KTH Department of Energy Technology

Division of Energy
Systems Analysis

WORLD BANK GROUP

Afghanistan Energy Study

Introduction to basic GIS concepts

Prepared by:
KTH-dESA

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Outline

1. What is GIS and why is it useful in energy planning?
2. GIS software options
3. Basic GIS concepts in energy planning
4. Data acquisition
5. Data creation and manipulation
6. Introduction to python and GIS
7. OnSSET dataset preparation

What is GIS and why is it useful?

A **G**eographic **I**nformation **S**ystem (**GIS**) is an integrated set of hardware and software tools, designed to capture, store, manipulate, analyse, manage, and digitally present spatial (or geographic) data and related attribute information.

GIS can relate information from different sources, using two key index variables space (or location) and time.

What is GIS and why is it useful?

Conventional long-term energy models such as OSeMOSYS, TIMES, MESSAGE etc. fail to take into account the spatio-temporal fluctuations of energy resources and demand side.

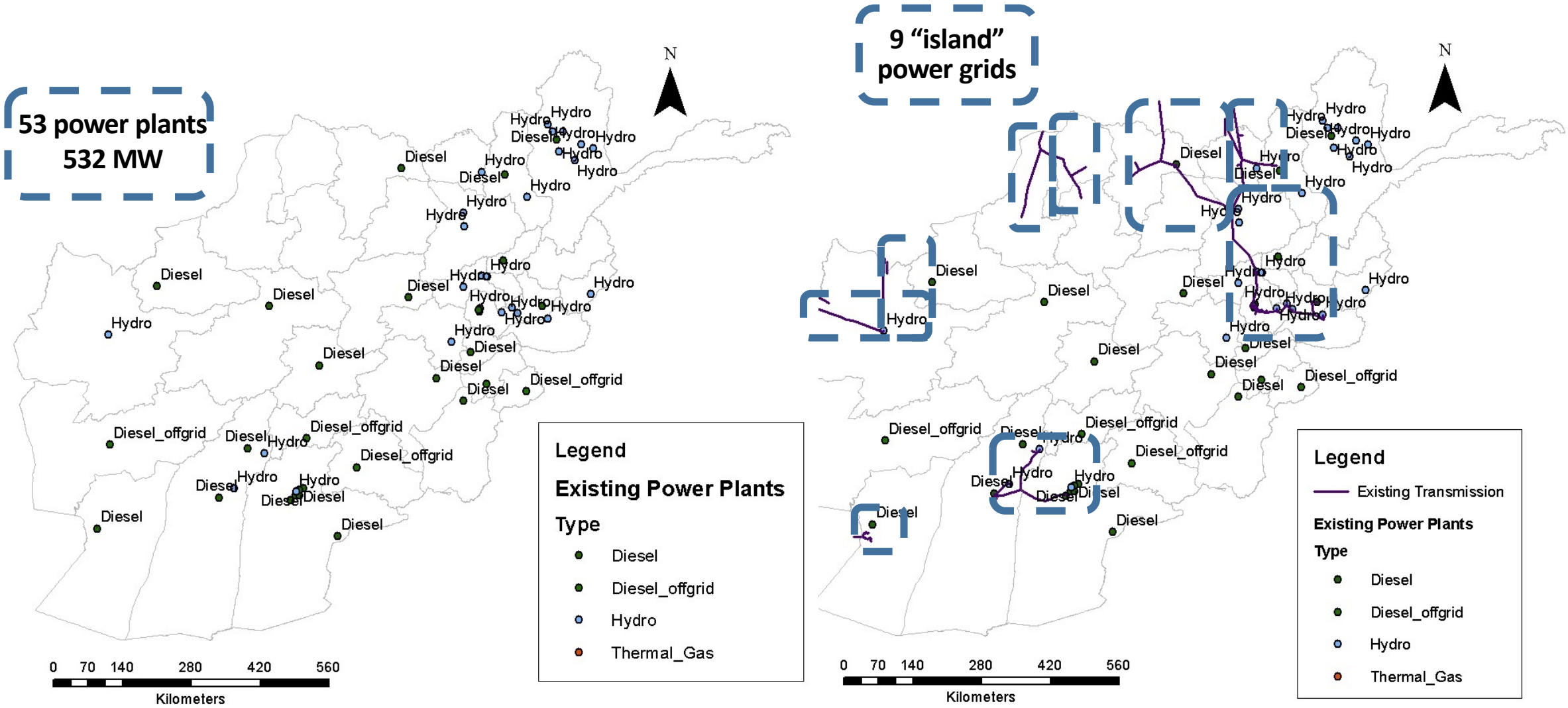
- To illustrate, the wind speed varies in time and space and so does the potential wind energy yield. The same applies to other energy sources with stochastic nature.
- Also, the power infrastructure differs from one area to another and so does the demand.
- Without GIS models, these details which are essential in energy planning cannot be captured.

What is GIS and why is it useful?

The use of GIS serves multiple purposes:

Location based assessments: GIS tools enable assessments to analyse energy related geospatial information.

Preparation of the model - Infrastructure



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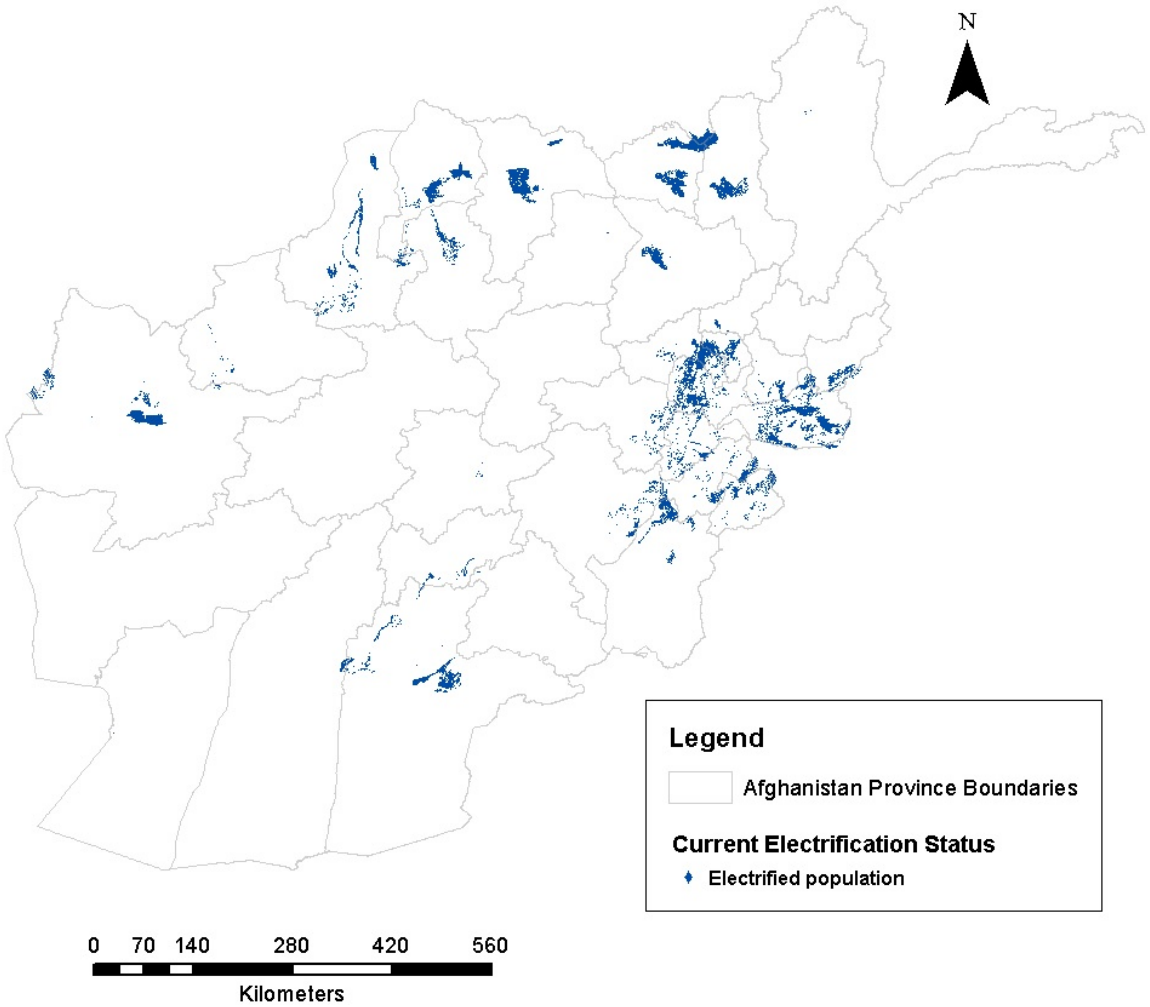

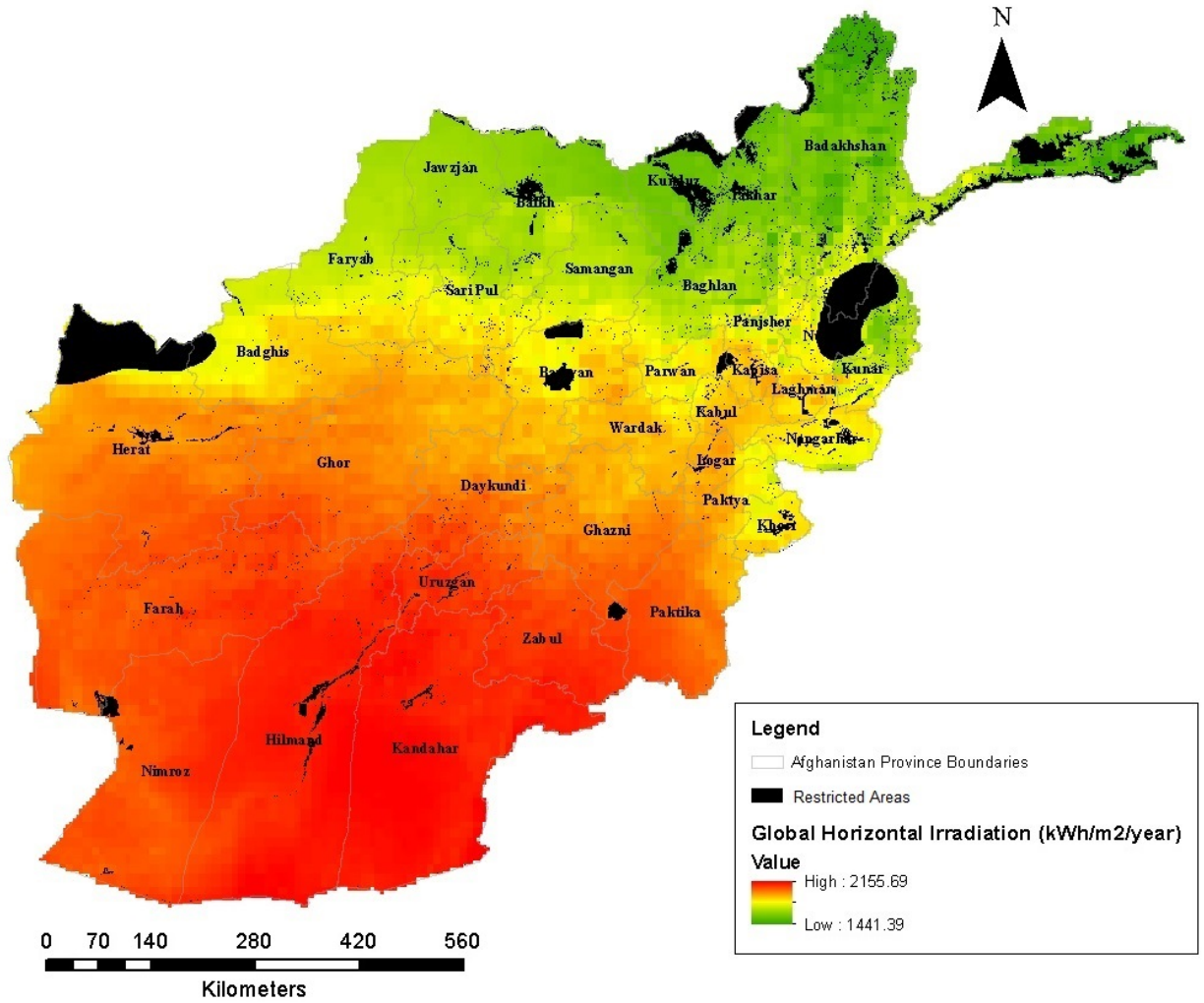

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Illustration of results: GIS is used to illustrate results in interactive maps, providing an effective science – policy interface.

GIS software options

Open Source Software – Desktop based tools

- QGIS (Quantum GIS)
- GRASS GIS
- SAGA GIS

…and many more

Open Source Software – Web based tools
(Open Street Maps)

Mapnik

…and many more

Commercial Software – Desktop based tools

- Autodesk - AutoCAD
- **ESRI – ArcGIS**

…and many more

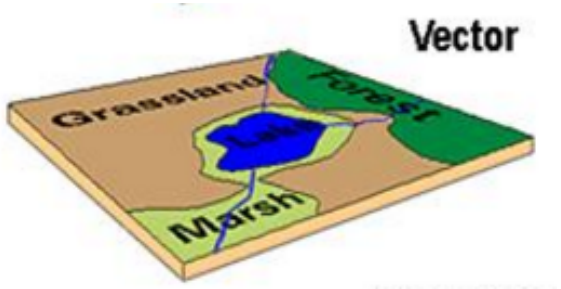
Choose according to your needs!

Basic GIS concepts of energy planning

Common Data types (models)

Spatial Data: Describe the absolute and relative location of geographic features.

Vectors

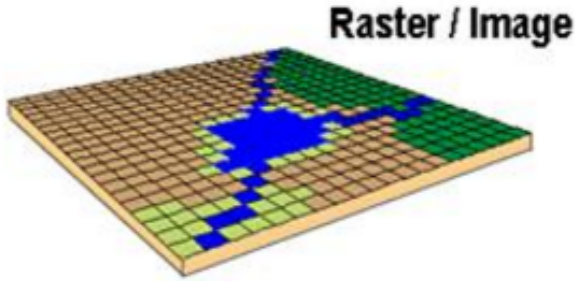


Arcs (Polylines): Line segments forming individual linear features

Polygons: Areas enclosed by arcs

Points: Single coordinate pairs

Rasters



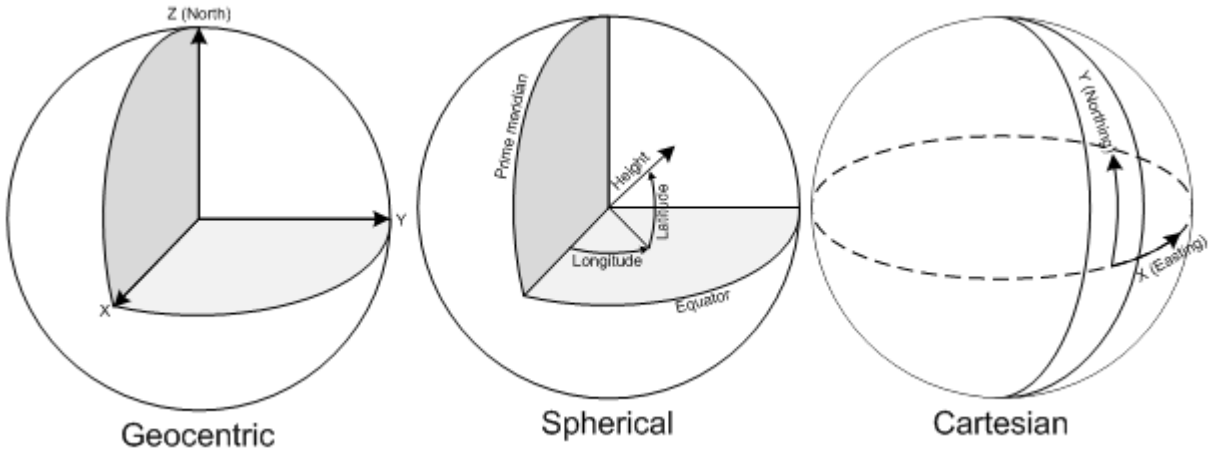
Grid-Cells: single column/row positions

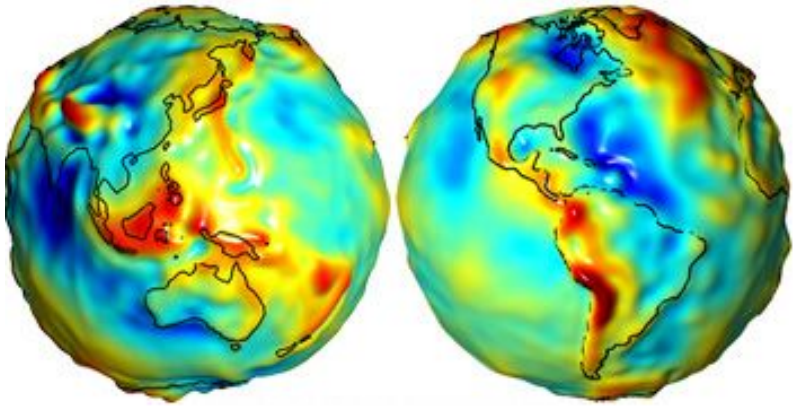
Cell size: Resolution or else the accuracy of the data

Attribute data: Describe characteristics of the spatial features. These characteristics can be quantitative and/or qualitative in nature. Attribute data is often referred to as tabular data.

Basic GIS concepts of energy planning

Ellipsoid, Datum & Geographic Coordinate System





Coordinate System: Simply put, it is a way of describing a spatial property relative to a center

Datum: The center and orientation of the ellipsoid

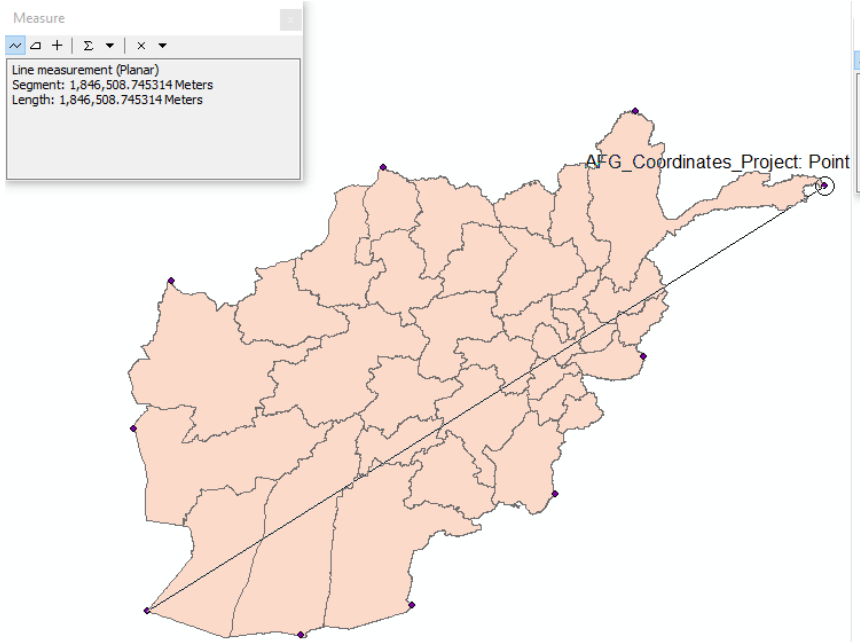
World Geodetic Datum 1984 (WGS84)

Basic GIS concepts of energy planning

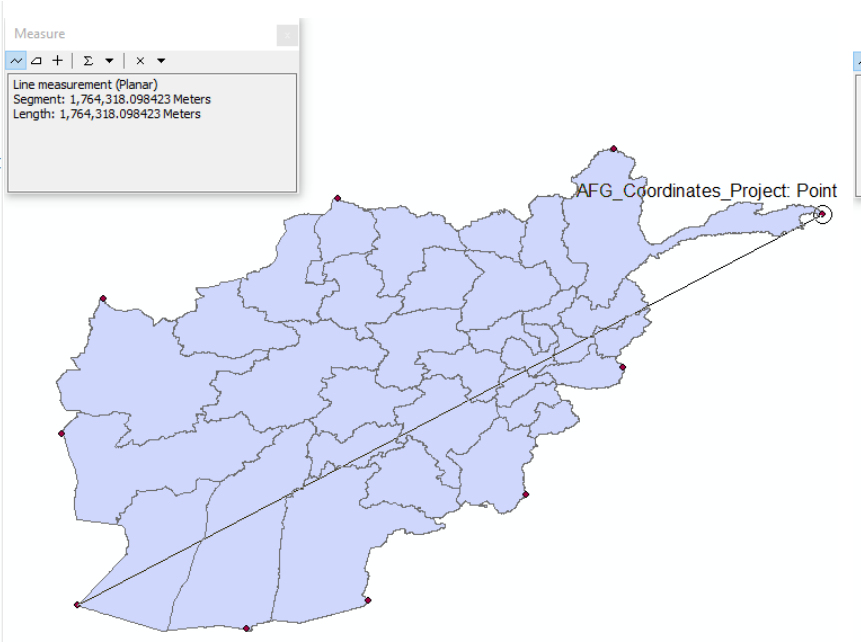
Projected Coordinate System & Spatial Reference

Projection is the systematic transformation of the **latitude** and **longitude** of a location into a pair of two dimensional coordinates or else the position of this location on a plane (flat) surface.

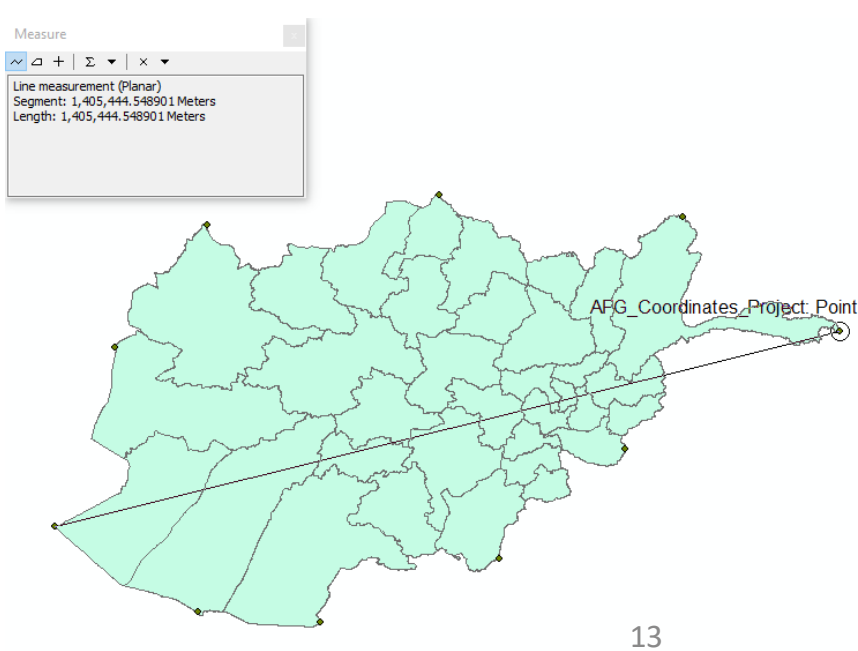
A projection is necessary every time a map is created and **all map projections distort the surface in some fashion**.



WGS 1984 World Mercator



World Equidistant Cylindrical (Sphere)



Asia North Lambert Conformal Conic

Basic GIS concepts of energy planning

List of datasets used in OnSSET analysis

#	Dataset	Type
1	Population density & distribution	Raster
2	Admin boundary level 0	Raster
3	Admin boundary level 1	Raster
4	Roads	Line shapefile
5	Substations	Point Shapefile
6	Existing grid network	Line shapefile
7	Planned grid network	Line shapefile
8	Solar Restrictions	Raster

#	Dataset	Type
9	Nighttime lights	Raster
10	GHI	Raster
11	Wind speed	Raster
12	Hydro power potential	Point shapefile
13	Travel time	Raster
14	Elevation Map	Raster
15	Slope	Raster
16	Land Cover	Raster

GIS data requirements may vary depending on the objective of the electrification study

Data acquisition

Setting up the GIS environment

1. Create a folder on your Desktop named OnSSET_model
2. Open ArcGIS and create a new map
3. Right click to layers → Properties → Coordinate system → Geographic Coordinate Systems → World → WGS 1984
4. Go to Catalog → Connect to folder
5. Insert one by one the layers required for the analysis

Data acquisition

Examples – Basic functions – Projection

Polygons

Layer:
Administrative Boundaries level 0 – level 1

Source:
http://www.gadm.org/country

1. Download data in main folder
2. Insert data in the map as a new layer
3. Convert feature to raster

Lines

Layer:
Road network

Source:
https://energydata.info/

1. Download data in main folder
2. Check attribute table and create two sub-layers of primary and secondary roads
3. Project data using the WGS 1984 World Mercator system

Points

Layer:
Mineral Resources

Source:
https://mrdata.usgs.gov/general/global.html

1. Download data in main folder as csv
2. Insert data as a layer using Add XY data..
3. Clip only the points that belong to Afghanistan
4. Export data as shapefile in the folder

Raster

Layer:
Population Asia

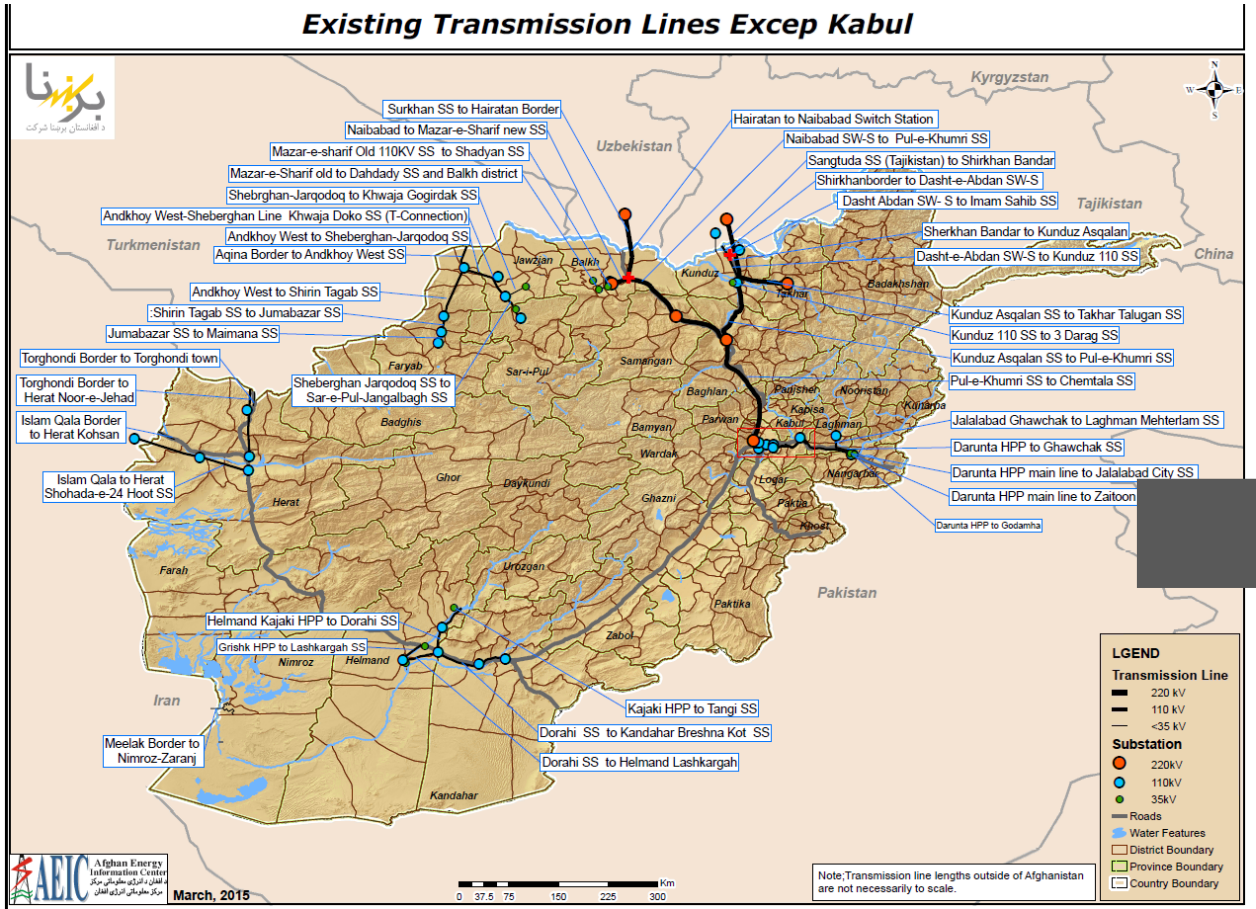
Source:
http://www.worldpop.org.uk/

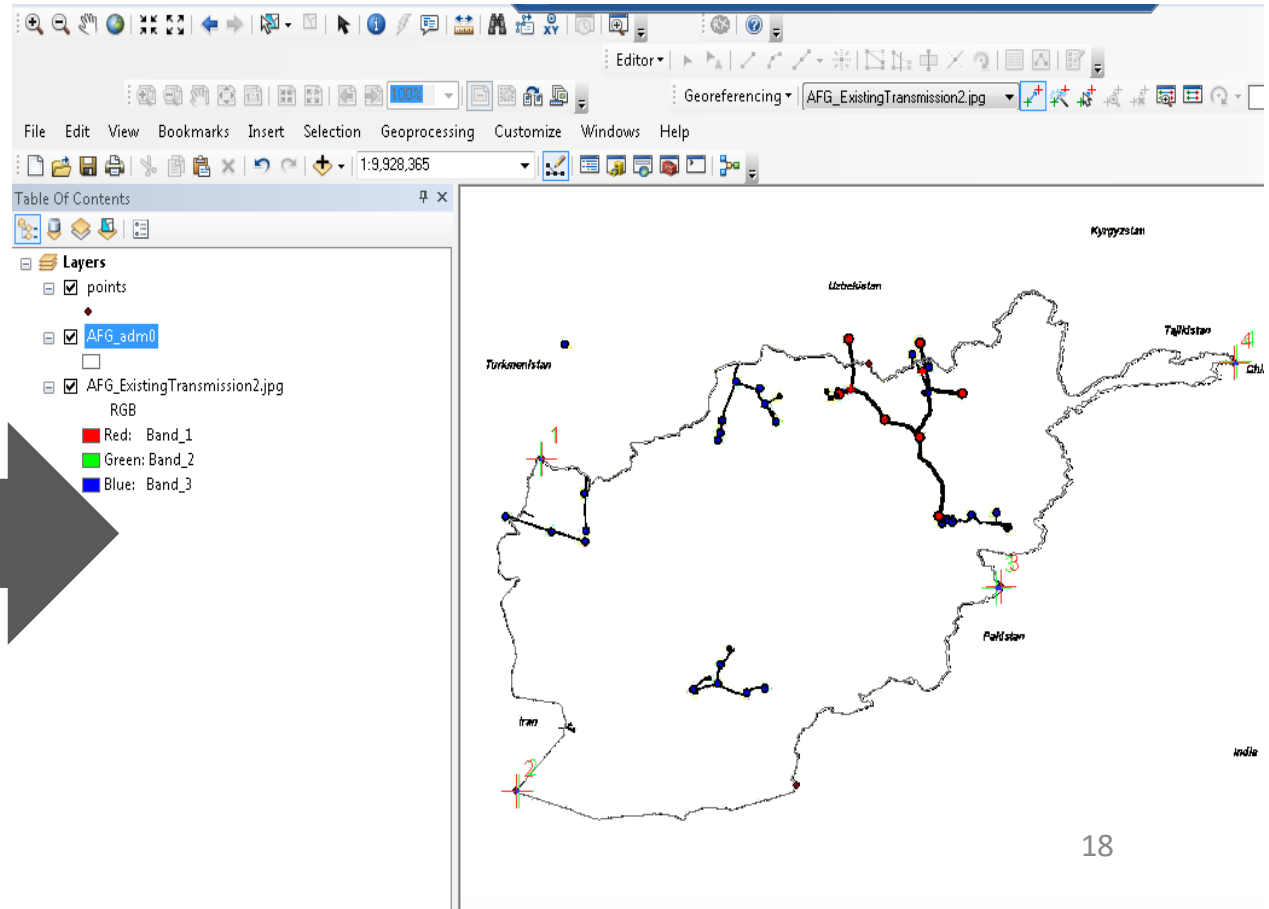
1. Download data
2. Use Extract by mask function to keep data only for Afghanistan
3. Project data using the WGS 1984 World Mercator system

Data creation-manipulation

Digitization

How to transform a pdf or jpeg to a digitized map in GIS for further processing





OnSSET dataset preparation

Creating and populating a geo-database

Step 1. Secure that you have all the 16 datasets required as layers onto your map (the geographic coordinate systems should be WGS84).

Step 2. Project every single layer using the WGS 1984 World Mercator system

Step 3. Create and populate a geo-database with all the layers needed and the correct naming convention.

Refer to the instruction sheet for a step by step explanation of the process

OnSSET dataset preparation

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Step 4. Use GIS functions and tools to assign a number of important attributes to every single settlement (please note the spatial resolution at the starting point).

Use the GIS Commands for processing file provided by KTH dESA

Introduction to python and GIS

What is python?

Python in an open source – object oriented – programming language that is nowadays used in multiple applications and various sectors.

Why using python?

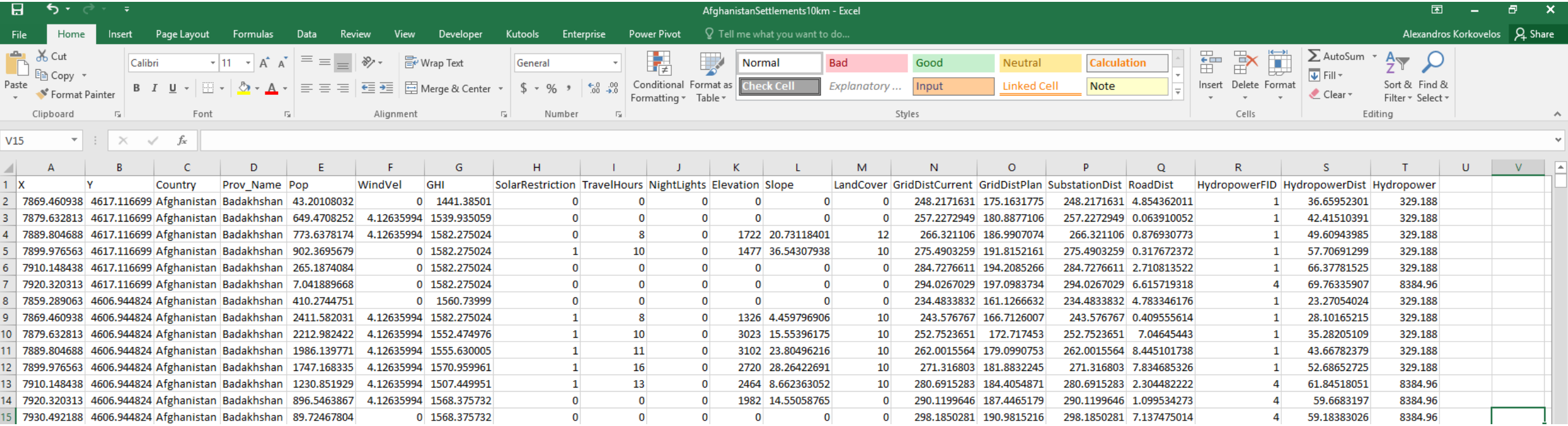
- Python in open source
- Is easy to learn
- Large number of resources are available (and growing)
- Supports multiple systems and platforms (e.g. ArcGIS, QGIS)

Python and GIS what do I need to know?

- ArcGIS uses a python interface to automate processes (python v. 2.7..)
- Important module – arcpy
- Every tool in ArcGIS provides a corresponding python syntax example
- Auto-complete function when typing is clear and useful

OnSSET dataset preparation

Creating the final csv file



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	X	Y	Country	Prov_Name	Pop	WindVel	GHI	SolarRestriction	TravelHours	NightLights	Elevation	Slope	LandCover	GridDistCurrent	GridDistPlan	SubstationDist	RoadDist	HydropowerFID	HydropowerDist	Hydropower		
2	7869.460938	4617.116699	Afghanistan	Badakhshan	43.20108032	0	1441.38501	0	0	0	0	0	0	248.2171631	175.1631775	248.2171631	4.854362011	1	36.65952301	329.188		
3	7879.632813	4617.116699	Afghanistan	Badakhshan	649.4708252	4.12635994	1539.935059	0	0	0	0	0	0	257.2272949	180.8877106	257.2272949	0.063910052	1	42.41510391	329.188		
4	7889.804688	4617.116699	Afghanistan	Badakhshan	773.6378174	4.12635994	1582.275024	0	8	0	1722	20.73118401	12	266.321106	186.9907074	266.321106	0.876930773	1	49.60943985	329.188		
5	7899.976563	4617.116699	Afghanistan	Badakhshan	902.3695679	0	1582.275024	1	10	0	1477	36.54307938	10	275.4903259	191.8152161	275.4903259	0.317672372	1	57.70691299	329.188		
6	7910.148438	4617.116699	Afghanistan	Badakhshan	265.1874084	0	1582.275024	0	0	0	0	0	0	284.7276611	194.2085266	284.7276611	2.710813522	1	66.37781525	329.188		
7	7920.320313	4617.116699	Afghanistan	Badakhshan	7.041889668	0	1582.275024	0	0	0	0	0	0	294.0267029	197.0983734	294.0267029	6.615719318	4	69.76335907	8384.96		
8	7859.289063	4606.944824	Afghanistan	Badakhshan	410.2744751	0	1560.73999	0	0	0	0	0	0	234.4833832	161.1266632	234.4833832	4.783346176	1	23.27054024	329.188		
9	7869.460938	4606.944824	Afghanistan	Badakhshan	2411.582031	4.12635994	1582.275024	1	8	0	1326	4.459796906	10	243.576767	166.7126007	243.576767	0.409555614	1	28.10165215	329.188		
10	7879.632813	4606.944824	Afghanistan	Badakhshan	2212.982422	4.12635994	1552.474976	1	10	0	3023	15.55396175	10	252.7523651	172.717453	252.7523651	7.04645443	1	35.28205109	329.188		
11	7889.804688	4606.944824	Afghanistan	Badakhshan	1986.139771	4.12635994	1555.630005	1	11	0	3102	23.80496216	10	262.0015564	179.0990753	262.0015564	8.445101738	1	43.66782379	329.188		
12	7899.976563	4606.944824	Afghanistan	Badakhshan	1747.168335	4.12635994	1570.959961	1	16	0	2720	28.26422691	10	271.316803	181.8832245	271.316803	7.834685326	1	52.68652725	329.188		
13	7910.148438	4606.944824	Afghanistan	Badakhshan	1230.851929	4.12635994	1507.449951	1	13	0	2464	8.662363052	10	280.6915283	184.4054871	280.6915283	2.304482222	4	61.84518051	8384.96		
14	7920.320313	4606.944824	Afghanistan	Badakhshan	896.5463867	4.12635994	1568.375732	0	0	0	1982	14.55058765	0	290.1199646	187.4465179	290.1199646	1.099534273	4	59.6683197	8384.96		
15	7930.492188	4606.944824	Afghanistan	Badakhshan	89.72467804	0	1568.375732	0	0	0	0	0	0	298.1850281	190.9815216	298.1850281	7.137475014	4	59.18383026	8384.96		

The output of the process will be a dbf file. Excel can be used to open this file and save it again as csv.

or

Use the CSV extraction - python - tool developed by KTH dESA! *#OnSSET_GIS_Tool*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