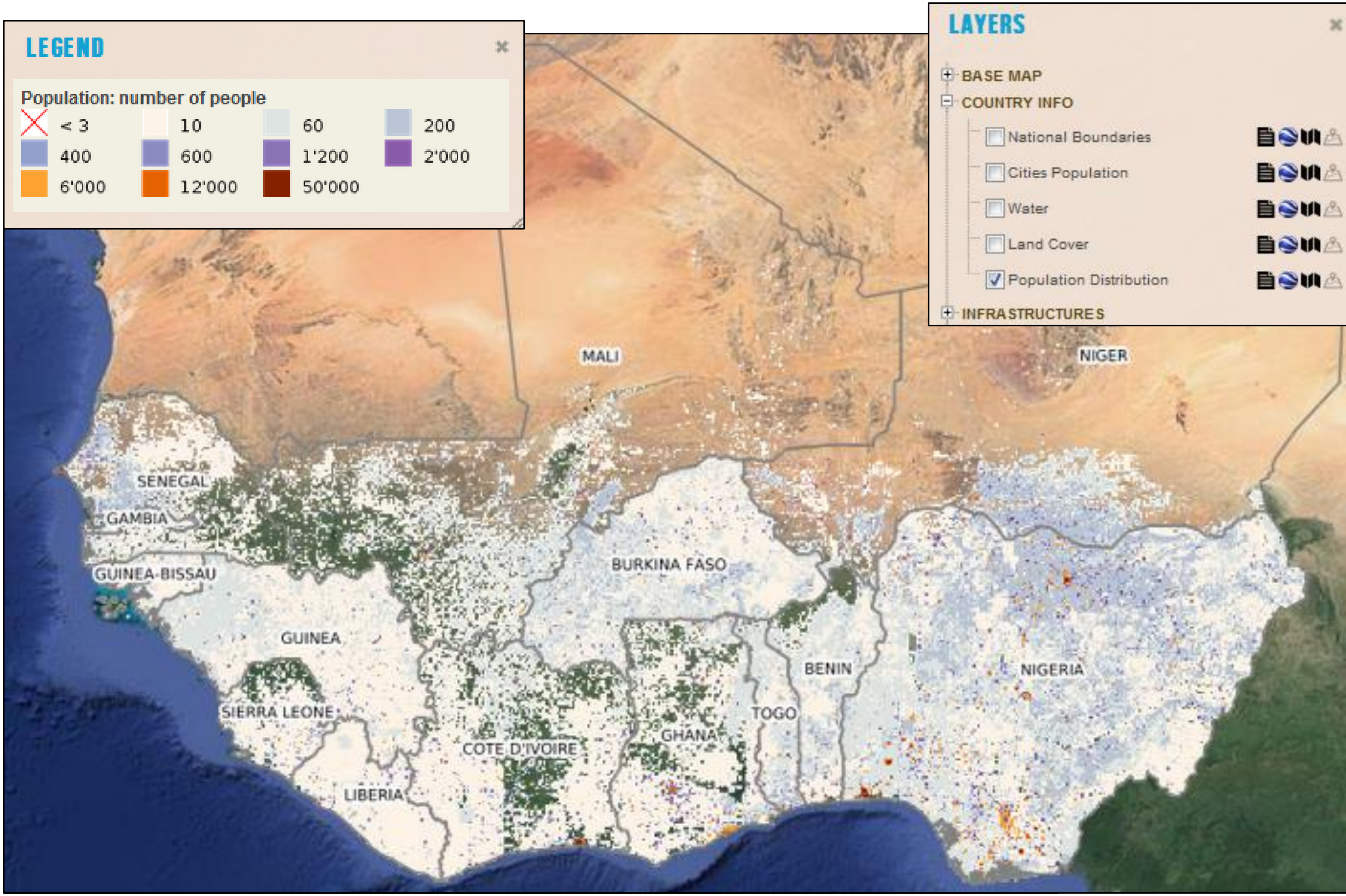
2) Perspectives of new maps of energy demand / green energy production potential

2.1 List of produced maps

LAYERS

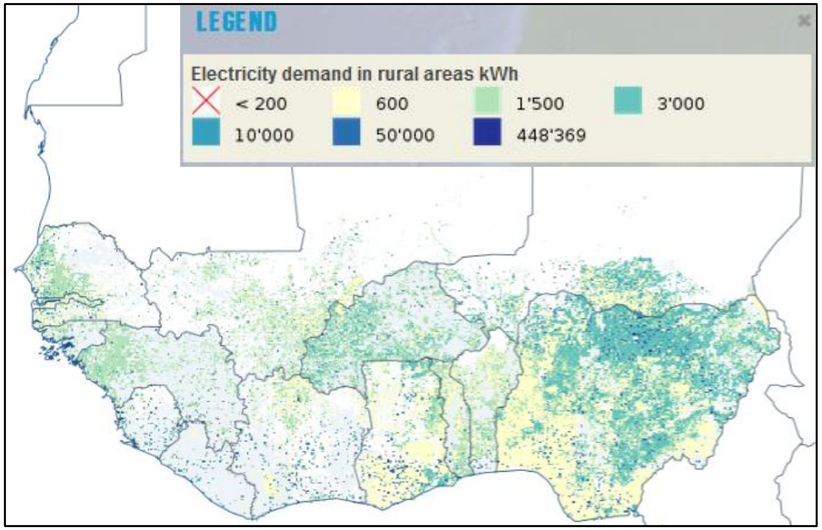
- BASE MAP
- COUNTRY INFO
  - National Boundaries
  - Cities Population
  - Water
  - Land Cover
  - Population Distribution
- INFRASTRUCTURES
- RENEWABLE ENERGY POTENTIAL
  - RESOURCES
    - Solar DNI Energy Resource
    - Solar GHI Energy Resource
    - Wind Energy Resource
    - SOLAR SUITABILITY MAPS
      - Suitability for large-scale grid-connected CSP systems
      - Suitability for large-scale grid-connected PV systems
      - Suitability for off-grid PV systems
    - WIND SUITABILITY MAPS
      - Suitability for Grid connected installations - practical scenario
      - Suitability for Grid connected installations - ecological scenario
      - Suitability for off-Grid installations - practical scenario
      - Suitability for off-Grid installations - ecological scenario
    - ENERGY DEMAND
      - Electricity demand for rural areas (kWh/year) - based on real demand
      - Electricity demand for rural areas (kWh/year) - based on threshold level
      - Electricity demand for urban areas (GWh/year)
    - POTENTIAL OF SOLAR ENERGY PRODUCTION
      - Potential of solar electricity production (GWh/year) - grid-connected CSP systems
      - Potential of solar electricity production (GWh/year) - grid-connected PV systems
      - Potential of solar electricity production (GWh/year) - off-grid PV systems

Population distribution map

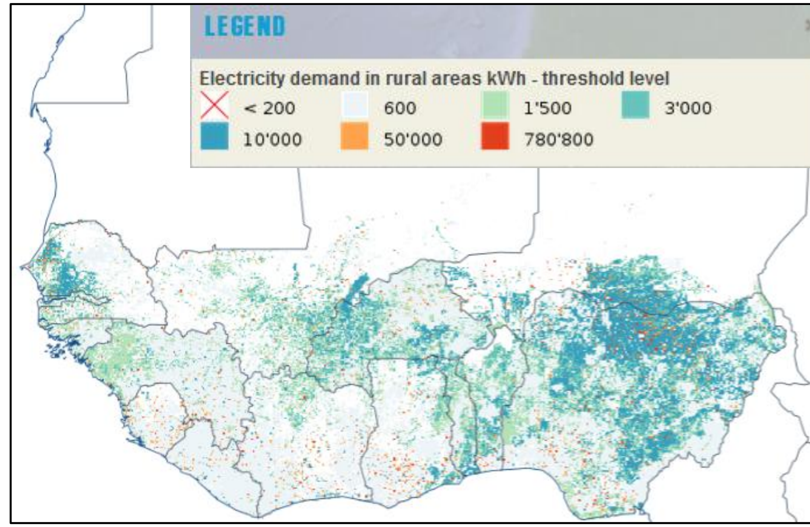


Electricity demand (rural areas, urban agglomerations)

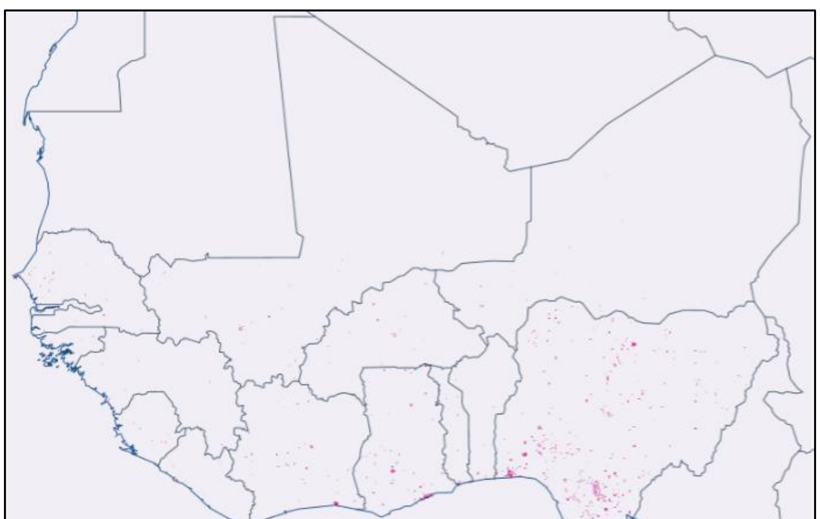
Electricity demand for rural areas (kWh)
- based on real demands

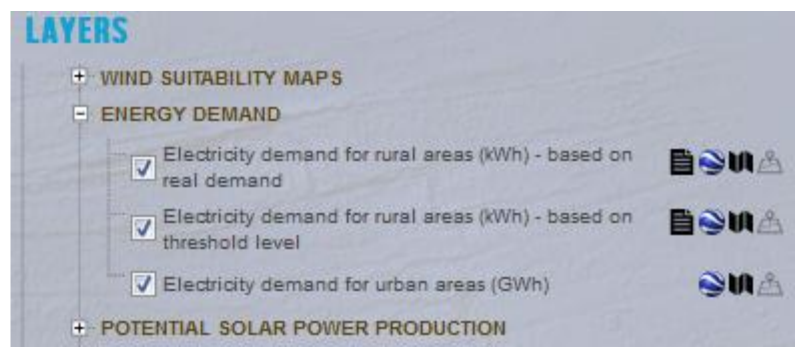


Electricity demand for rural areas (kWh)
- based on threshold level

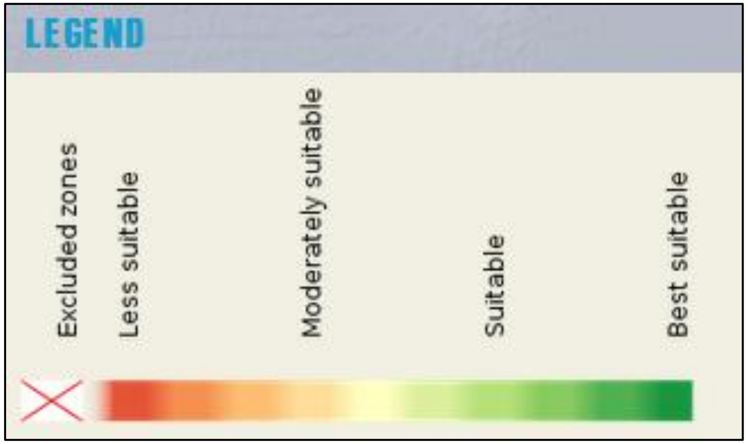


Electricity demand for urban areas (GWh)



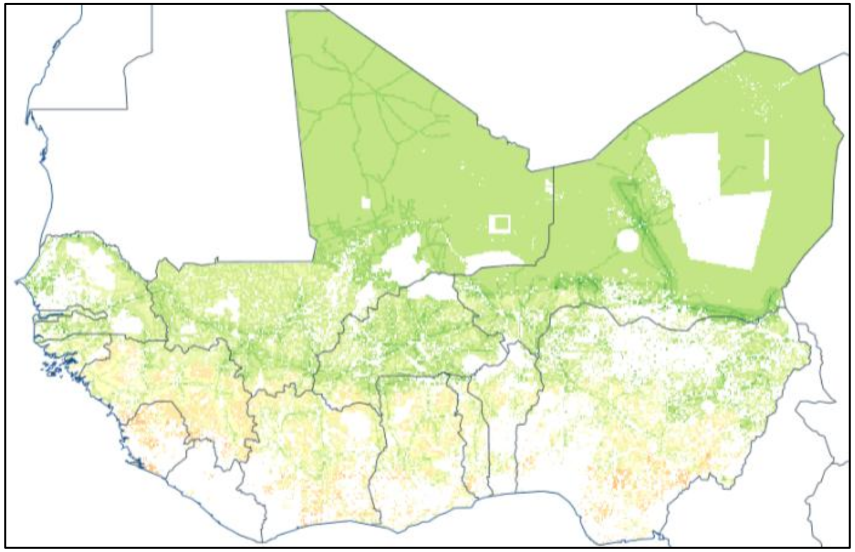


Land Suitability maps for solar & wind installations

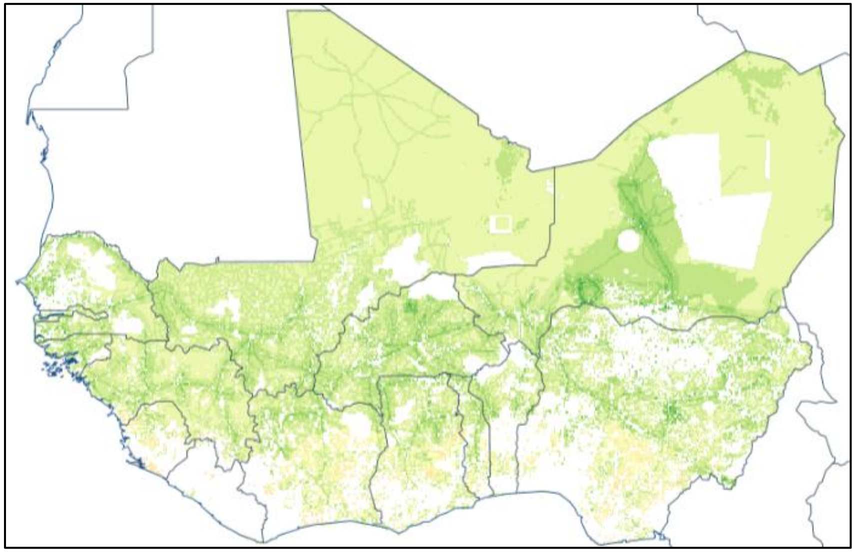


Land suitability maps - solar

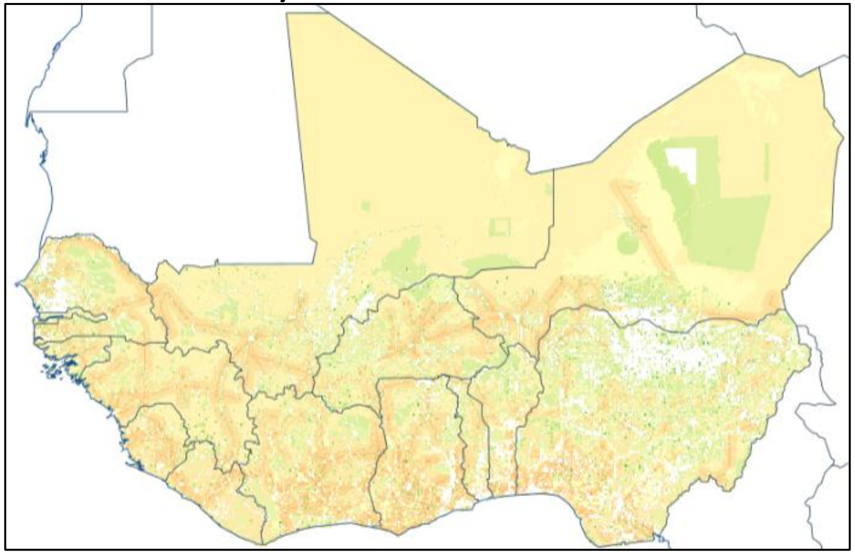
Land suitability classes CSP Grid connected



Land suitability classes PV Grid connected

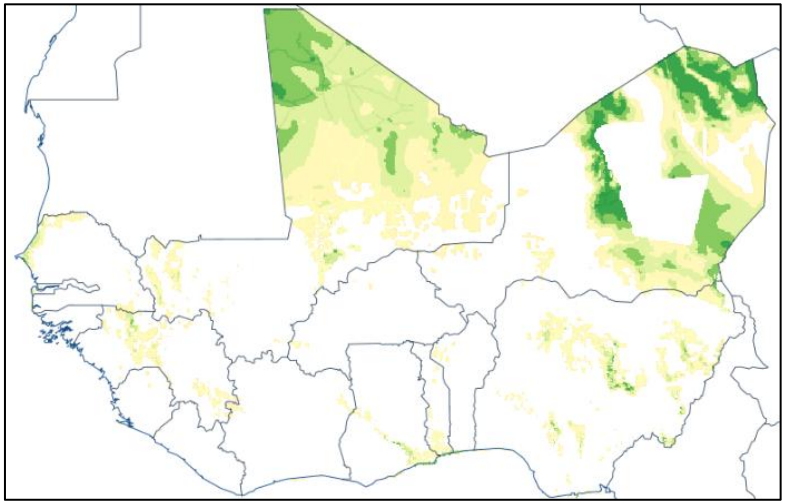


Land suitability classes PV off-Grid

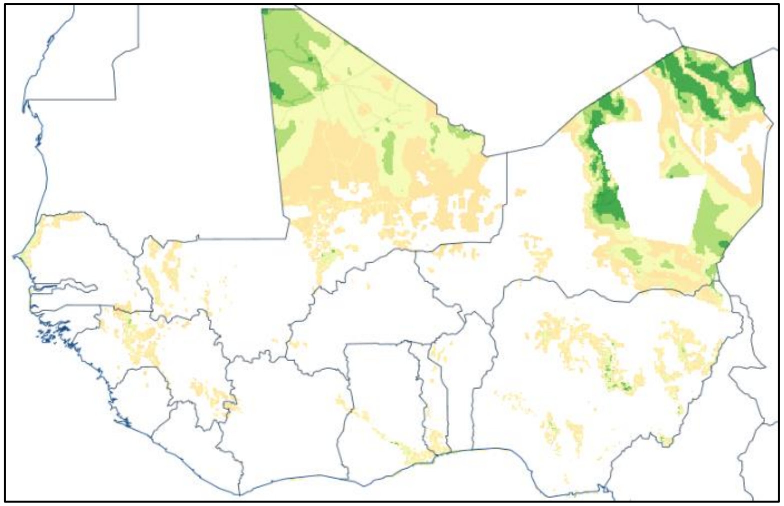


Land suitability maps - wind

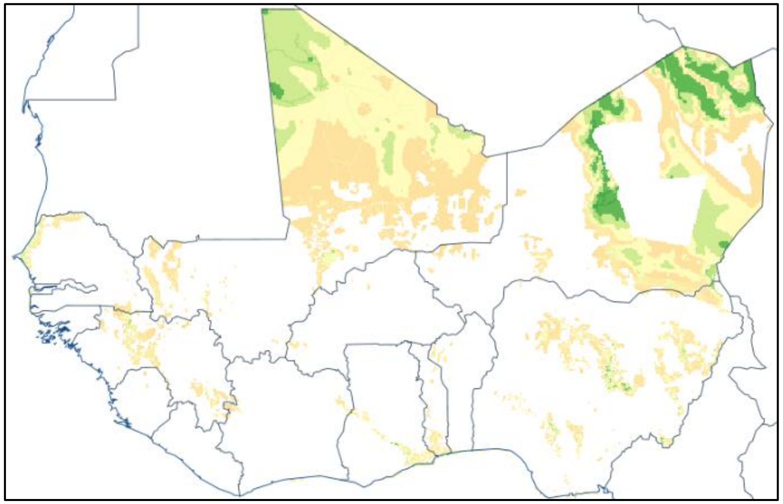
Suitability for off-Grid installations - ecological scenario



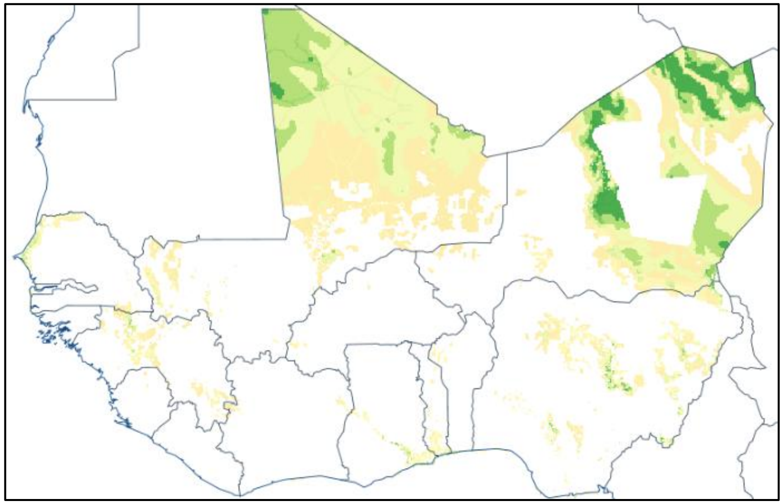
Suitability for off-Grid installations - practical scenario



Suitability for Grid connected installations - practical scenario

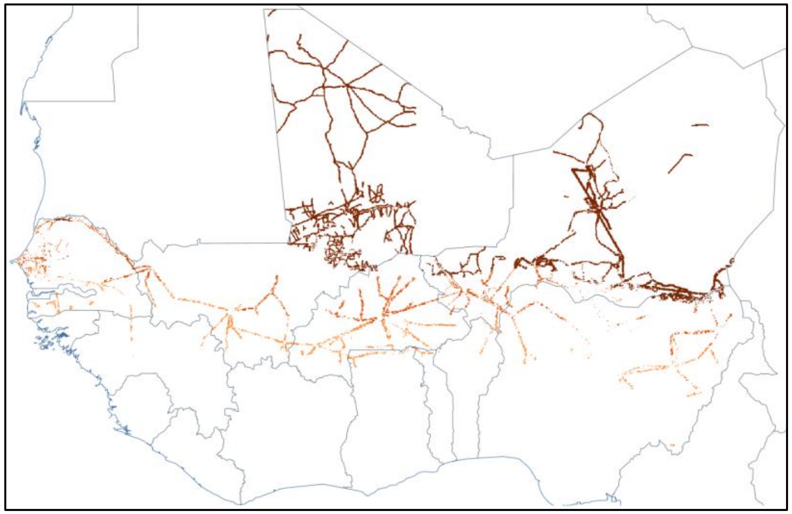


Suitability for Grid connected installations - ecological scenario

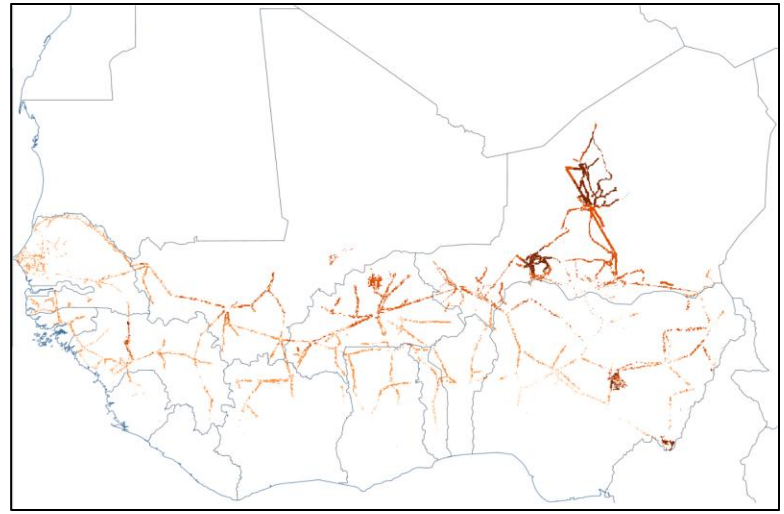


Potential of electricity production maps - solar

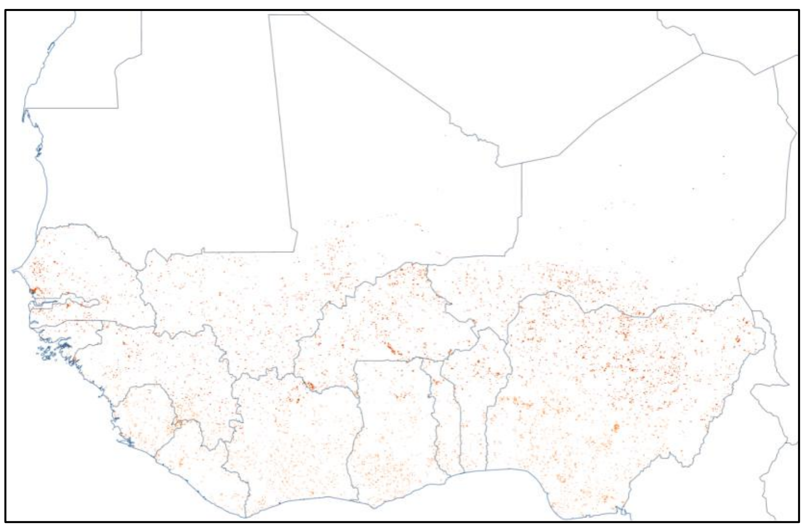
Grid-connected CSP systems (GWh/year)



Grid-connected PV systems (GWh/year)



Off-grid PV systems (GWh/year)



LAYERS

- POTENTIAL OF SOLAR ENERGY PRODUCTION
  - Potential of solar electricity production (GWh/year) - grid-connected CSP systems
  - Potential of solar electricity production (GWh/year) - grid-connected PV systems
  - Potential of solar electricity production (GWh/year) - off-grid PV systems
- CAPE VERDE
- SENEGAL

LEGEND

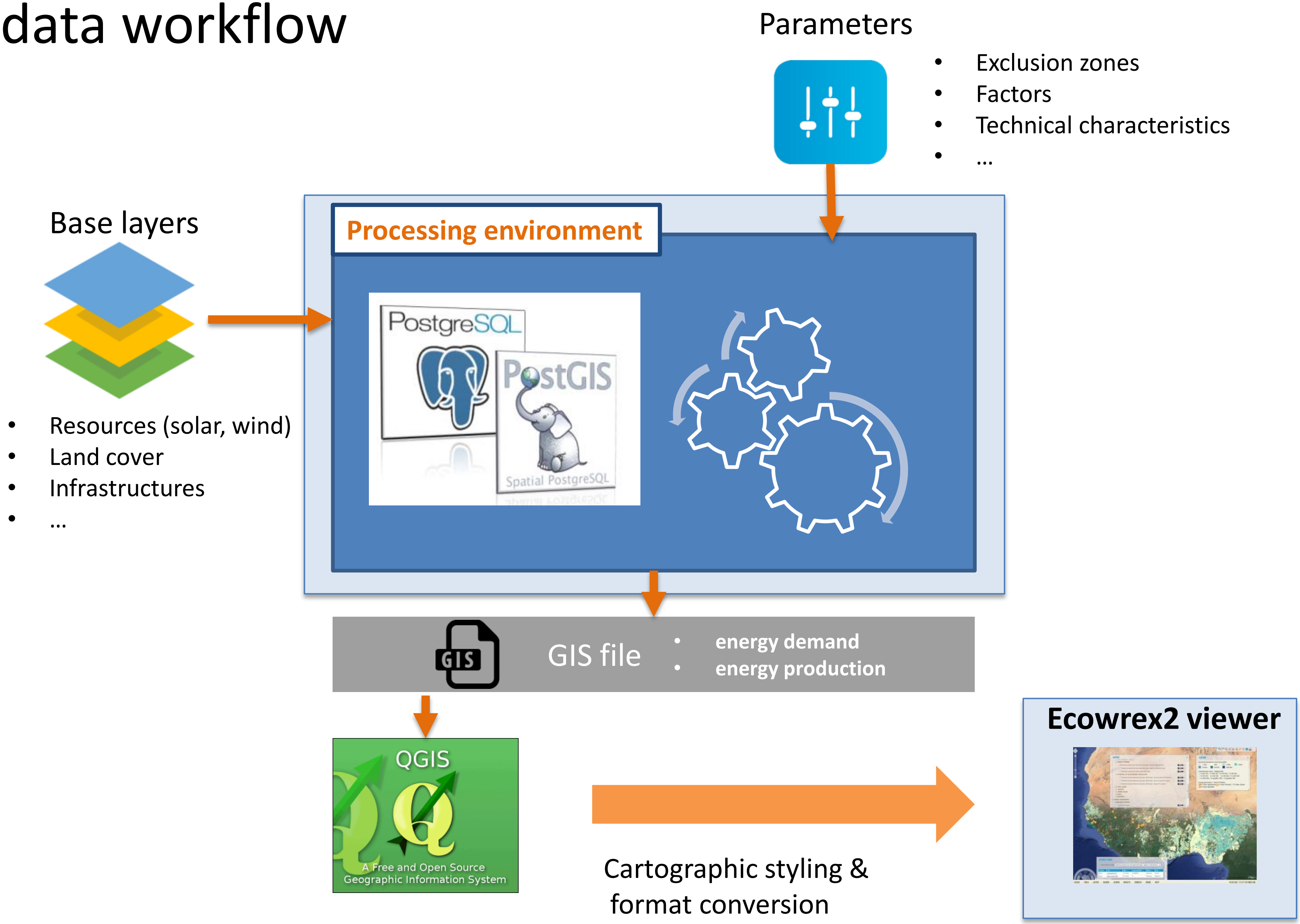
electricity production (GWh/year) - off-grid PV systems
0 50 57 65 70

electricity production (GWh/year) - grid-connected PV systems
0 200 210 220 243

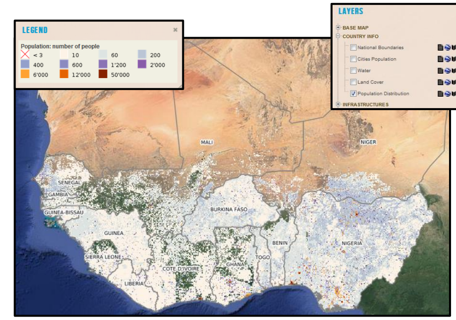
electricity production (GWh/year) - grid-connected CSP systems
0 115 130 140 155

2.2 Discussion of the process and methodology

data workflow



Population distribution map



although data set already exists (WorldPop, Grump) they do not pay the necessary attention to the **repartition of the population in rural areas**, which is a crucial point for our analysis.

As a result of what we have therefore decided to set up a new model for the rural and urban population distribution on the field, at 1km x1km resolution, entirely based on public and freely available datasets:

WorldPop (www.worldpop.org.uk/)
Global Land cover 30m (http://www.globallandcover.com/)
GPWv4 (http://beta.sedac.ciesin.columbia.edu/data/collection/gpw-v4)
OpenStreet map (www.openstreetmap.org)
Geonames (www.geonames.org/)

We decided to develop our Population grid map: EcowPop

Requirements for gridded population data for EcowrexII:

1) Free of costs
2) Open access license: (re-distributable)
3) Emphasize settlements (where people live)
4) Full control for further improvements: dynamic workflow in an open source development environment

II Population distribution:

Basically the model subdivides the population to allocate into two main categories:

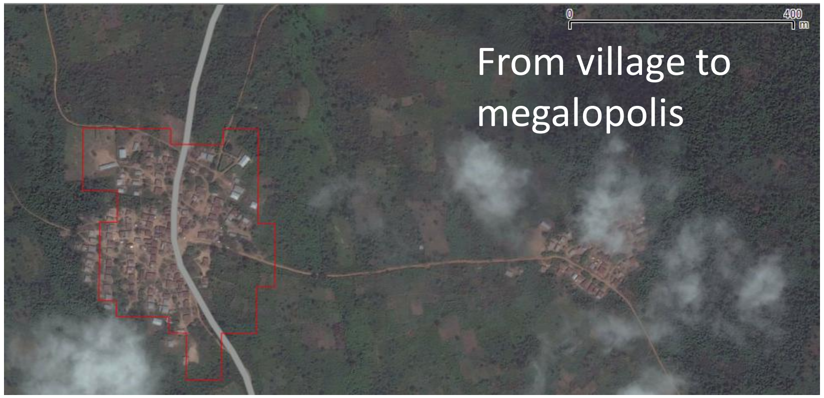
1) peoples living settlements from cities to smallest villages that can be captured by remote sensing
2) the so called “sparse population” or rather the remaining population living in such small villages or isolates buildings that cannot be captured by remote sensing or that re not listed in the common gazetteers.

The identification of the first category is done principally by using the artificial surface class from Global Land Cover (GLC) 30m of resolution (from Landsat imagery), together with Gazetteer (OSM, Geonames).
The people allocation is based on WorldPop figures improved using densities rules and thresholds based on national values

The sparse population is estimated using relative weights associated with land use classes (Linard et al., 2012, Tatem et al., 2012).

Population subdivided in two main typologies

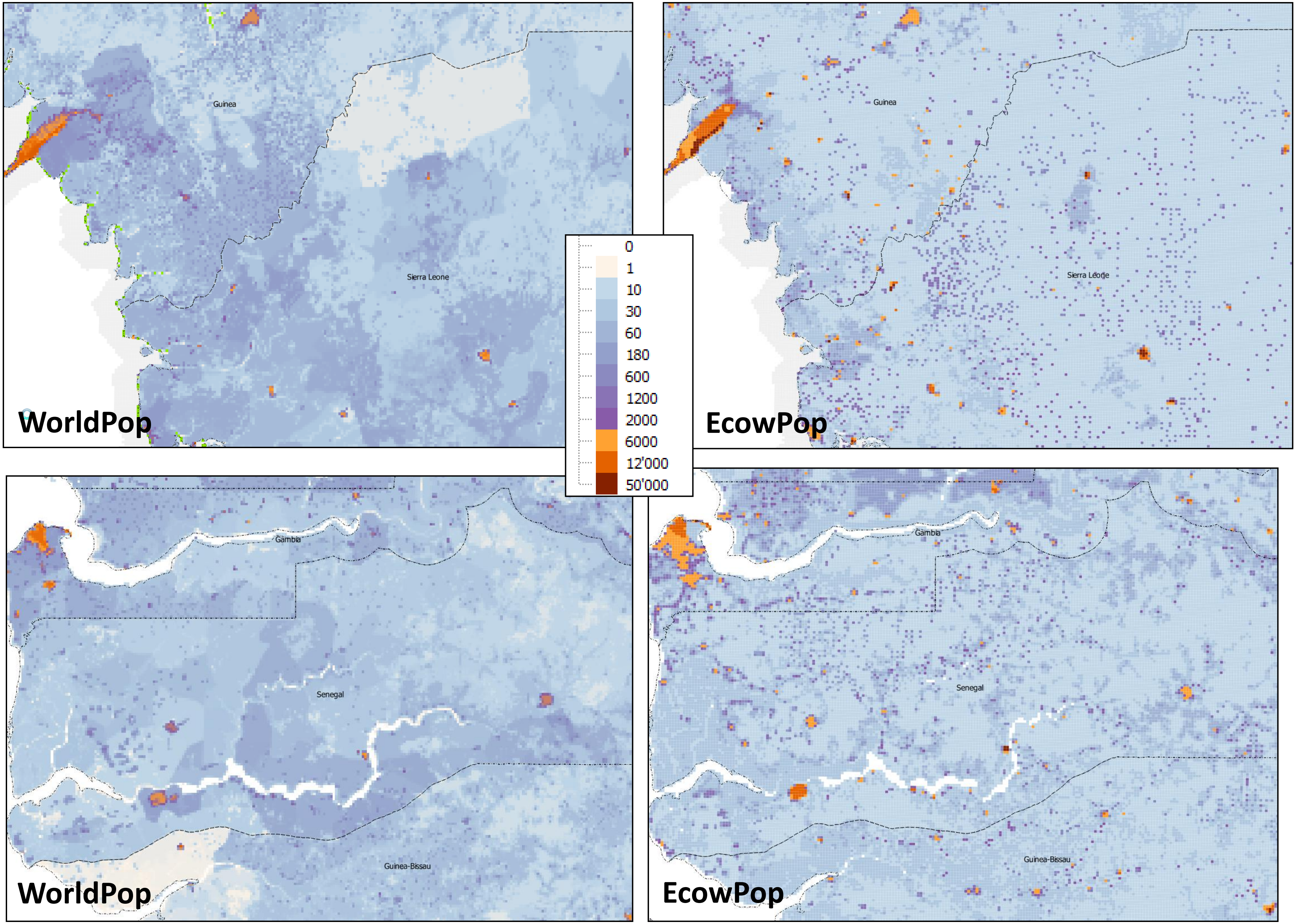
Category 1): Peoples living in settlements



Built-up areas from **remote sensing** and Gazetteers

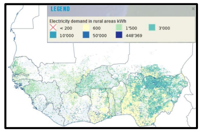
Category2): Sparse population

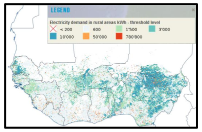
(**not detected** by remote sensing)

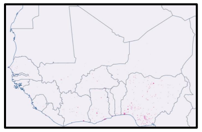


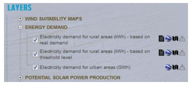
Guinea
Sierra Leone
WorldPop
Guinea
Sierra Leone
EcowPop
0
1
10
30
60
180
600
1200
2000
6000
12'000
50'000
Gambia
Senegal
Guinea-Bissau
WorldPop
Gambia
Senegal
Guinea-Bissau
EcowPop

Electricity demand (rural areas, urban agglomerations)









disaggregation of data on electricity consumption per country into a regular geographic grid at 1km resolution using ancillary data.

Each country's secondary **electricity demand** was divided into three categories according to WAPP (2013)*

- **Heavy industry** (e.g. mining), which connects to generation at a high voltage and generally requires less transmission and no distribution infrastructure.
- **Urban residential, commercial, and small industries,** which are connected to generation via relatively more transmission and distribution infrastructure.
- **Rural residential** and **commercial,** which require even more transmission and distribution infrastructure.

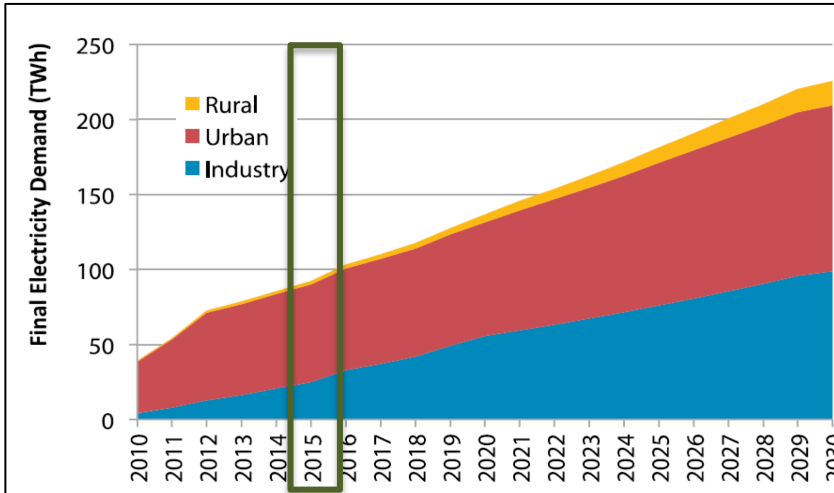


Figure 3. Total Final Electricity Demand, 2010-2030, by Category

****WEST AFRICAN POWER POOL (WAPP):** Planning and Prospects for Renewable Energy, IRENA 2013*

Before going further we need to address a dilemma….

Where is the “limit” between urban and rural??

Several approaches and definitions possible…

The theoretical threshold between rural and urban settlements varies according to time and geographical areas.
It may also vary between regions in individual countries. In Western Africa, it is generally set at between 5,000 and 10,000 inhabitants, and most commonly around 7,000-8,000. Several consideration and tests have allowed to confirm the choice of 10,000 inhabitants as the threshold chosen for the Geopolis database.

Africapolis, Urbanization Trends, analytical report

The limit is set to 10’000 inhabitants per all Ecowas countries

Electricity demand at national level: two different approaches

1) Measured / estimated “real” data: WAPP - IRENA 2013
2) Minimum level of electricity: IEA 2011

1) Electricity demand for rural areas based on measured / estimated

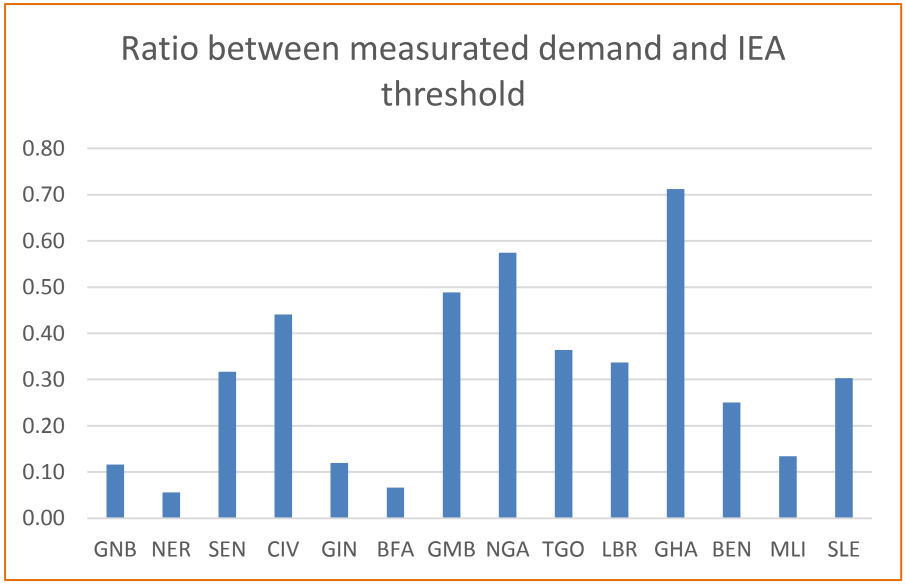
country	Final electricity demand Projections GWh (WPP) 2015					population
Name	rural - **%**	urban/services/small Industry - **%**	sum – total **GWh**	rural – total **GWh**	rural – capita **kWh**	rural – total **nb. people**
Benin	3%	77%	1'887	**56.6**	12.5	4'525'730
Burkina	3%	77%	1'173	**35.2**	3.3	10'681'200
Cabo Verde						
Cote d'Ivoire	3%	77%	7'731	**231.9**	22.0	10'520'900
Gambia	3%	62%	586	**17.6**	24.4	719'072
Ghana	3%	77%	14'455	**433.7**	35.6	12'175'200
Guinea	3%	63%	1'563	**46.9**	6.0	7'841'400
Guinea-Bissau	3%	65%	176	**5.3**	5.8	910'184
Liberia	3%	57%	1'446	**43.4**	16.9	2'574'340
Mali	3%	57%	2'226	**66.8**	6.7	9'976'610
Niger	3%	72%	1'235	**37.1**	2.8	13'295'000
Nigeria	3%	72%	68'830	**2'064.9**	28.7	71'909'500
Senegal	3%	77%	3'744	**112.3**	15.9	7'084'620
Sierra Leone	3%	57%	1'498	**44.9**	15.2	2'965'690
Togo	3%	77%	1'660	**49.8**	18.2	2'735'440
Togo/Benin	3%	77%	3'547	**106.4**	12.5	

2) Electricity demand for rural areas based on threshold level: "Equal access scenario"

Access to electricity involves consumption of a specific minimum level of electricity. IEA estimates the initial threshold level of electricity consumption for rural households to be **250 kilowatt-hours (kWh) per household per year.**

> There is no universally-agreed and universally-adopted definition of modern energy access. For our analysis, we define modern energy access as "*a household having reliable and affordable access to clean cooking facilities, a first connection to electricity and then an increasing level of electricity consumption over time to reach the regional average.*"
>
> *IEA 2011: Energy for All*

Country name	rural demand: WPP estimation (GWh)	rural demand IEA threshold (GWh)
Benin	57	**226**
Burkina	35	**534**
Cabo Verde		**25**
Cote d'Ivoire	232	**526**
Gambia	18	**36**
Ghana	434	**609**
Guinea	47	**392**
Guinea-Bissau	5	**46**
Liberia	43	**129**
Mali	67	**499**
Niger	37	**665**
Nigeria	2'065	**3'595**
Senegal	112	**354**
Sierra Leone	45	**148**
Togo	50	**137**



Geographic breakdown:

heavy industry : **Out of scope:** ✖

This sector can be definite and quantified only with specific infrastructure georefered data, within associated attributes related to energy consumption.
Collect such kind of data, with public domain license, is an issue.

Urban residential, commercial, and small industries, **secondary purpose** ✔

Urban population living in urban agglomerations, isolated (extra urban) small industrial sites

Rural residential and **commercial** **main purpose** ✔ ✔

Peoples living in rural areas in small settlements or in isolated dwellings (sparse population)

- **Focus on energy consumption (especially) in rural areas**
- **Population distribution become the main proxy for energy consumption**

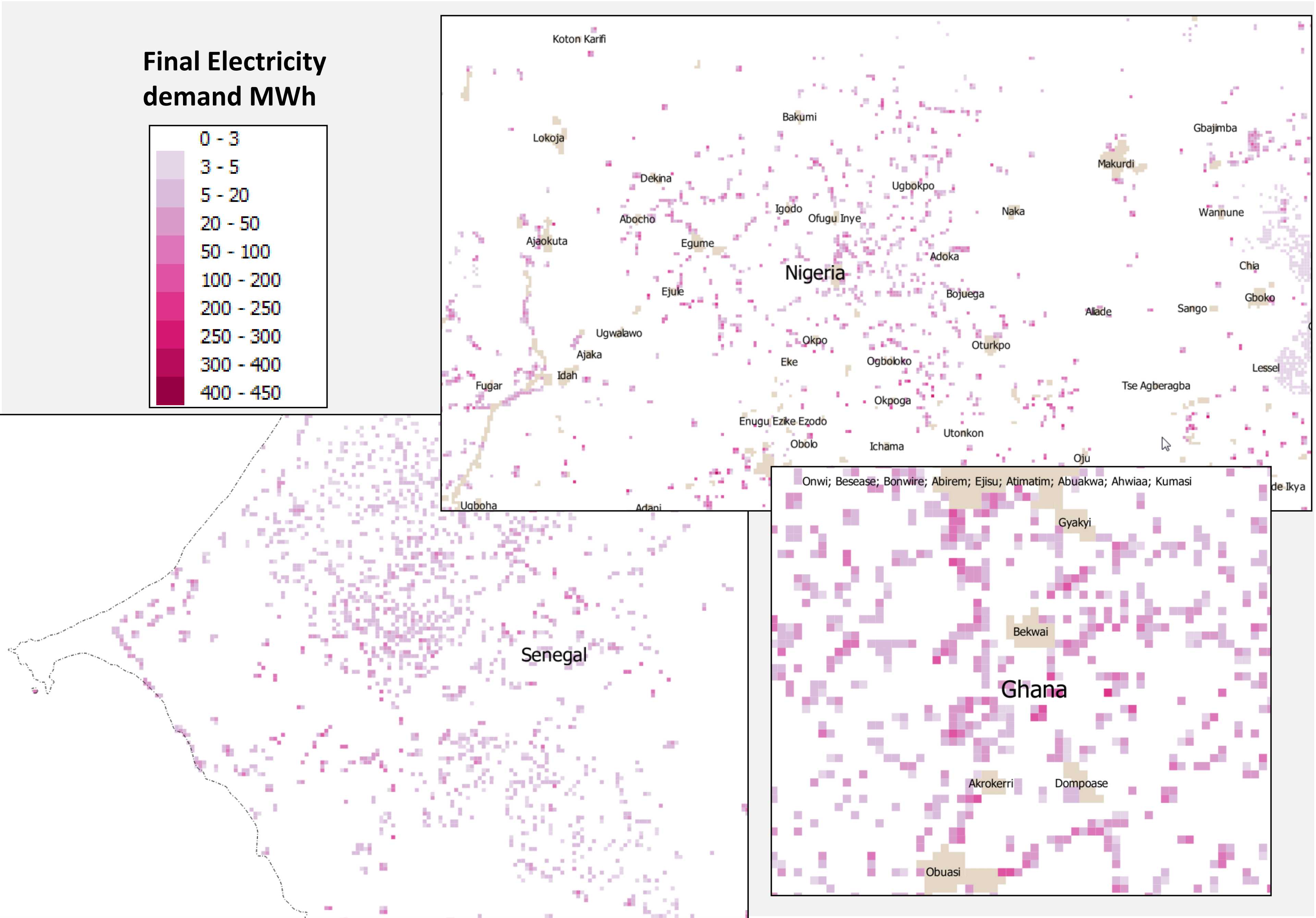
Considering that in **rural areas** the electricity demand can be considered closely **related to the number of inhabitants**, the principal disaggregation algorithm, that estimates the electricity demand for each cell (x,y) of the geographic grid is based on:

$$\text{Electricity demand}_{(x,y)} = \text{electricity demand}_{(capita)} * \text{number people}_{(x,y)}$$

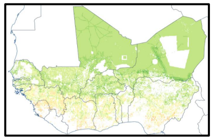
where the electricity demand per capita is calculated according to national and international (IEA, WAPP) data bases.

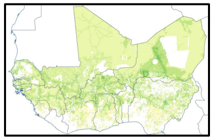
The Ecowpop dataset is utilized for the estimation of the distribution of the population on the field (number $\text{people}_{(x,y)}$),

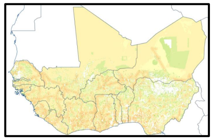
Electricity demand: outputs (RURAL), WAPP



Land suitability maps - solar







The suitability maps, contain information on locations suitable for installation of the respective solar systems in accordance with the restrictive criteria adopted.

Locations are evaluated according to their suitability for solar systems deployment according to topographical, legal, and social constraints, as well as factors that could facilitate or impede solar generation development.

Solar systems

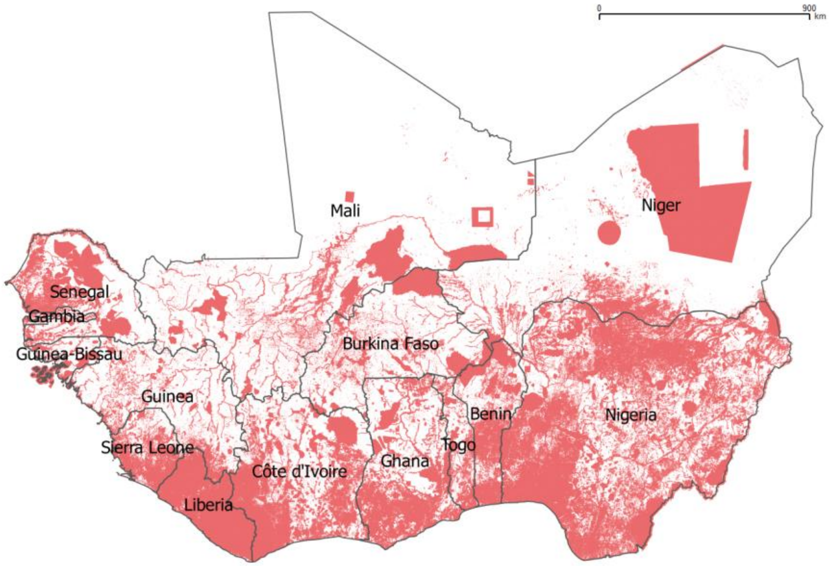
Types of solar technologies

- **Grid-connected large scale Solar Photovoltaic (PV)** systems. Large-scale PV systems may have capacities from 10 MW to over 100 MW, and generally require a surface exceeding 1km2
- **Off-grid Solar Photovoltaic (PV) systems**. Off-grid systems may supply energy to a single consumer, or a number of consumers via a midi-grid (with no connection to major electricity grid lines). Off-grid systems provide with opportunities for power supply in remote areas while avoiding costly investments in distribution and transmission systems
- **Grid-connected Concentrated solar power (CSP).** CSP technology is based on mirrors that transform solar energy into heat in order to generate electricity with a use of steam turbines, gas turbines, or Stirling engines. CSP is currently represented by centralized grid-connected power plants, with capacities that may exceed 100 MW.

Solar

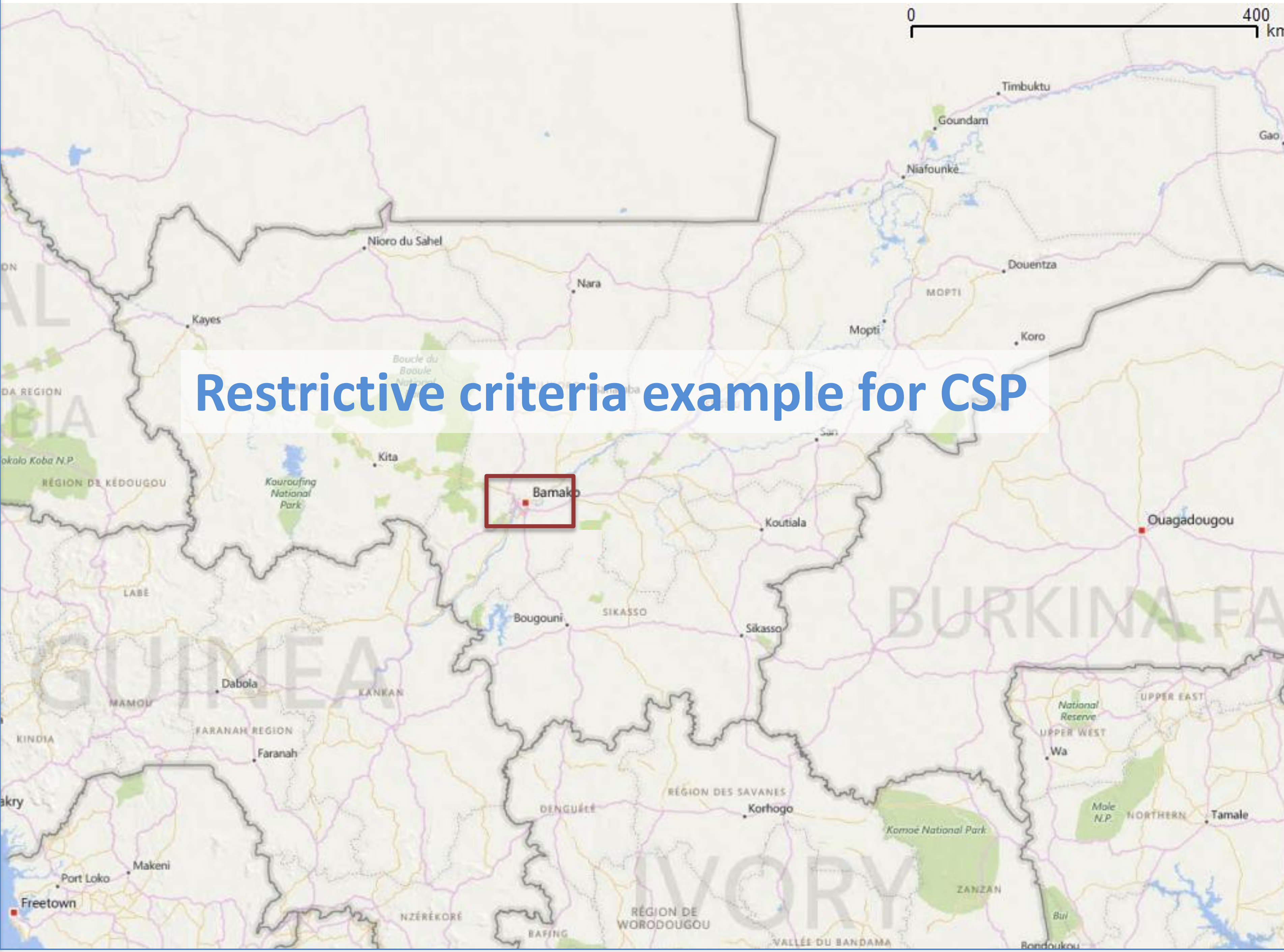
1) Restrictive criteria

The first step consists to define restrictive criteria **to eliminate** areas not suitable for solar power development.

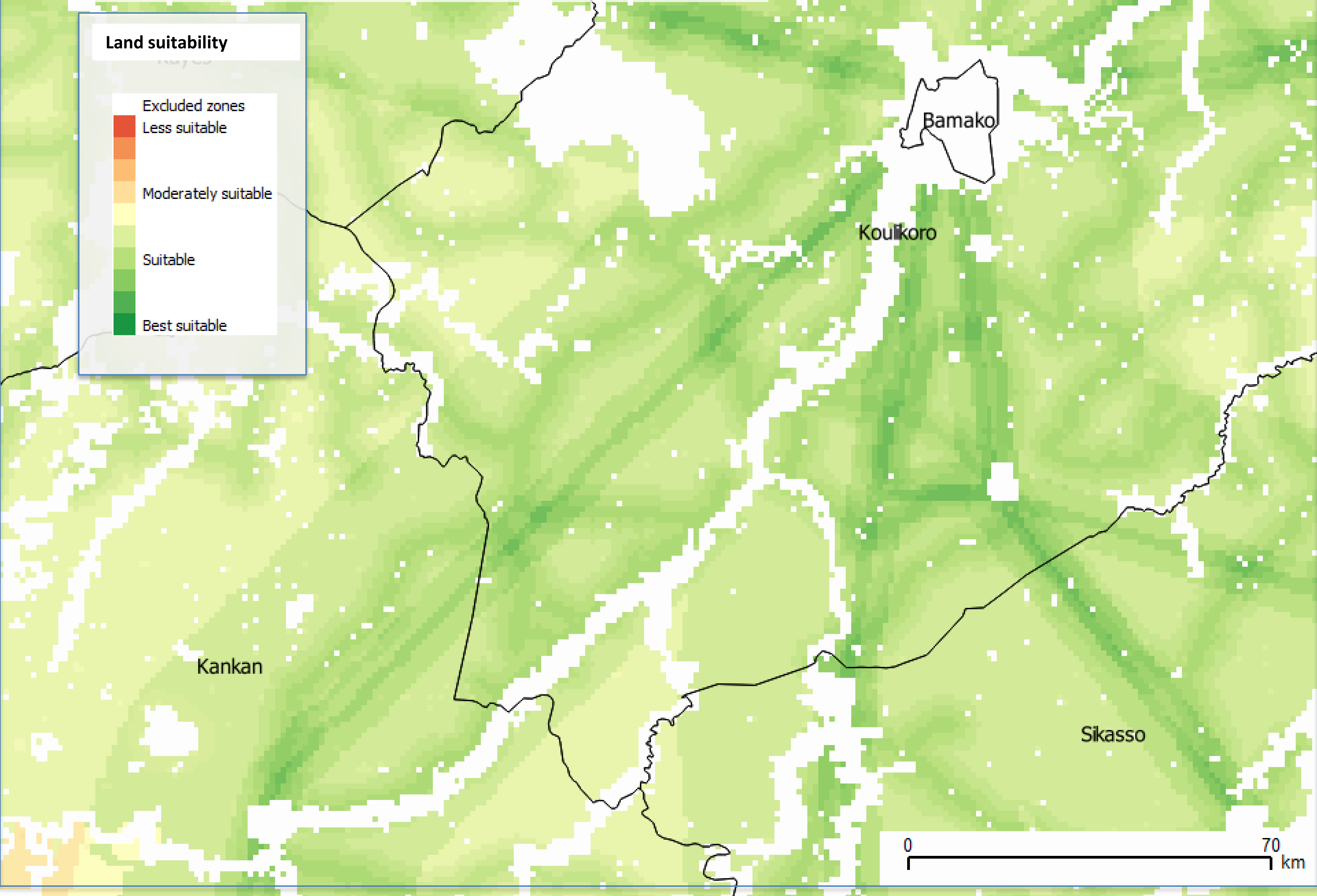


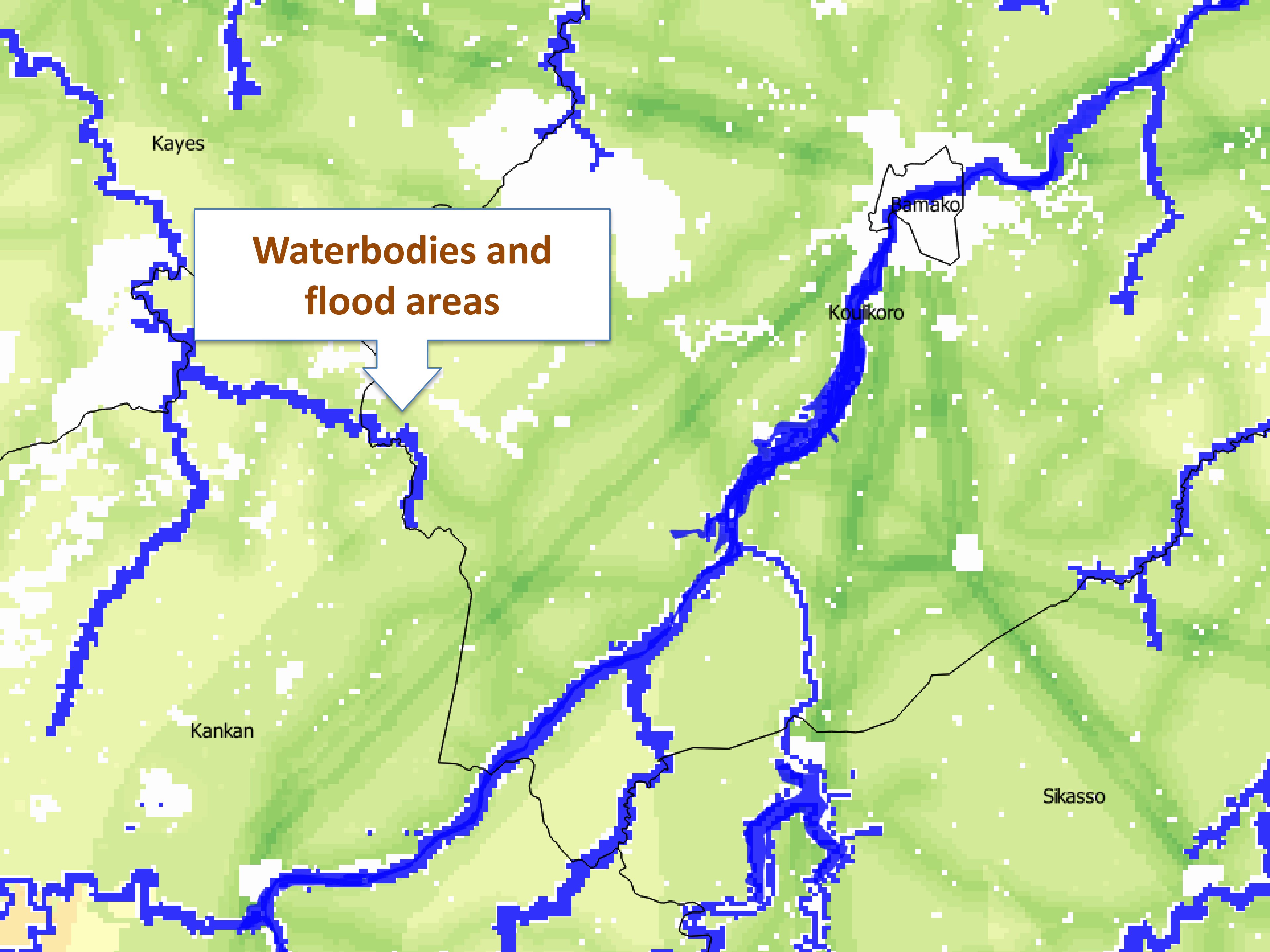
Criteria	Description	PV off-Grid	PV Grid connected	CSP Grid connected
Urban settlements	Urban settlements (>10'000 inhabitants), with 1 km buffer	urban areas	urban areas	urban areas
Land cover	the sum of surface occupied by selected land use classes is equal or over 75%	forests, wetlands, and water bodies	build-up areas, agricultural zones, forests, wetlands, and water bodies	build-up areas, agricultural zones, forests, wetlands, and water bodies
Risk areas	Flood zones in which the expected average number of flood event per 100 years is equal or over 1	Flood zones	Flood zones	Flood zones
Protected areas	IUCN class I - VI and not classified	only Ia (Strict Nature Reserve) IUCN classification	All included	All included
Land slope	cells in which over 75% of surface has a slope exceeding a threshold value	-	10% (or 5.71°)	2% (or 1.15°)
Population density	Rural cells in which population density exceeding a threshold value	-	>500 inhab/km2	>500 inhab/km2

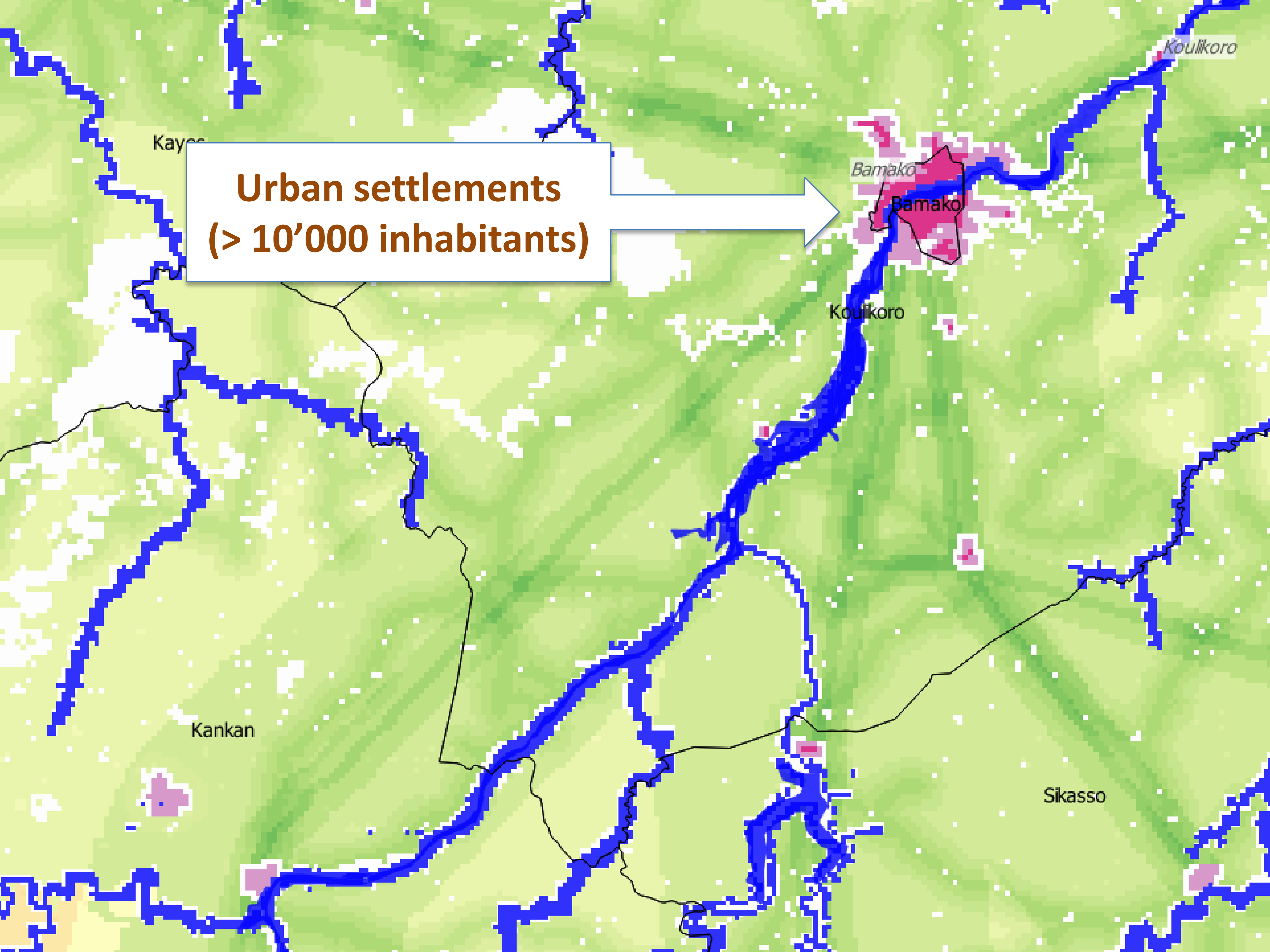
Restrictive criteria example for CSP



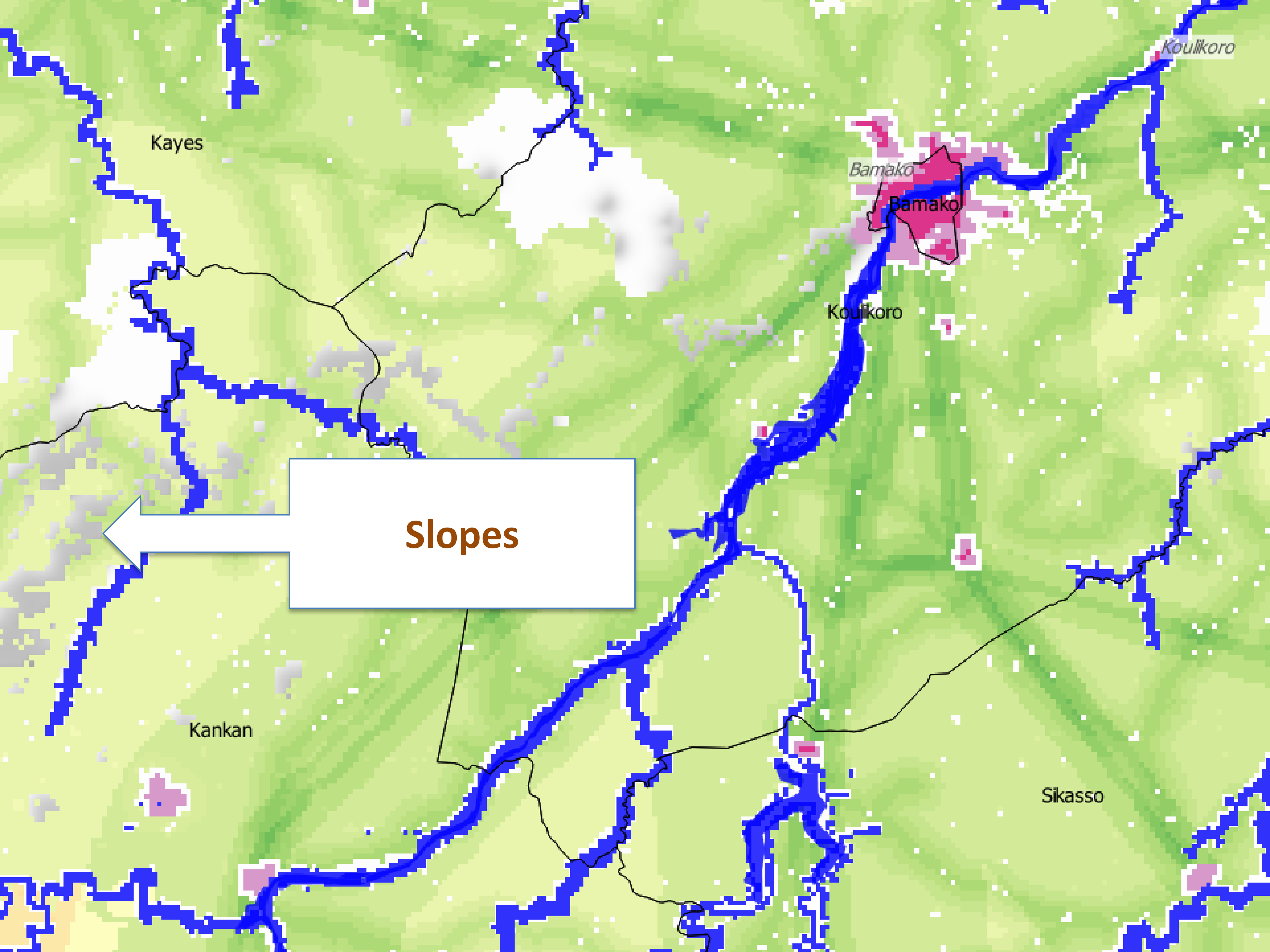
Land suitability classes CSP Grid connected



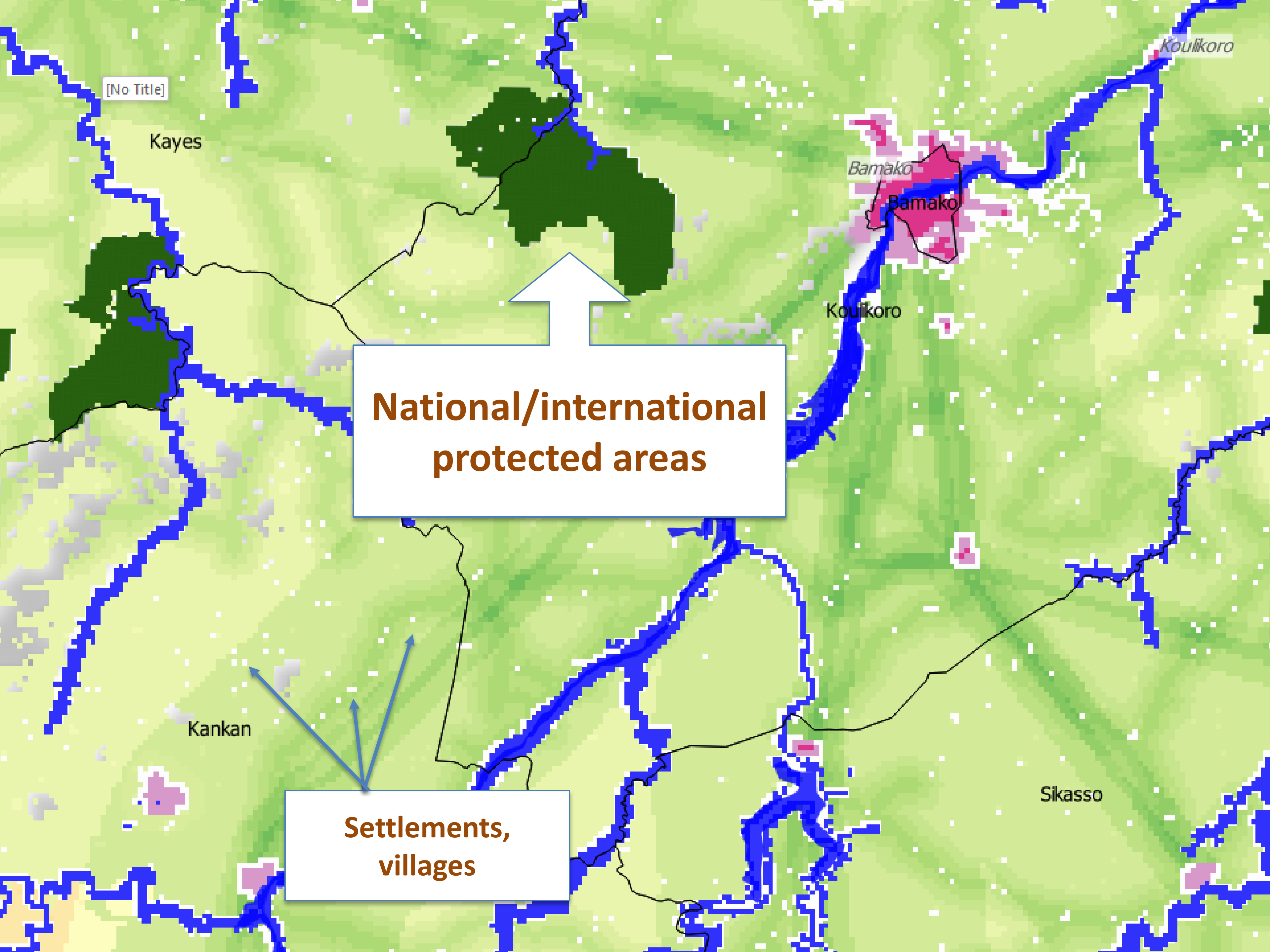

Waterbodies and flood areas
Kayes
Bamako
Koulikoro
Kankan
Sikasso



Urban settlements
(> 10’000 inhabitants)
Koulikoro
Kayes
Bamako
Bamako
Koulikoro
Kankan
Sikasso



Koulikoro
Kayes
Bamako
Bamako
Koulikoro
Slopes
Kankan
Sikasso


[No Title]
Kayes
Koulikoro
Bamako
Bamako
Koulikoro
National/international protected areas
Kankan
Sikasso
Settlements, villages

2) Factors classification (suitability classes)

The second step consists to consider different factors in order to classify the remaining areas according to their suitability.

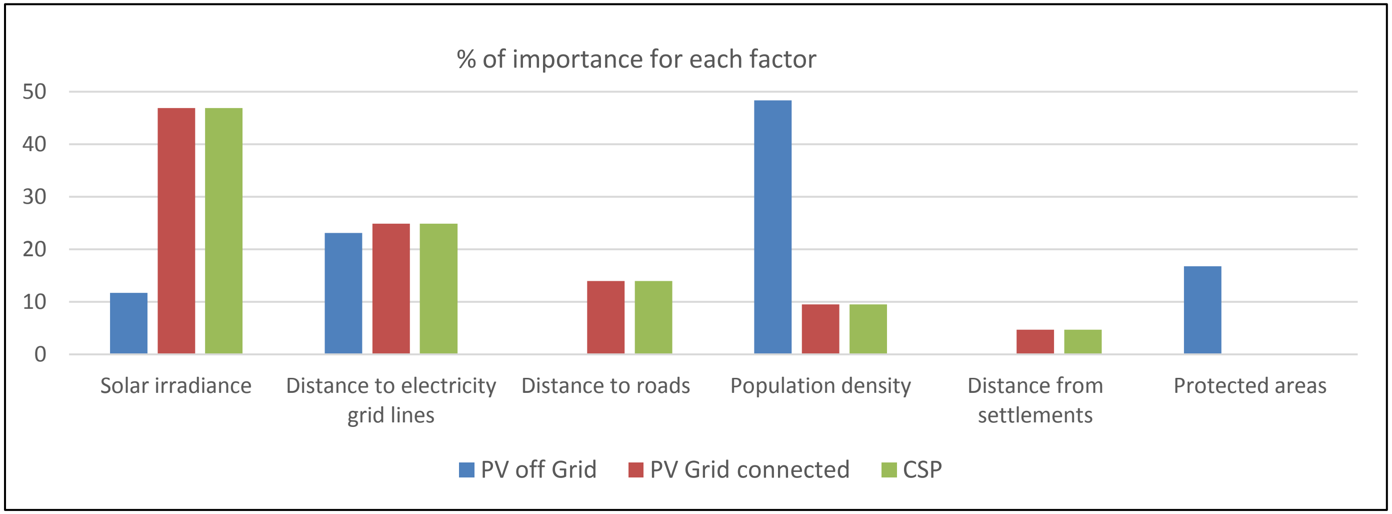
- Less suitable = 1
- Moderately suitable = 2
- Suitable = 3
- Best suitable = 4

Factor	Objective	Classification - PV off Grid	Classification - PV Grid connected	Classification - CSP
Solar irradiance	For PV: maximize GHI For CSP: maximize DNI	1: < 4.93 kWh/m2/day	1: < 4.93 kWh/m2/day	1: < 1800 kWh/m2/year
		2: 4.93-5.75 kWh/m2/day	2: 4.93-5.75 kWh/m2/day	2: 1800-2300 kWh/m2/year
		3: 5.75-6.03 kWh/m2/day	3: 5.75-6.03 kWh/m2/day	3: 2300-2700 kWh/m2/year
		4: > 6.03 kWh/m2/day	4: > 6.03 kWh/m2/day	4: > 2700 kWh/m2/year
Distance to electricity grid lines	Grid Connected: Minimize distance, Off-Grid Maximize distance	1: < 1 km	1: > 30 km	1: > 30 km
		2: 1-5 km	2: 5-30 km	2: 5-30 km
		3: 5-30 km	3: 1-5 km	3: 1-5 km
		4: > 30 km	4: < 1 km	4: < 1 km
Distance to roads	Minimize distance	-	1: > 5 km	1: > 5 km
			2: 3-5 km	2: 3-5 km
			3: 1-3 km	3: 1-3 km
			4: < 1 km	4: < 1 km
Population density	Grid Connected: Minimize density, Off-Grid Maximize density	1: 20 inhabitants /km2	1: > 500 inhabitants /km2	1: > 500 inhabitants /km2
		2: 1-100 inhabitants /km2	2: 100-500 inhabitants /km2	2: 100-500 inhabitants /km2
		3: 100-500 inhabitants /km2	3: 1-100 inhabitants /km2	3: 1-100 inhabitants /km2
		4: >500 inhabitants /km2	4: 0 inhabitants /km2	4: 0 inhabitants /km2
Distance from settlements	Grid connected: Optimize distance from urban settlements (>10'000 inhabitants)	-	1: < 1 km	1: < 1 km
			2: 1-2 km	2: 1-2 km
			3: 2-5 km	3: 2-5 km
			4: > 5 km	4: > 5 km
Protected areas	Preference to locations classified as protected	1: non-classified as protected areas	-	-
		4: classified as protected areas		

3) Factor weights (% of importance) for each factor

Third step consists to assign weights of relative importance to each factor. Therefore, the resulting classification of areas depends on the choice of factors and their weights. Multi-criteria decision making (MCDM) methods are often used in this context, we applied an Analytic Hierarchy Process (AHP) method.

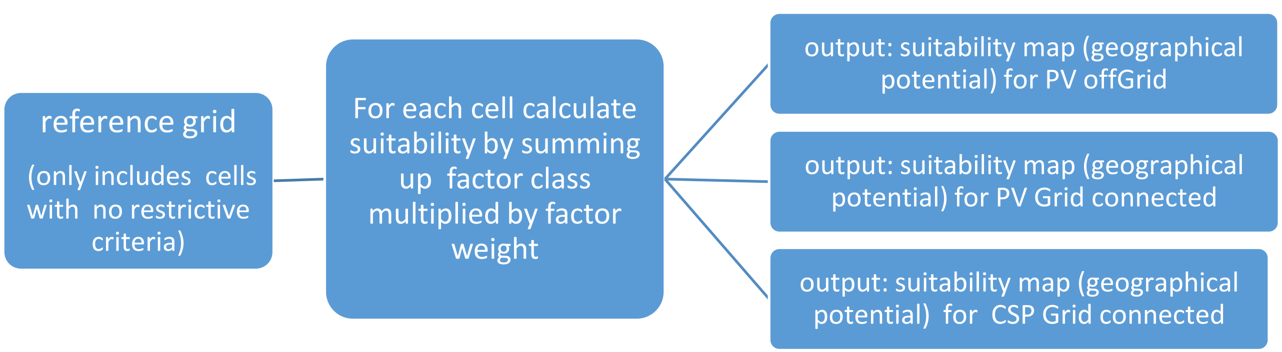
Factor	Objectives	PV off Grid	PV Grid connected	CSP
Solar irradiance	For PV: maximize GHI For CSP: maximize DNI	11.7%	46.9%	46.9%
Distance to electricity grid lines	Grid Connected: Minimize distance, Off-Grid Maximize distance	(-)23.1%	24.9%	24.9%
Distance to roads	Minimize distance		14%	14%
Population density	Grid Connected: Minimize density, Off-Grid Maximize density	48.4%	9.5%	9.5%
Distance from settlements	Grid connected: Optimize distance from urban settlements (>10'000 inhabitants)		4.7%	4.7%
Protected areas	Preference to locations classified as protected	16.8%	-	-



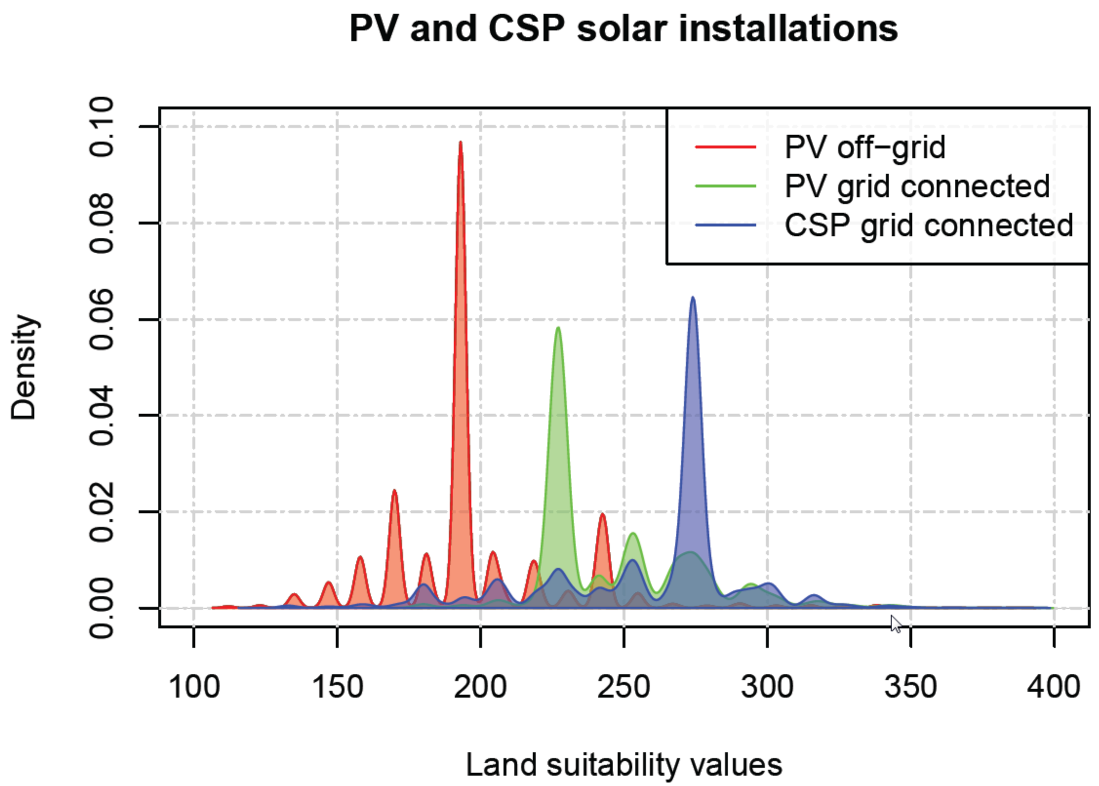
4) Suitability per cell

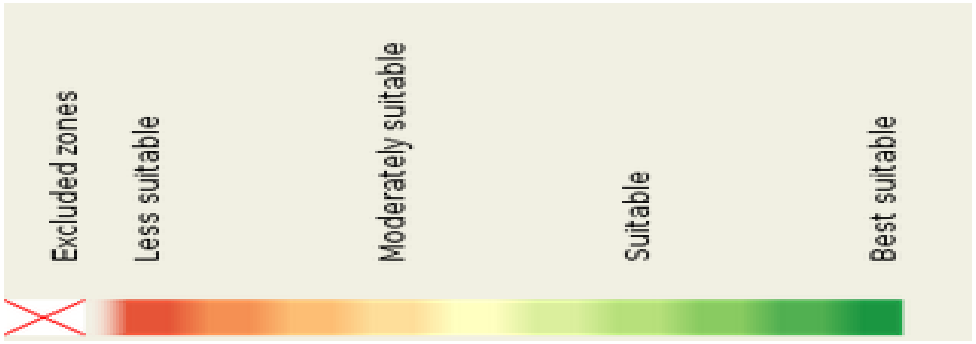
Finally, the suitability for each cell will be done by the sum of the scores of each of the six factors multiplied by the corresponding relative importance, as shown in the following equation.

$$\mathbf{SuitabilityCell}\boldsymbol{n}_{(xy)} = \sum_{n=1}^{6} \left(\text{FactorClassCell}n_{(xy)} * \ \text{FactorWeightCell}n_{(xy)}\right) /\ 100$$



5) Classification

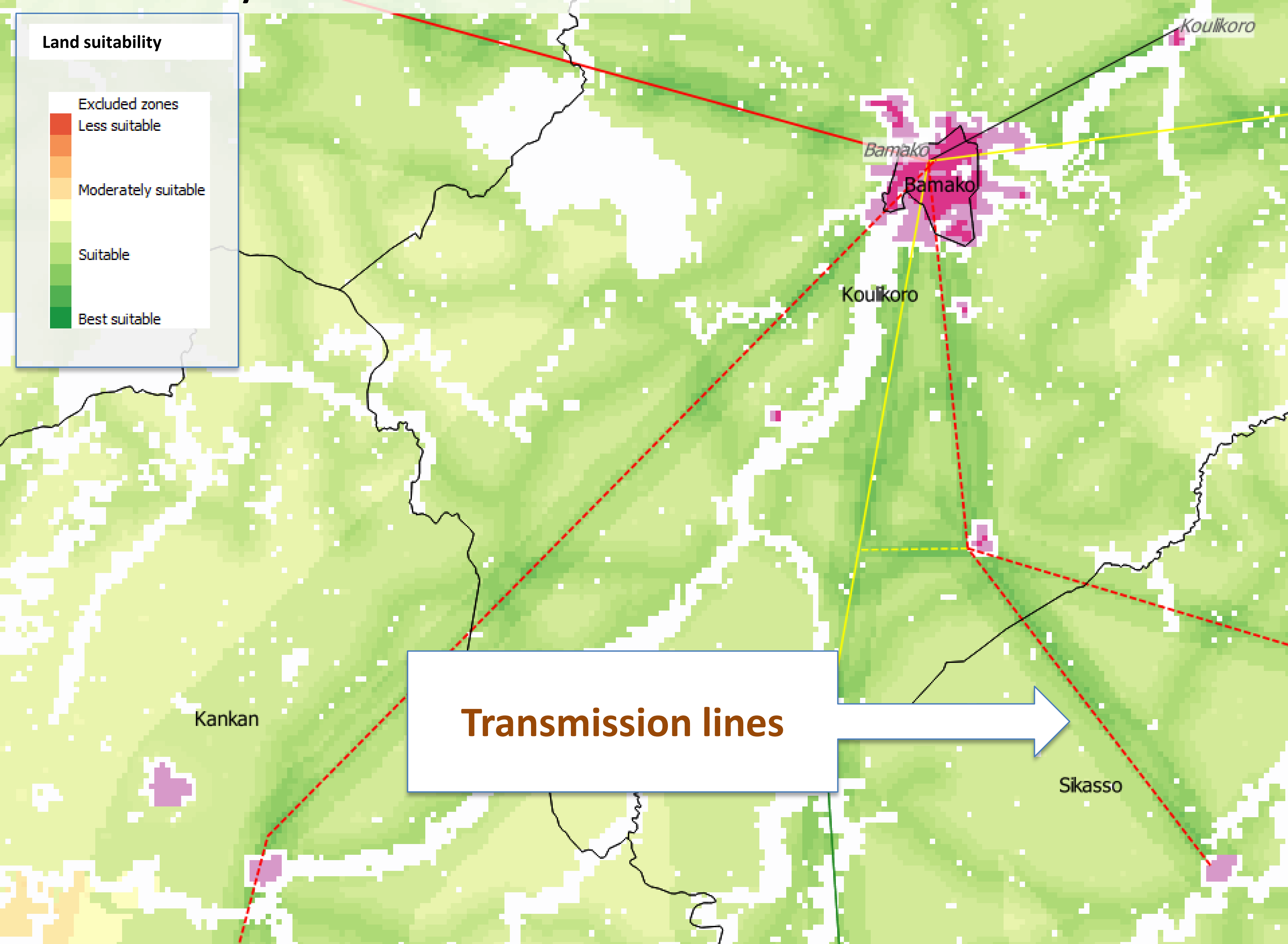




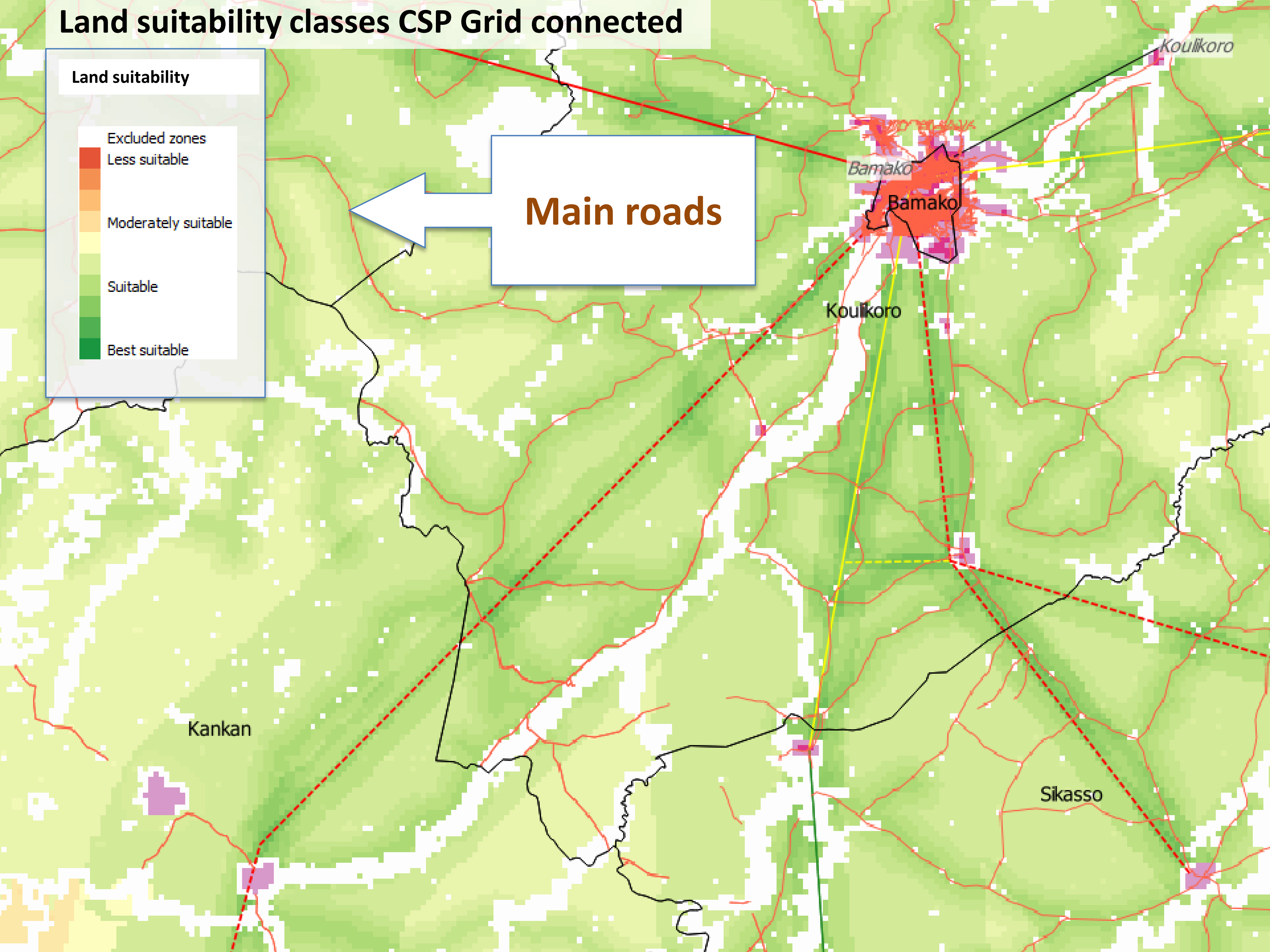
Results on land suitability presented in this section were classified according a continuous qualitative scale ranging from 100 to 390.

Values close to 100 are considered as Less suitable, while those approaching the maximum value as Best suitable.

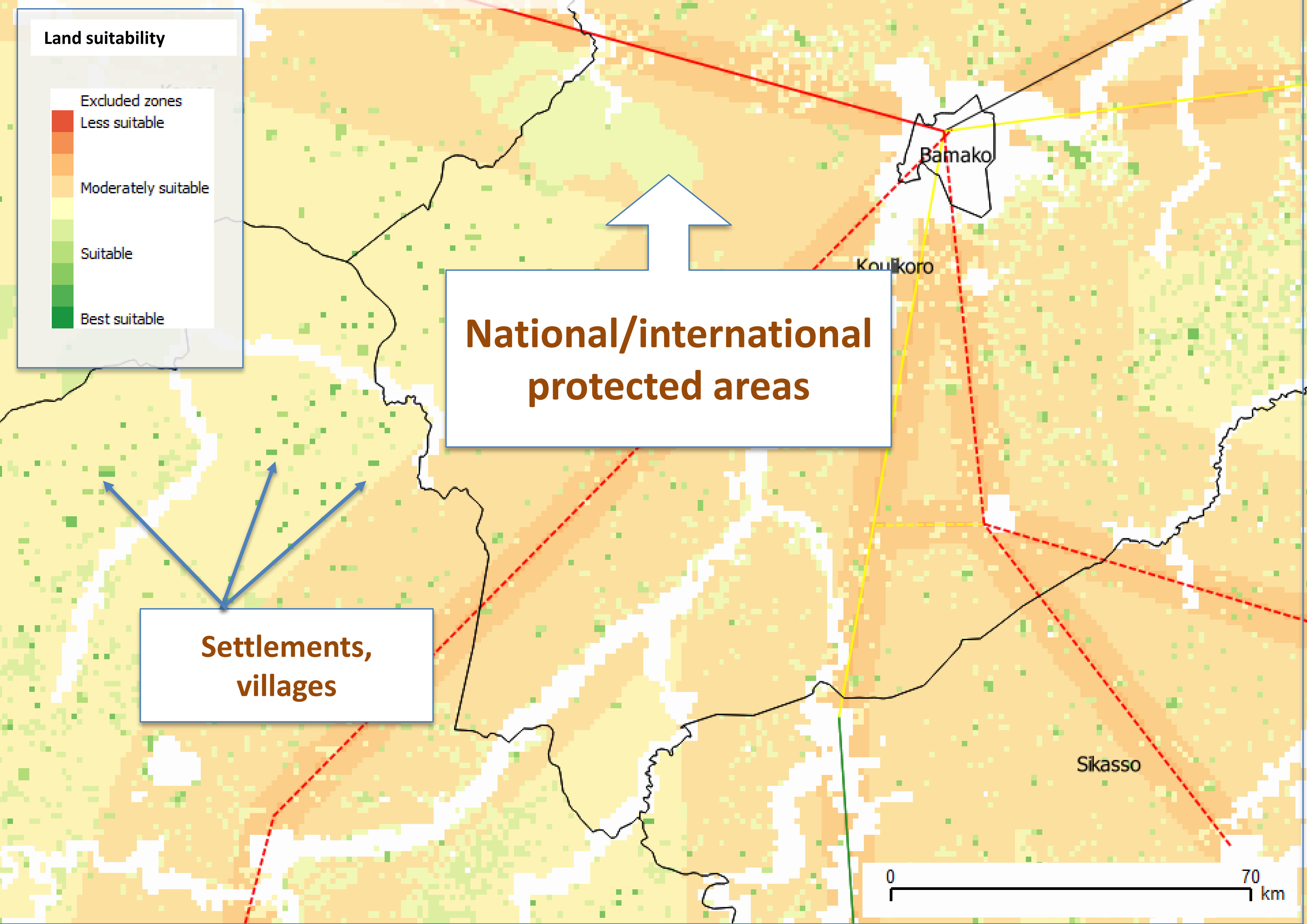
Land suitability classes CSP Grid connected



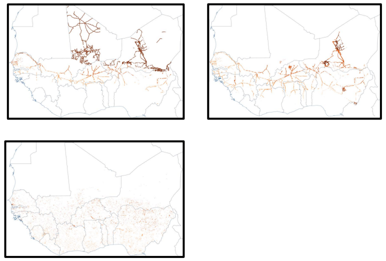
Land suitability classes CSP Grid connected



Land suitability classes PV Off-Grid



Potential of electricity production maps - solar



Disaggregation of data regarding maximum available energy per technology per country into a grid at 1km, when considering technically feasible levels of penetration… by subtracting any irrelevant or else unsuitable areas for energy generation

Technical potential of solar generation in a chosen area may be defined as the amount of the total yearly solar radiation available in that area, taking into account existing geographical constraints, ("suitability maps") that can be converted into electricity given the available solar power technologies.

In other words, the technical potential will be calculated only keeping in account the ***best available area*** previously evaluated during the development of suitability maps.

The available area was selected on the basis of histogram and map analysis. It has been set as follows:

- CSP (grid connected) best available area: cells with land suitability score > 302 (5% of total cells)
- PV (grid connected) best available area: only cells with land suitability score > 299 (5% of total cells)
- PV (off grid) best available area: only cells with land suitability score > 255 (5% of total cells)

Solar

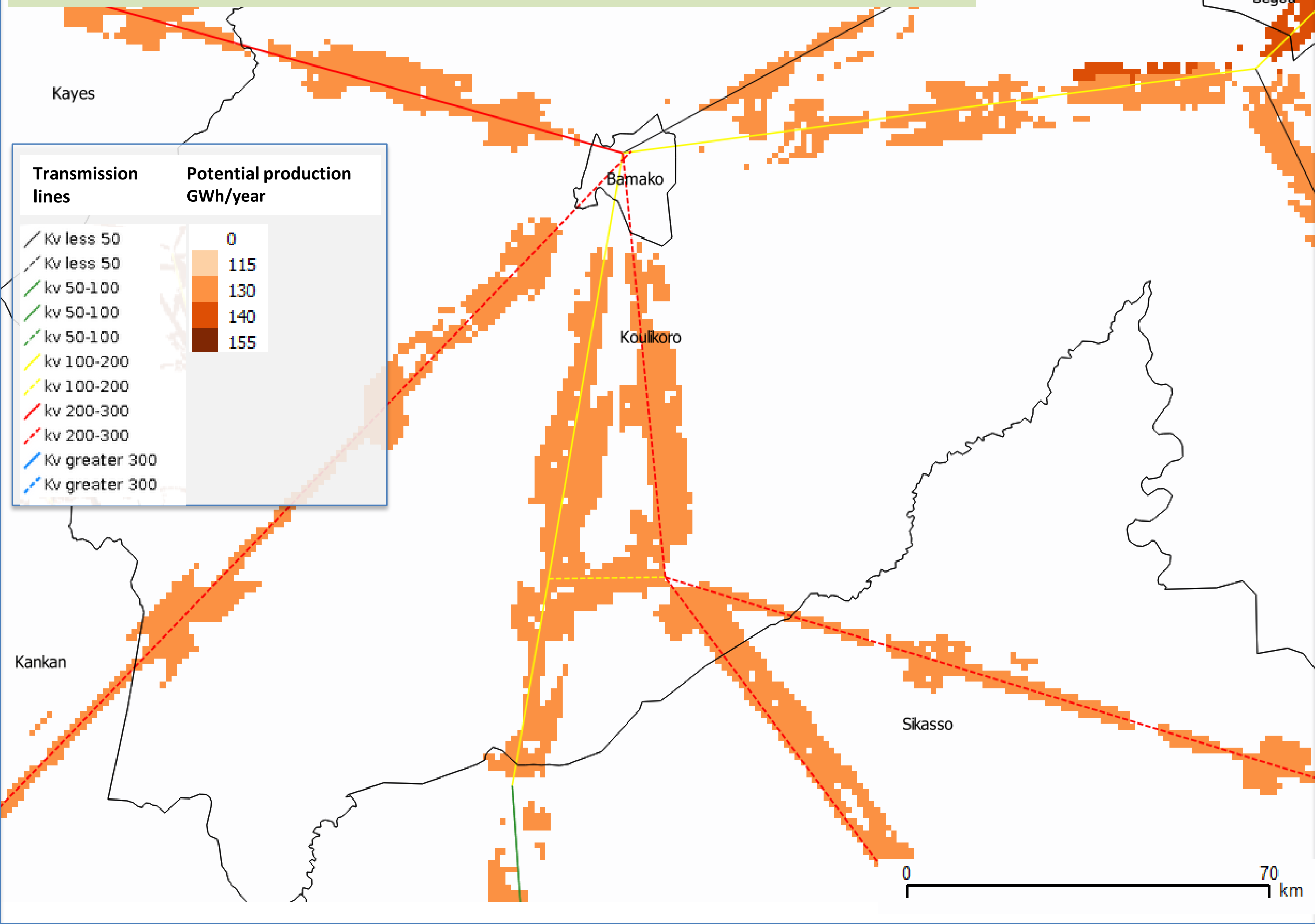
Technical

Criteria	Description	PV off Grid	PV Grid connected	CSP
Technology type		Monocryst alline cells	Monocryst alline cells	Parabolic trough
Module efficiency	Module efficiency claimed by manufacturer	15.5%	15.5%	15%
Performance Ratio (PR)	Performance ratio: difference between efficiency claimed and real (System efficiency is module efficiency multiplied by PR.)	85%	85%	-
Land occupancy factor (spacing factor)	Represents a ratio of total land requirements to the surface of PV panels or CSP collectors. The chosen values are taken from the reviewed literature	5	1.4	3

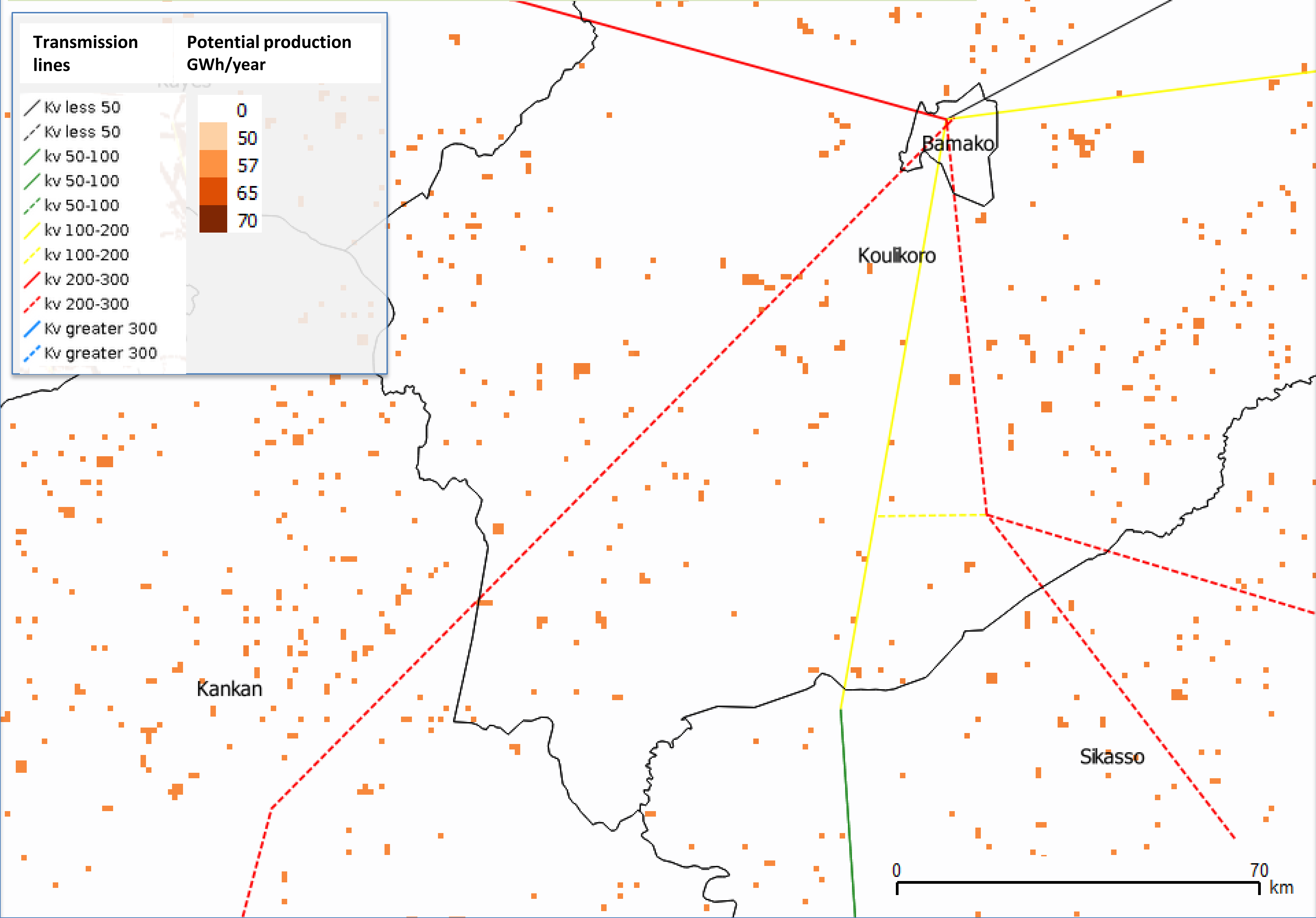
$$\mathbf{TechnicalPotCell}_{(xy)} = \mathrm{DNI}_{(xy)} \left(or\mathrm{GHI}_{(xy)} \right) * Efficiency * PR * \frac{\mathrm{AvailArea}_{(xy)}}{\mathrm{LandOcc}}$$

Elements:	solar irradiance	Module efficiency	PR	Land occupancy	Available area	**Technical potential**
Units:	kWh/m2/year	[%]	[%]	[-]	[km2]	**[GWh/year]**
Example Values:	2000	15	85	5	1	**51**

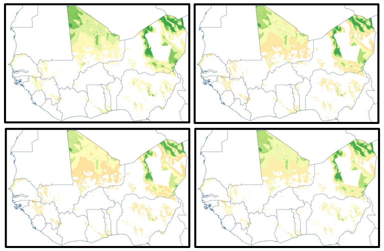
Potential production grid-connected CSP systems (GWh/year)



Potential production off-grid PV systems (GWh/year)



Land suitability maps - wind



In the present study we focus exclusively **on land suitability** for the installation of onshore wind turbine and wind farm. For several reasons:

- Minimum data to properly define wind conditions in is not available (as **wind speed average at 50 m** is the only available data). Therefore, "the amount of the total yearly wind available" (Sun et al., 2013) cannot be estimated.
- The efficiency of wind speed conversion to electricity depends on the type of material to be used. Consequently, " the amount of geographical potential... that can be converted into electricity " (Sun et al., 2013) cannot be estimated.

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By Steve Wilson from Orpington, UK - CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=22777884

1) Restrictive criteria

Criteria	Description	Value
Wind speed	Wind speed	<= 4.5 m/s
Distance to agglomeration	Distance to agglomeration (>10'000 inhabitants), with 1 km buffer	<= 2000 m
Distance to airport	Distance to main airports	>= 2500
Population density	Rural cells in which population density	>= 500 hab/km^2
Land cover	Percentage of cell surface occupied by built-up, wetland and forest land cover	>= 75%
Water bodies	Percentage of cell surface occupied by water land cover	>= 50%
Risk areas	Expected average number of flood event per 100 years	>= 1
Distance to protected areas	Distance to IUCN class I - VI and not classified protected area	<= 100 m
Land slope	75% of the surface of the cell has a slope	>= 20 %

2) Factors classification (suitability classes)

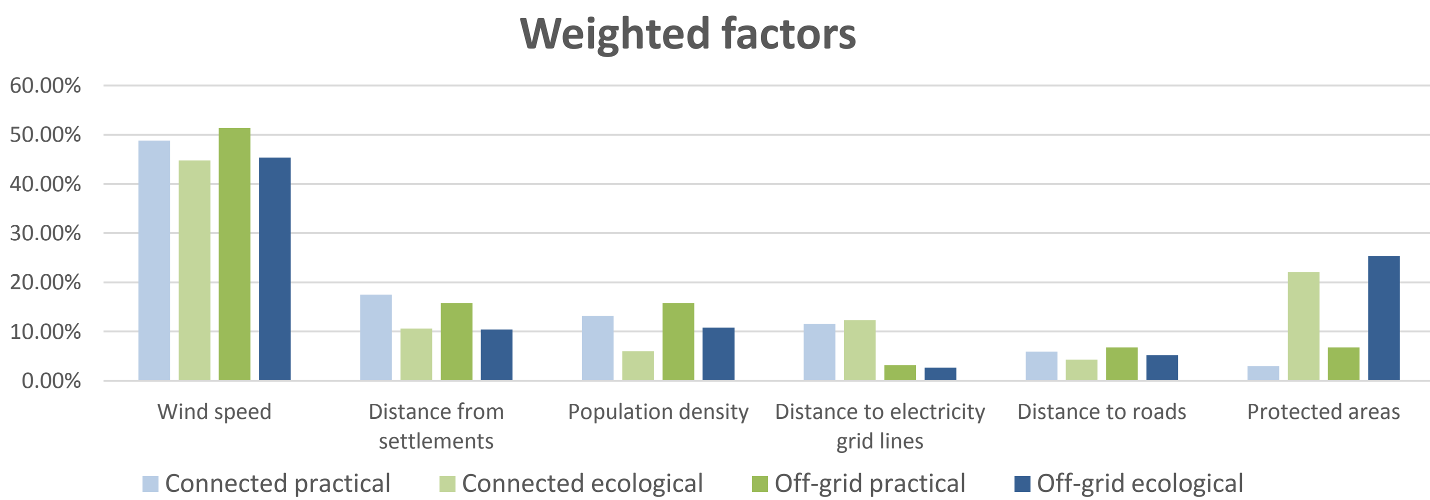
Factor	Off Grid	Connected to Grid
Wind speed	1: 4.5 -5.0 m/s	1: 4.5 -5.0 m/s
	2: 5.0-5.5 m/s	2: 5.0-5.5 m/s
	3: 5.5-6.0 m/s	3: 5.5-6.0 m/s
	4: > 6.0 m/s	4: > 6.0 m/s
Distance to electricity grid lines	1: < 1 km	1: > 30 km
	2: 1-5 km	2: 5-30 km
	3: 5-30 km	3: 1-5 km
	4: > 30 km	4: < 1 km
Distance to roads	1: > 5 km	1: > 5 km
	2: 3-5 km	2: 3-5 km
	3: 1-3 km	3: 1-3 km
	4: < 1 km	4: < 1 km
Population density	1: 0 inhabitants /km^2	1: > 500 inhabitants /km^2
	2: 1-100 inhabitants /km^2	2: 100-500 inhabitants /km^2
	3: 100-500 inhabitants /km^2	3: 1-100 inhabitants /km^2
	4: >500 inhabitants /km	4: 0 inhabitants /km^2
Distance from settlements	1: < 1 km	1: < 1 km
	2: 1-3 km	2: 1-3 km
	3: 3-5 km	3: 3-5 km
	4: > 30 km	4: > 30 km
Protected areas	1: < 1 km	1: < 1 km
	2: 1-3 km	2: 1-3 km
	3: 3-5 km	3: 3-5 km
	4: > 30 km	4: > 30 km

3a) Scenarios

	Off Grid	Connected to Grid
Ecological	Installation NOT connected to the electrical grid, environmental impacts minimized	Installation connected to the electrical grid, environmental impacts minimized
Practical	Installation NOT connected to the electrical grid, ease of installation maximized	Installation connected to the electrical grid, ease of installation maximized

3b) Factor weights (% of importance) for each factor

Factor	Conn_pract	Conn_eco	Offgrid_pract	Offgrid_eco
Wind speed	48.8%	44.8%	51.4%	45.4
Distance to electricity grid lines	11.6%	12.3%	3.2%	2.7%
Distance to roads	5.9%	4.3%	6.8%	5.2%
Population density	13.2%	6.0%	15.8%	10.8%
Distance from settlements	17.5%	10.6%	15.8%	10.4%
Protected areas	3.0%	22.1%	6.8%	25.4%

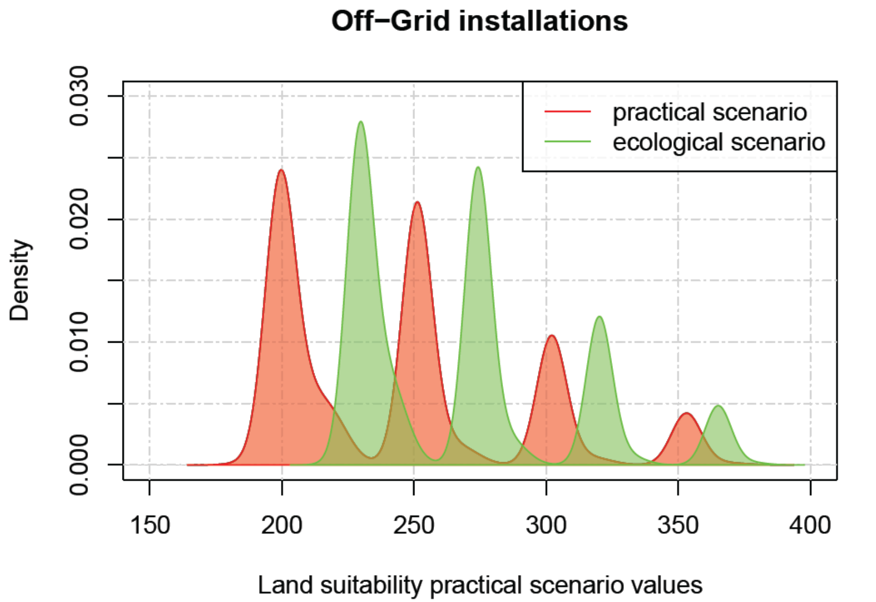


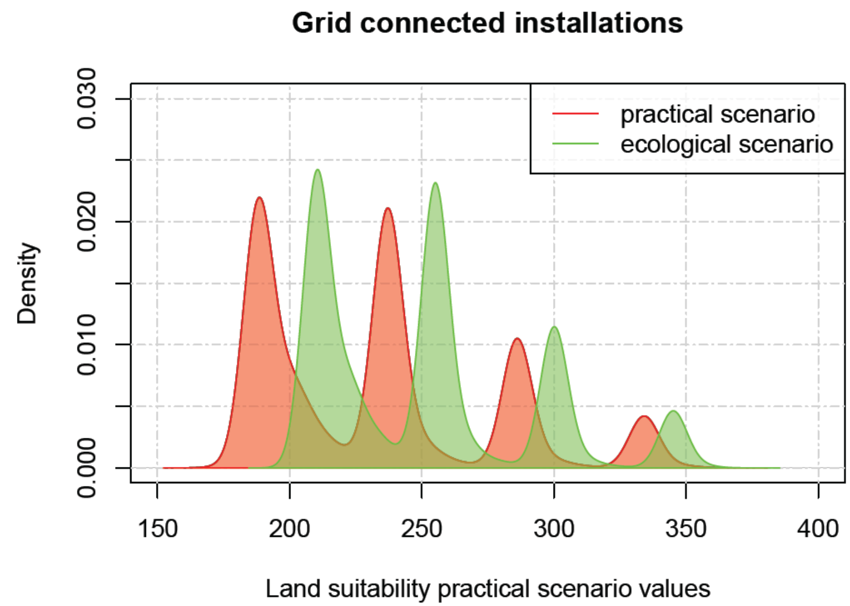
4) Suitability per cell

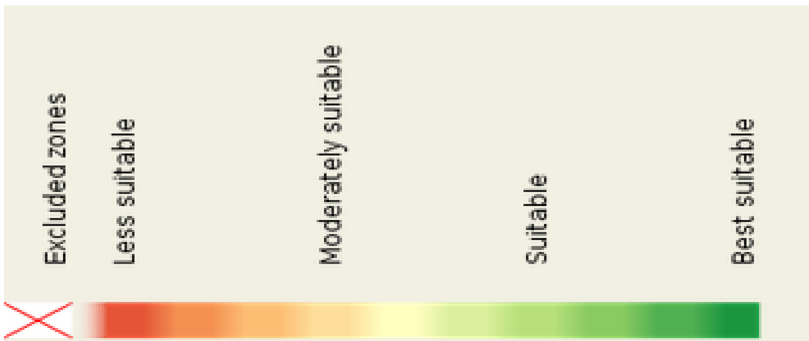
Finally, the suitability for each cell will be done by the sum of the scores of each of the six factors multiplied by the corresponding relative importance, as shown in the following equation.

$$\mathbf{SuitabilityCell}\boldsymbol{n}_{(\boldsymbol{xy})} = \sum_{n=1}^{6} \left(\mathrm{FactorClassCell}n_{(xy)} * \ \mathrm{FactorWeightCell}n_{(xy)}\right) /\ 100$$

5) Classification







Results on land suitability presented in this section were classified according a continuous qualitative scale ranging from 150 to 380.

Values close to 150 are considered as Less suitable, while those approaching the maximum value as Best suitable.

The amount of power that a turbine generates depends on the wind availability (proportion of the time that the turbine is available to produce power, including those periods when the turbine is on standby during calm and very high winds).

As the only parameter available is average wind speed, **wind potential cannot be estimated.**

Limitations (solar and wind)

- Legal constraints not included: eg constructible area, military zone etc..
- Lack of information about infrastructures
- overestimation of protected areas
- There is no data on solar generation potential in Cape Verde as solar irradiance datasets do not include data on this location
- No economic constraints
- some CSP technologies require water for cooling Therefore, it might be useful to integrate proximity and availability to water resources as an additional weighted factor.
- Global data may be imprecise…
- the present study is made on a regional scale. For actual implementation of solar power projects, a detailed analysis based on high resolution spatial data, and other types of local data is needed.

More considerations

The applied methodology should be taken into account while interpreting the results of the present study.

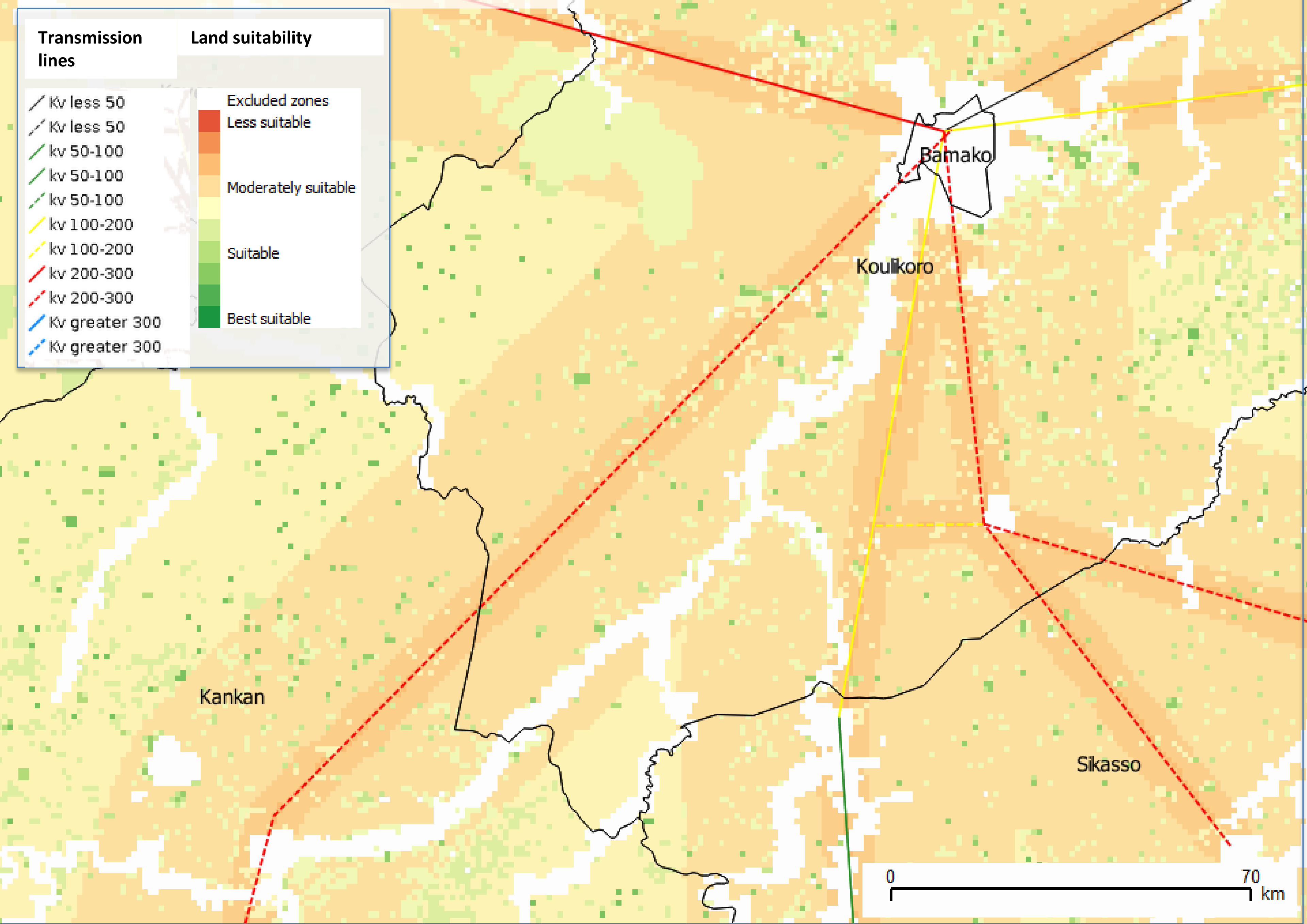
The preference of one wind scenario over another should depend on the objectives of the evaluator. A greater vision could be obtained if the results of the various scenarios are evaluated together. It would be also preferable to analyze these results together with electricity grid expansion planning data.

The results should be treated with caution in regards to data quality, and hypotheses used. For example, in evaluation of technical scenarios, a preference is given to locations which are situated along roads. In practice, as the road width is tiny compared to the size of the reference grid used, and as the wind infrastructures cannot be built on or near by roads, it tends to overestimate area identified as suitable.

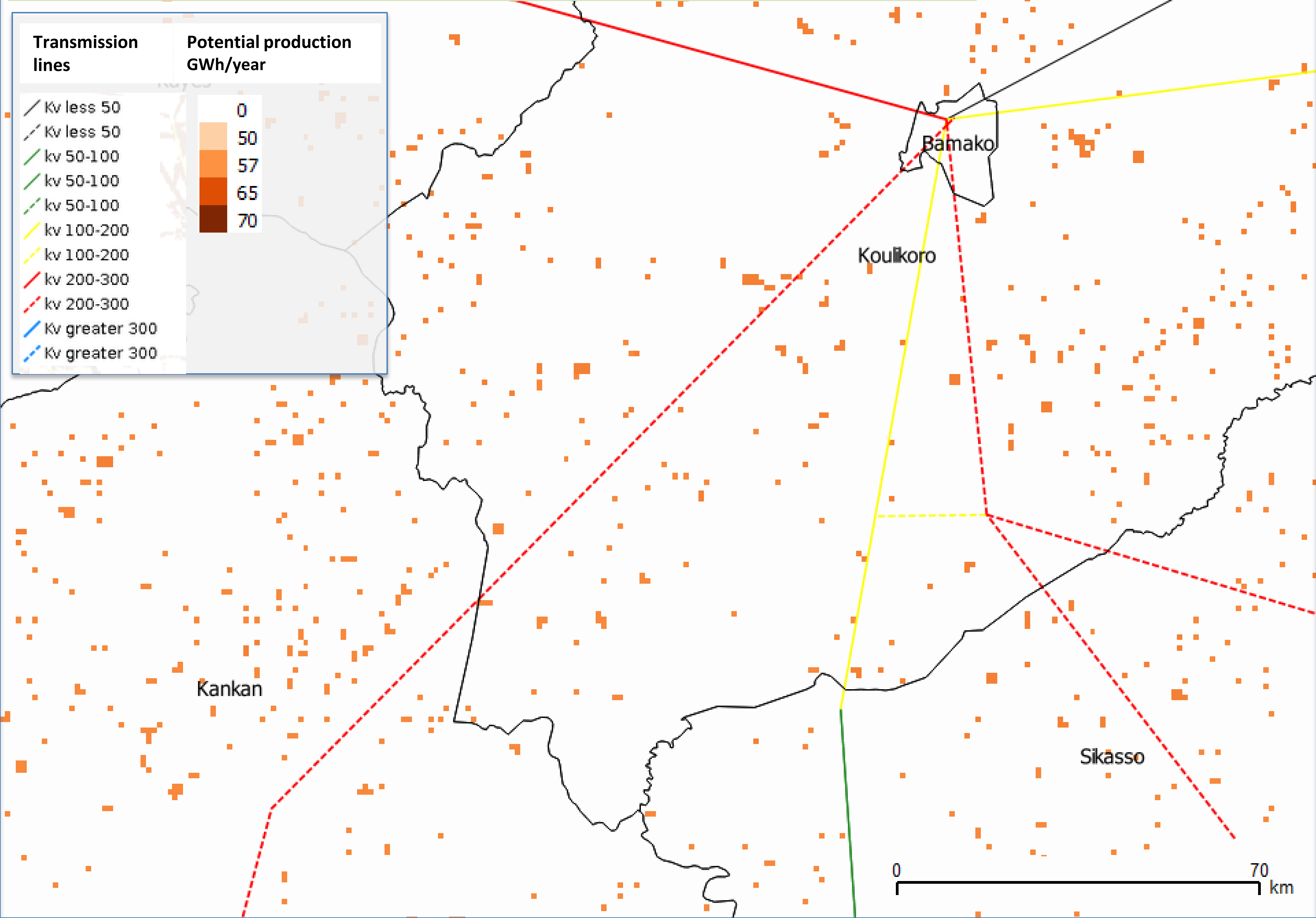
In grid connected scenarios, a preference is given to locations which are situated near from the electricity grid lines. In practice, close distance to the grid is not a guarantee of connection (for example, in the case of a small village situated close to a high voltage electricity grid-line).

2.3 Benefits of maps / demonstration of maps usability

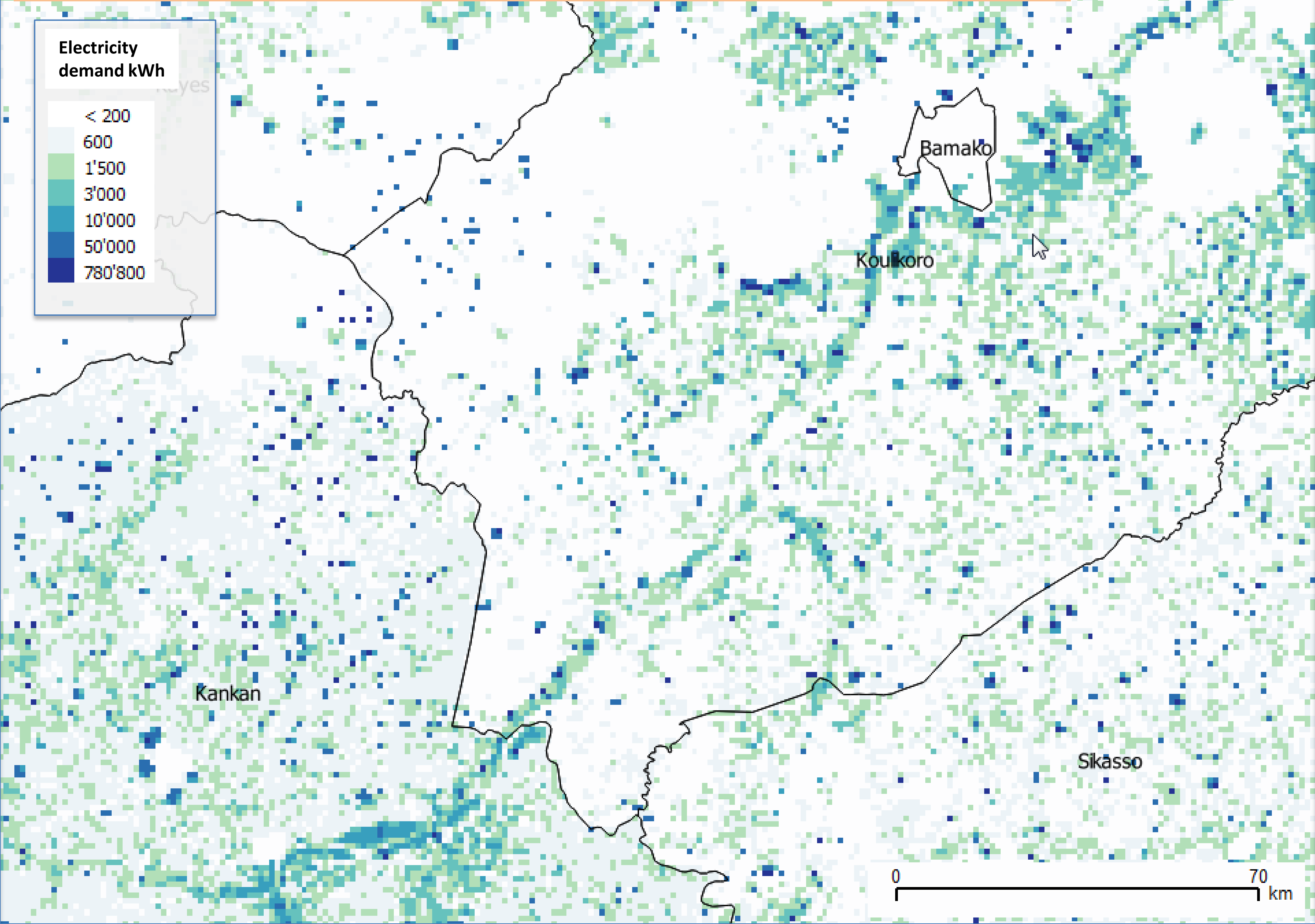
Land suitability classes PV Off-Grid

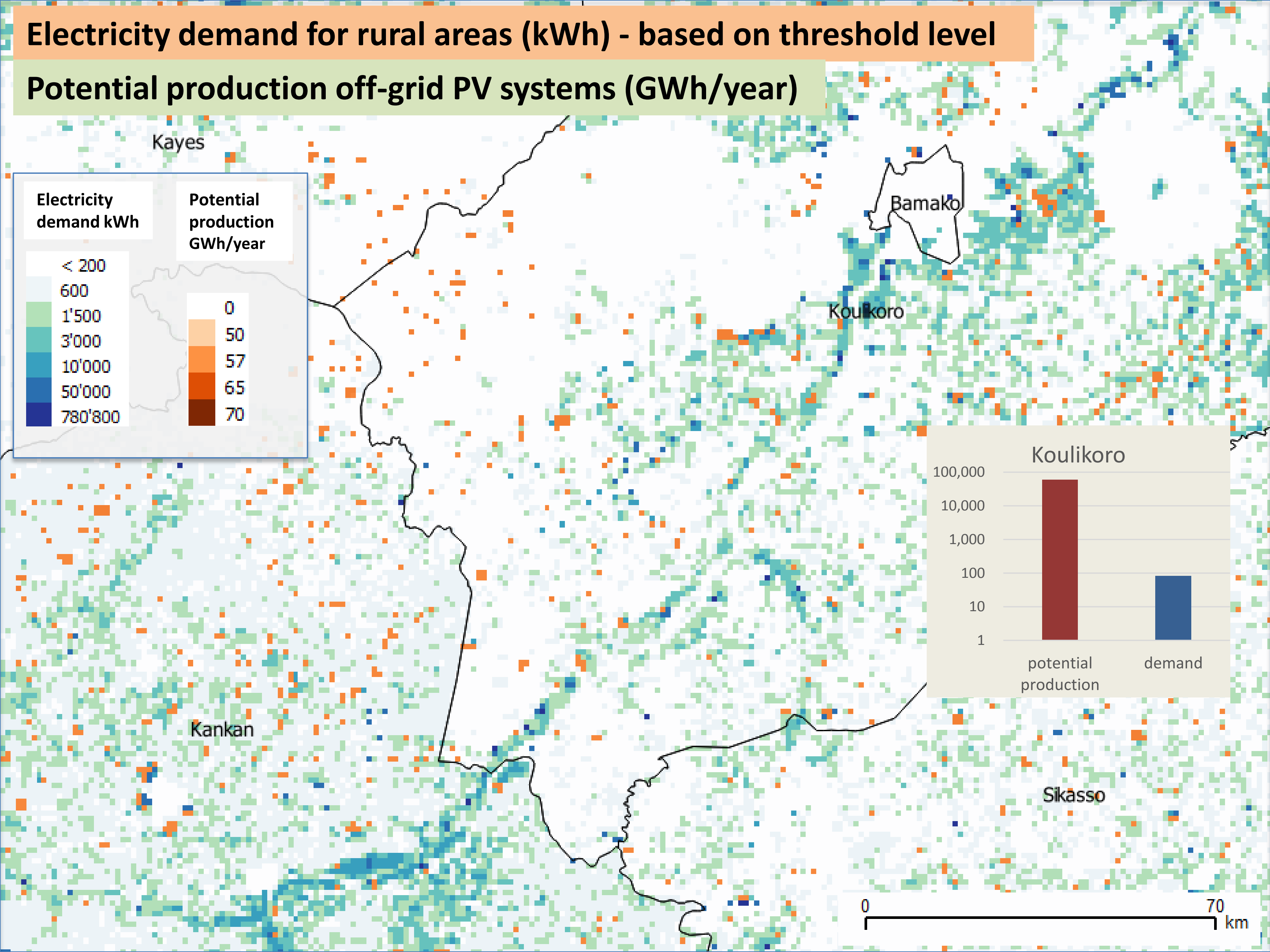


Potential production off-grid PV systems (GWh/year)



Electricity demand for rural areas (kWh) - based on threshold level

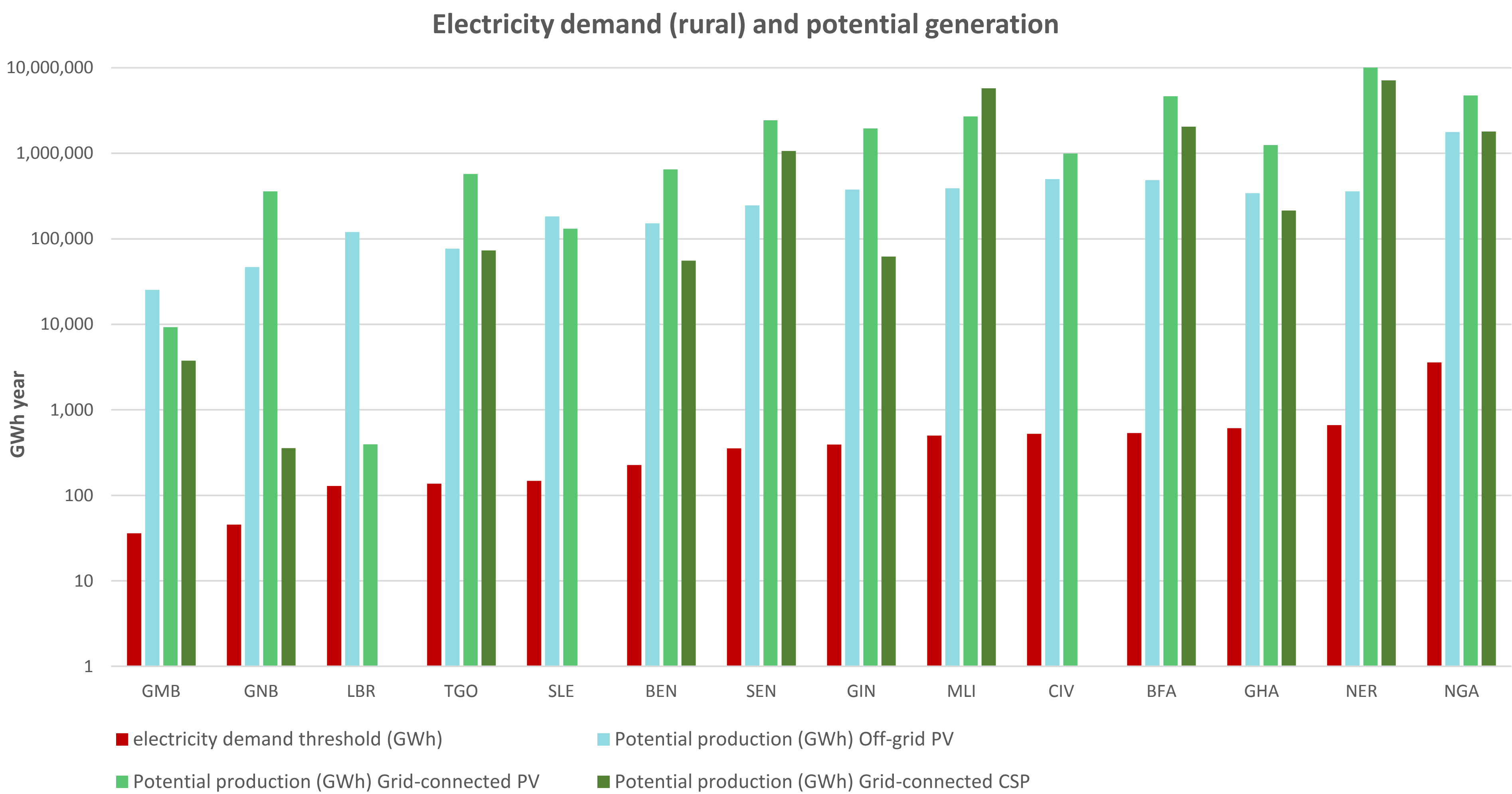




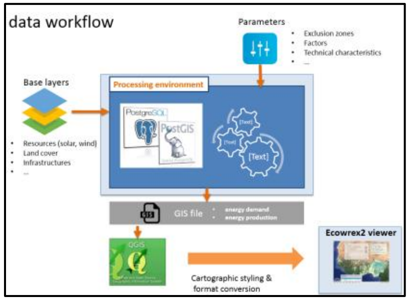
Electricity demand for rural areas (kWh) - based on threshold level
Potential production off-grid PV systems (GWh/year)
Kayes
Bamako
Koulikoro
Kankan
Sikasso
Electricity demand kWh
< 200
600
1'500
3'000
10'000
50'000
780'800
Potential production GWh/year
0
50
57
65
70
Koulikoro
100,000
10,000
1,000
100
10
1
potential production
demand
0
70
km

Benefits of maps National/sub-national statistics

National



2.4 Future perspectives



Data flow

The whole process, which allowed to create new maps (demand, suitability, technical potential) , took place in an open source environment (PostGIS & QGis).

All inputs parameters (such as excluded zones) can be modified by the operator.
Currently the application runs locally and access is not user friendly.

Future improvements may include:

- Transfer the application on a server accessible from the exterior.
- Improve the code in order to provide access for registered users, with the possibility to change the input parameters, data and algorithms

Data quality

unfortunately it was not possible to use national data from the individual countries, certainly more detailed, appropriate and well-accepted
once collected enough data from countries, it will be extremely useful to develop new products using these data…

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Thank you

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