

Wind Resource Mapping in Pakistan

SITE IDENTIFICATION REPORT

FEBRUARY 2016



This report was prepared by [3E](#), under contract to [The World Bank](#).

It is one of several outputs from the wind **resource mapping component of the activity “Renewable Energy Resource Mapping and Geospatial Planning – Pakistan”** [Project ID: P146140]. This activity is funded and supported by the Energy Sector Management Assistance Program (ESMAP), a multi-donor trust fund administered by The World Bank, under a global initiative on Renewable Energy Resource Mapping. Further details on the initiative can be obtained from the [ESMAP website](#).

This report is an interim output from the above-mentioned project. Users are strongly advised to exercise caution when utilizing the information and data contained, as this has not been subject to validation using ground measurement data or peer review. The final output from this project will be a validated Pakistan Wind Atlas, which will be published once the project is completed.

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RENEWABLE ENERGY MAPPING: WIND - PAKISTAN

D1.5 CANDIDATE SITE IDENTIFICATION REPORT

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1 INTRODUCTION

In the framework of the wind mapping exercise for Pakistan, a mesoscale wind map has been calculated by the technical university of Denmark (DTU) (cf. Figure 1), which will be validated using data from several wind measurement masts to be installed throughout Pakistan.

The latest methodology developed at DTU Wind Energy uses the Weather Research and Forecasting (WRF) model in a dynamical downscaling mode to produce mesoscale analysis, and is used in this project.

Based on this preliminary wind mapping, DTU identified 10 areas where ground based wind measurement masts would be useful for the wind map validation (cf. Figure 1, blue areas), which are defined as follows:

- VR1: Southern Baluchistan
- VR2: Central Baluchistan - Quetta
- VR3: Southern Sindh - Karachi
- VR4: Northern Baluchistan
- VR5: Western Punjab - Dera Ghazi Khan
- VR6: Western Baluchistan
- VR7: Islamabad – Peshawar – Northern Punjab
- VR8: Northern Khyber Pakhtunkhwa and Baltistan (Northern mountains)
- VR9: Eastern Sindh
- VR10: Eastern Punjab - Bahawalpur

In parallel, the Alternative Energy Development Board of Pakistan (AEDB) identified potential areas for wind energy project developments, based on a previous wind map generated in 2006 by the National Renewable Energy Laboratory of the United States (NREL) (Figure 1, white areas).

Although the earlier NREL map is not as accurate as the new preliminary DTU map, we have observed that the areas identified by AEDB are most often overlapping with the areas from DTU, so that there would not be any need to choose between the areas.

AEDB also insisted that there should be available budget for additional masts from the 10 initial masts, which should be used in the framework of this study. 3E and their local partner SESI Pakistan have therefore looked for a list of potential sites longer than initially foreseen by the project.

The present report details the methodology for identification of wind measurement mast locations with the objective of validating the wind map from DTU.

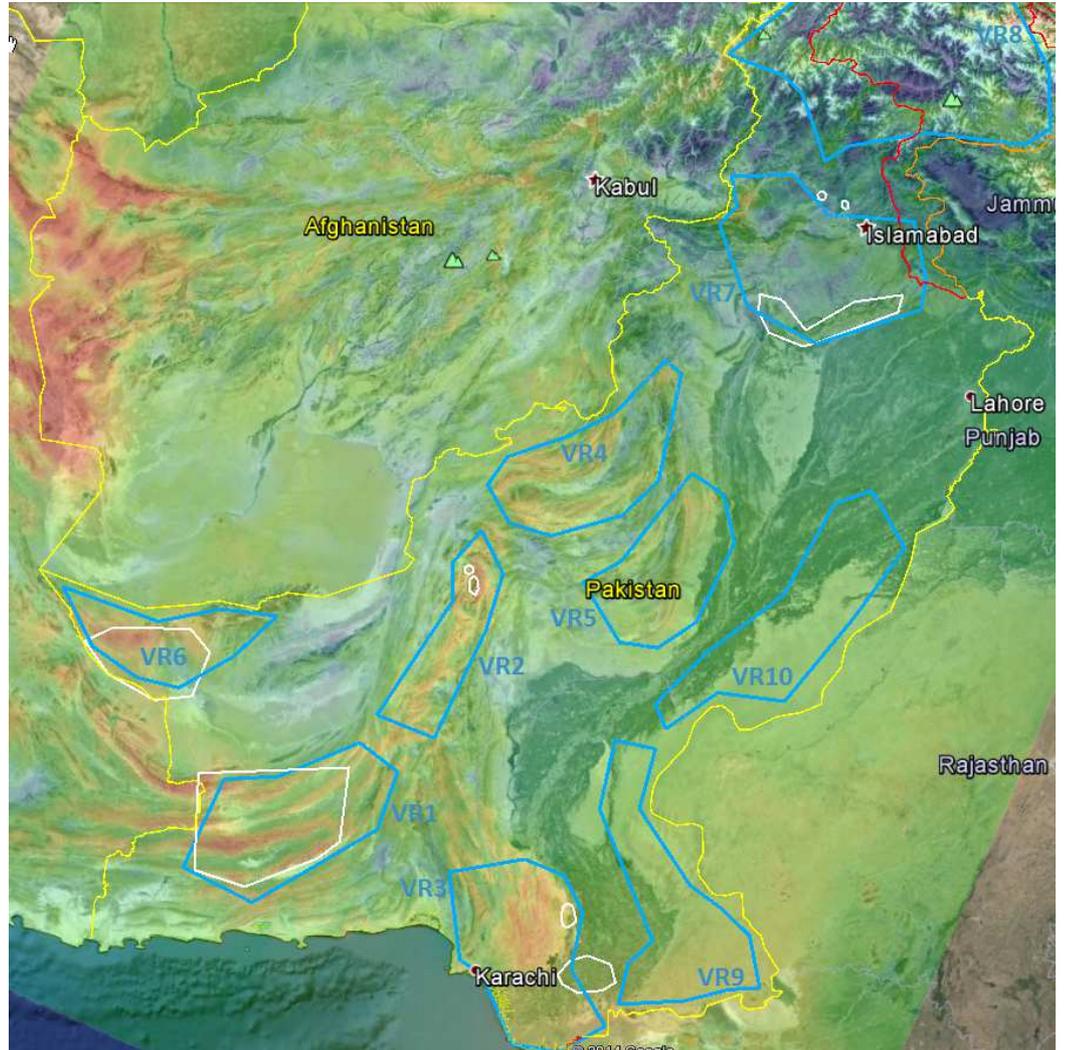


Figure 1: Validation areas identified by DTU for validation of the meso-scale wind map (blue areas named VR1 to VR10), and areas selected by AEDB based on 2006 NREL map (white areas). The background map is the wind map as calculated by DTU (warmer colours indicate higher expected wind speeds) in transparency above Google Earth image.

2 METHODOLOGY

In a first step, 3E gathered several available GIS data (Geographic Information System) of Pakistan from World Bank's database. GIS information covers cities, roads, railways, waterways, natural and protected areas, providing insight at country level, useful to identify suitable locations for the wind map validation.

In general for this type of study, the criteria used to select sites are the following:

- Well spread over the country - to capture as many potentially different wind regimes as possible.
- Accessible (road network, quality of the road), safe and secure
- GPRS coverage for data transmission
- Homogeneous in terms of terrain elevation - elevation differences less than 300m within a radius of 5 km if possible.
- Homogeneous in terms of roughness – not much changes of surface roughness (or land covers type) within a radius of 5 km if possible.
- Located inside or close to a region of interest for wind energy development:
 - High to moderate wind resource area
 - Close to electricity network and consumption center (electrical load)
 - Accessible for long trucks and heavy duty cranes.

Based on a desktop study, 3E identified potential sites within each of the zones identified by DTU, which were expected to be further assessed through site visits. This is presented in Section 4 (Desktop study).

Unfortunately, it was not possible to work this way as finding available land with clear ownership is a difficult task throughout Pakistan. To solve this problem, a more pragmatic approach was used: the local authorities were approached to help the team identifying suitable available land within the land owned by the government. This would also reduce the costs for land lease as government land would be free of use for met mast installation within the context of this World Bank Project.

In most cases, the team had to meet local authorities, explain the objective of site visits and the purpose of the study. After this first meeting, it was agreed that local authorities would bring the team to potential areas that were assessed in view of mast installation. This is the methodology that was finally used, and the sites that were identified this way are presented in Section 5.

In parallel, other potential sites with clear ownership have been identified on private land in various locations in the country and with specific focus in areas of interest as marked by AEDB and DTU.

The Northern mountainous areas (zone VR8) have been left aside for logistical reasons and because of the very complex orography within this area, limiting the validation procedure of the Atlas.

Many places in tribal areas and in Balochistan Province (zones VR1, VR2, VR4 and VR6) could also not be envisaged due to many security concerns at the time of the study. In Balochistan, only the area very close to Quetta was considered safe enough to ensure secure transportation of people and mast parts to site and to carry out 2 years of uninterrupted measurements.

3 GIS LAYERS

The following GIS layers were received from the World Bank:

- Tehsil (districts) boundaries
- Cities
- Roads
- Railways
- Waterways,
- Natural places,
- Buildings,
- Places.

Other information was also found on the Internet, like the general map, the orography map and the main electrical lines of the country.

Different layers/maps were combined, helping to identify regions of interest for the purpose of our project. The following maps are presented below:

- General map of Pakistan with province boundaries and important features
- Orography map
- Electrical network map
- Natural places and waterways map
- Roads network map
- Cities and railways map

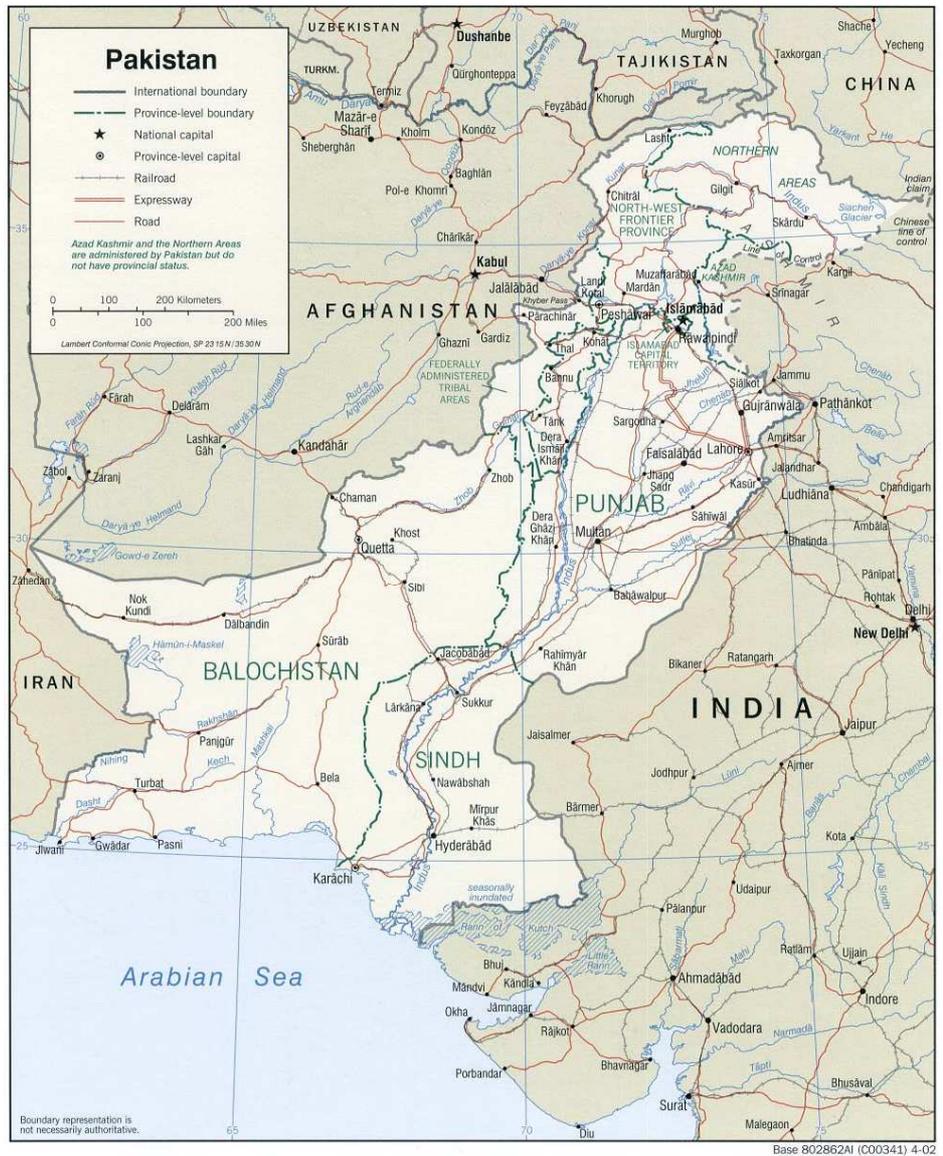


Figure 2: General map of Pakistan with province boundaries (Source: UTexas.edu)

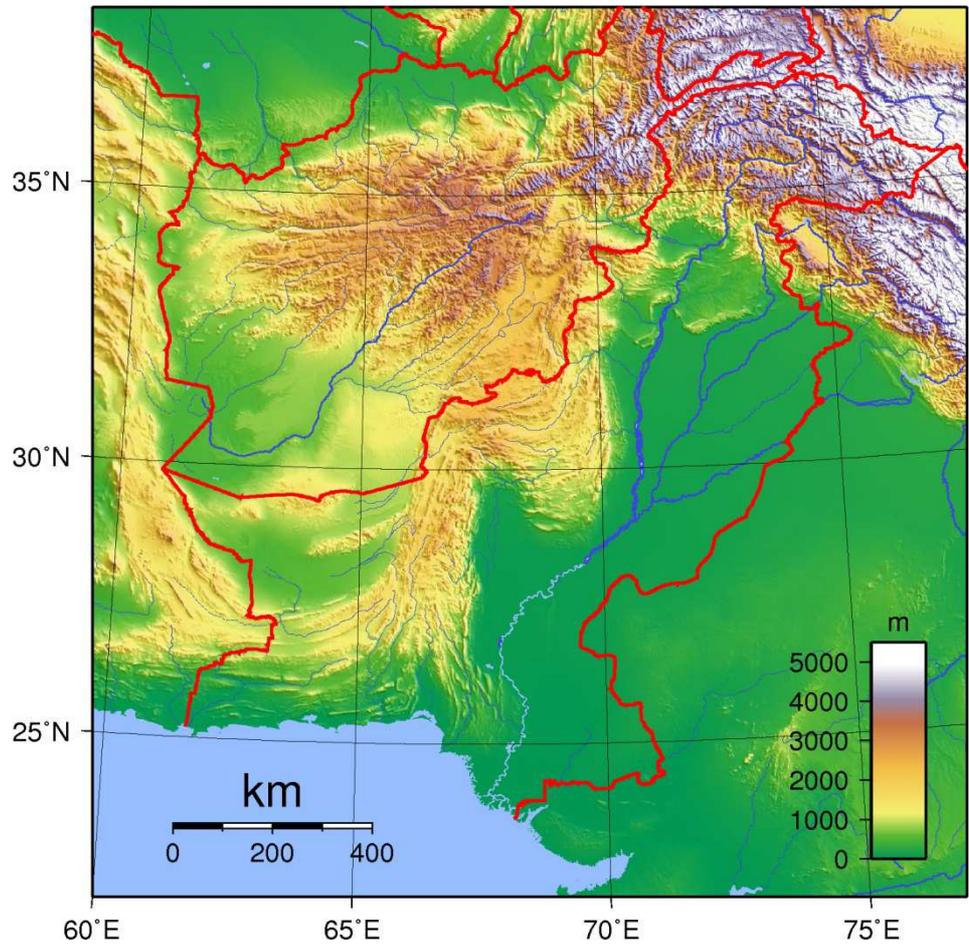


Figure 3: Orography map (Pakistan + Afghanistan; source: Graphatlas.com)



Figure 4: Electrical network map (source: Geni.org) [Important Note: The states of Jammu and Kashmir are disputed territories between India and Pakistan. The author does not take sides in this dispute, and only wishes to show transmission grids in Pakistan].

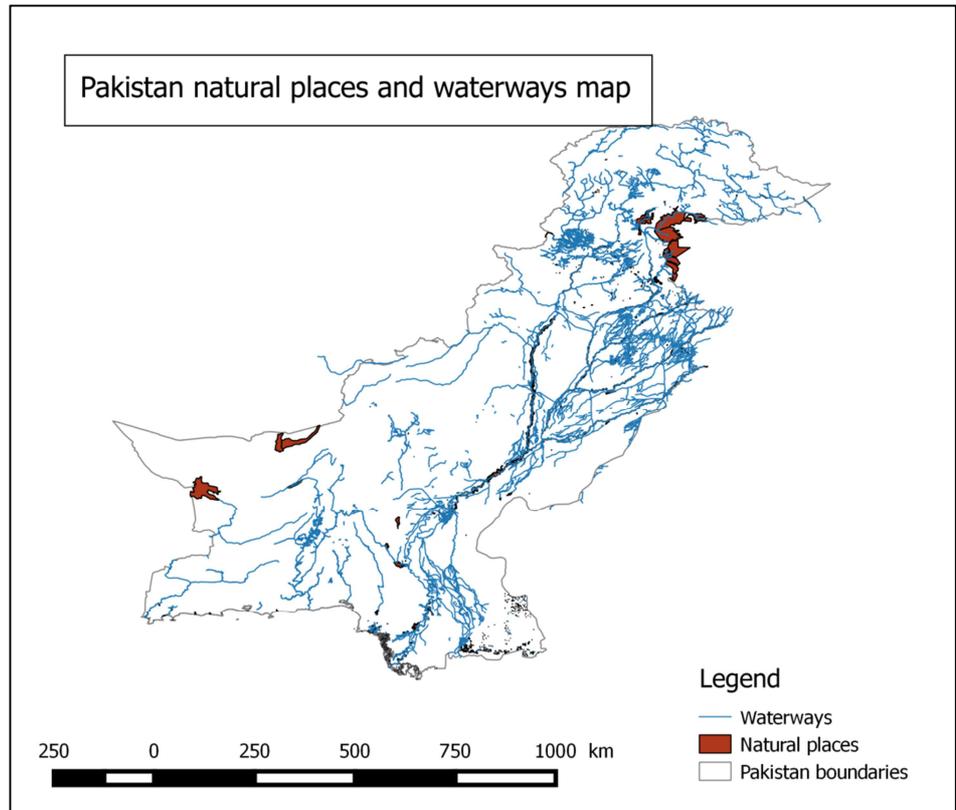


Figure 5: Natural places and waterways map (generated with GIS data from the World Bank database)

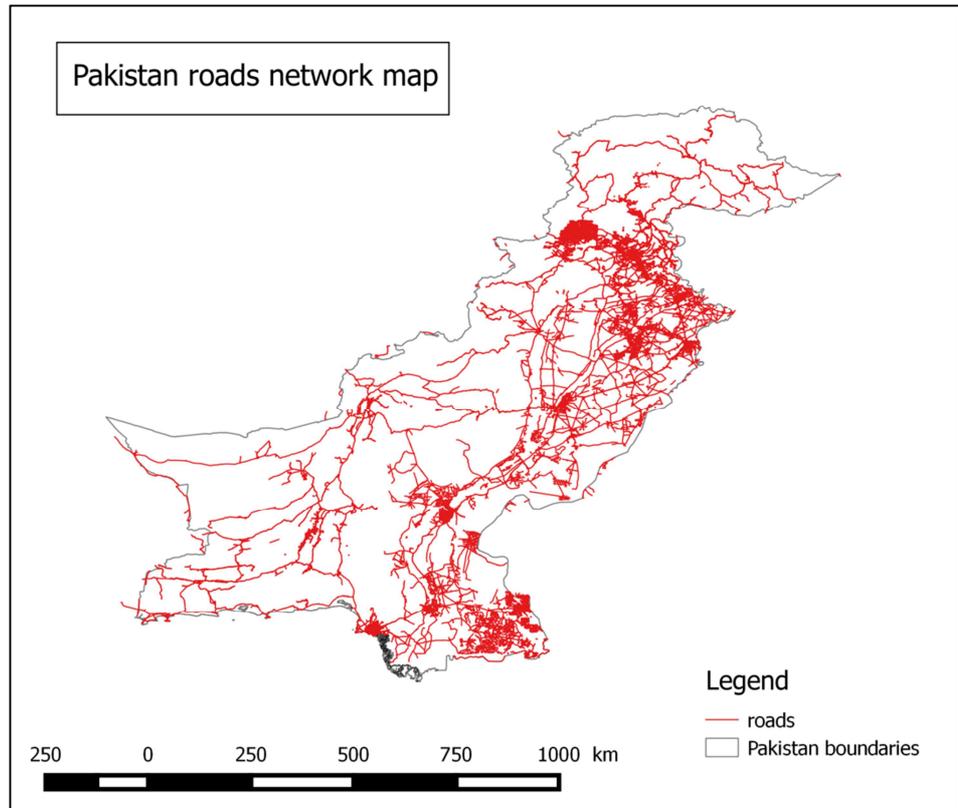


Figure 6: Roads network map (generated with GIS data from the World Bank database)

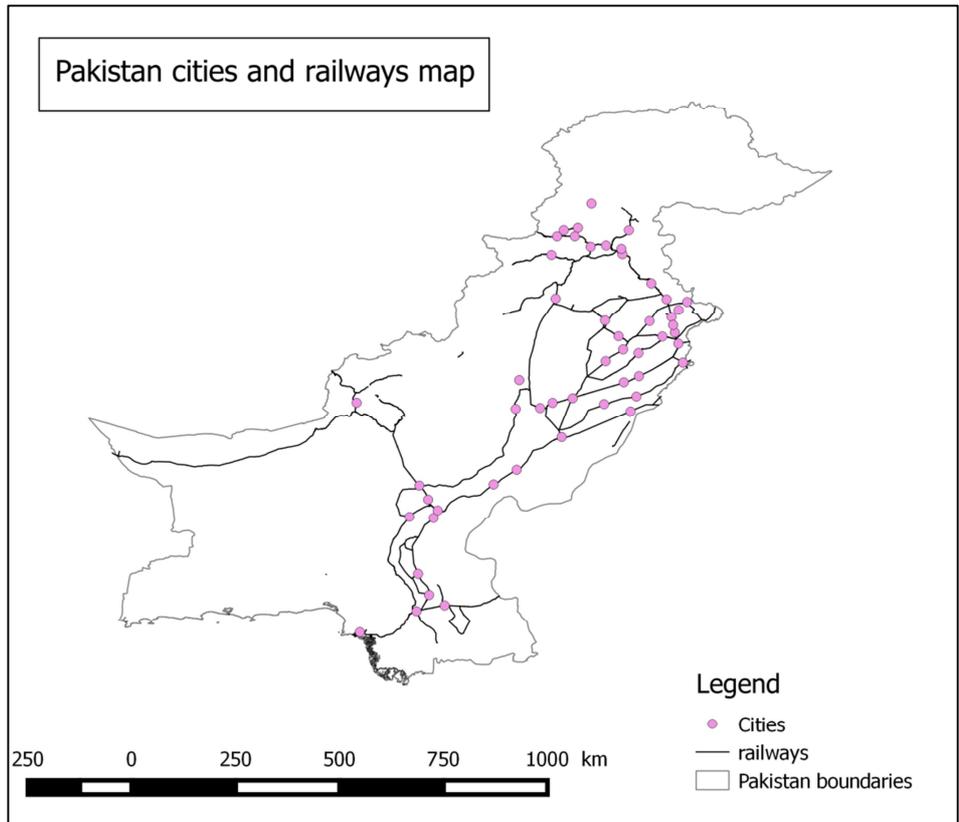


Figure 7: Cities and railways map (generated with GIS data from the World Bank database)

4 DESKTOP STUDY

In this section, various potential locations for mast installation are selected inside the zones identified by DTU (VR1 to VR10). For each VR zone, various interesting sites have been identified and are proposed (red markers). Among them, several have been ranked as higher potential locations according to the criteria listed above (blue markers).

Unfortunately, this initial desktop analysis as presented below could not be done for all areas. The team realized that some of the sites wouldn't be available for the use of the project. Such a desktop analysis was used in several other countries but was not applicable to Pakistan due to the difficulty of finding available land with clear ownership, and to the many security concerns at the time of the study.

4.1 ZONE VR1: SOUTHERN BALUCHISTAN

Panjgur, close to Tasp town: close to city of Panjgur and other towns (load), easily reachable from Tasp, rather flat and homogeneous area located more than 5km from the more complex zone to the north, good wind potential.

Tijaban village: very good wind potential, rather flat and homogeneous area located more than 5km from the more complex zone to the north, easily reachable by Karachi Road (M8) and N85, with many villages along the road (load).

Malar village: seen as an alternative to Tijaban village, with similar characteristics.

Unfortunately, the windiest zone in the centre of the white area (with red colour) is not very good for mast installation, because of its quite complex terrain and difficult accessibility.

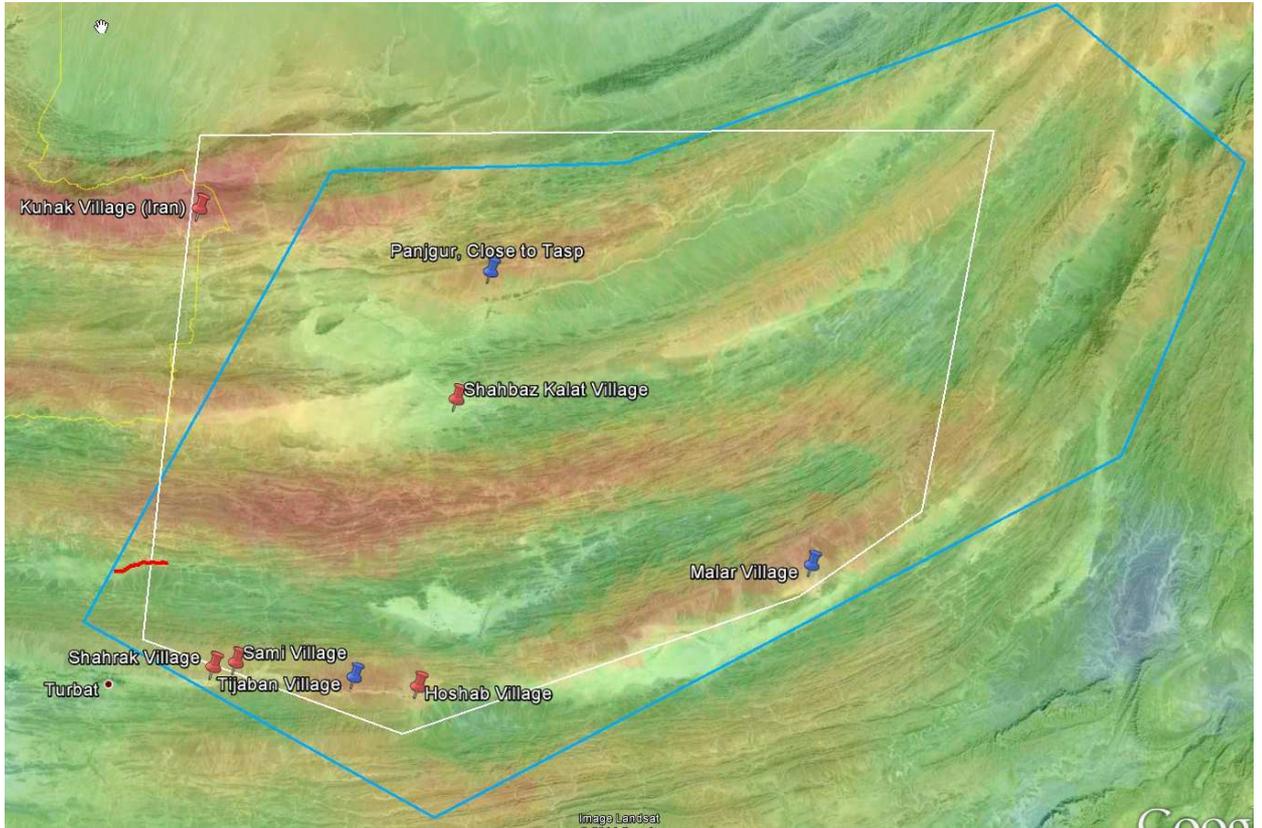


Figure 8: Identified potential sites in VR1 zone (Southern Baluchistan)

4.2 ZONE VR2: CENTRAL BALUCHISTAN - QUETTA

Crossroads: very remote but easily reachable by road, rather flat and homogeneous area located more than 3km from a more hilly zone to the east and north, good wind potential.

Abi Gum Village: easily reachable by road, rather flat and homogeneous area located more than 3km from the more hilly zone to the east and north, good wind potential.



Figure 9: Identified potential sites in VR2 zone (Central Baluchistan - Quetta)

4.3 ZONE VR3: SOUTHERN SINDH – KARACHI

This zone was not investigated because of the change in methodology when it was realized that the Desktop study would not be possible to implement.

4.4 ZONE VR4: NORTHERN BALUCHISTAN

This zone was not investigated because of the change in methodology when it was realized that the Desktop study would not be possible to implement.

4.5 ZONE VR5: WESTERN PUNJAB - DERA GHAZI KHAN

Unknown Village: between Fort Monroe and Sakhi Sarwar, easily reachable by road, rather flat and homogeneous area located more than 3km from a more hilly zone to the east, good wind potential.

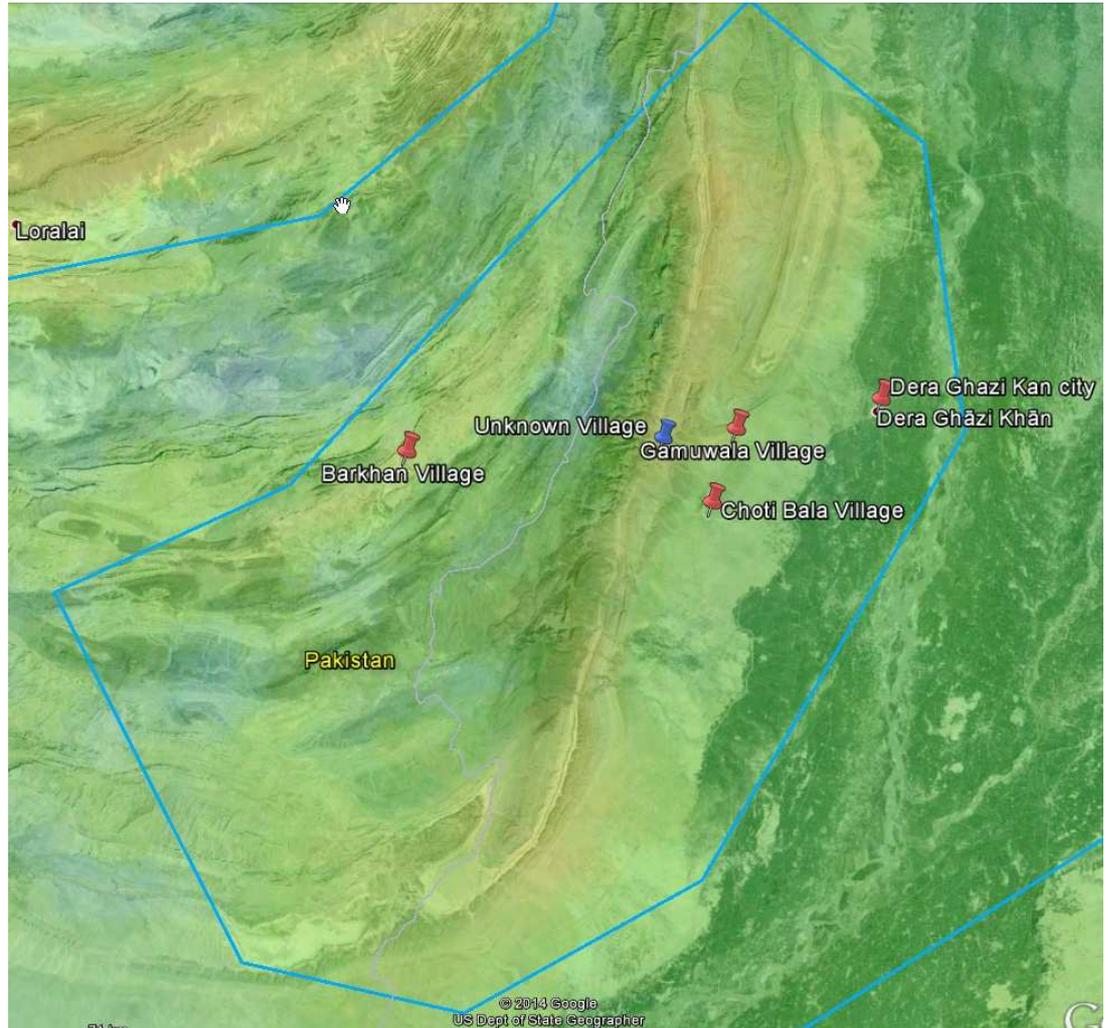


Figure 10: Identified potential sites in VR5 zone (Western Punjab - Dera Ghazi Khan)

4.6 ZONE VR6: WESTERN BALUCHISTAN

Juzzak village: close to city of Taftan (load), easily reachable by Saindak Road from Taftan, rather flat and homogeneous area, good wind potential.

Unknown village: very good wind potential, rather flat and homogeneous area, easily reachable by Nok Kundi – Saindak Road, Chagai Road and Reko Diq Road.

The Reko Diq airport could have been selected as an interesting location as such, but was not considered because it is quite remote, and the presence of the airport would probably impose an important buffer zone.

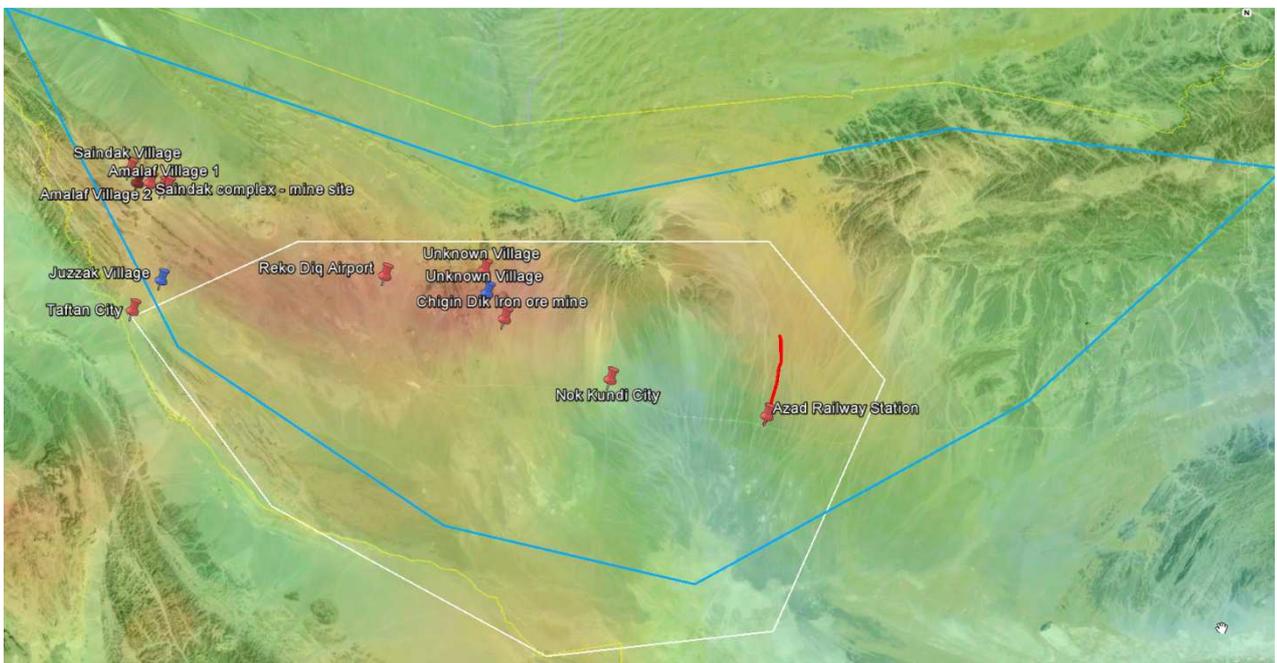


Figure 11: Identified potential sites in VR6 zone (Western Baluchistan)

4.7 ZONE VR7: ISLAMABAD – PESHAWAR – NORTHERN PUNJAB

In this area, few places have high wind potential. Only the north-west region around Peshawar represents a good expected potential. One interesting area has been found with relatively flat terrain. Many other places with lower wind have easy road access and are located close to villages or cities, so it will not be a problem to find complementary locations for mast installation. The availability of land should be assessed beforehand.

It might also be possible to find a suitable location within the white area to the south (as proposed by AEDB).

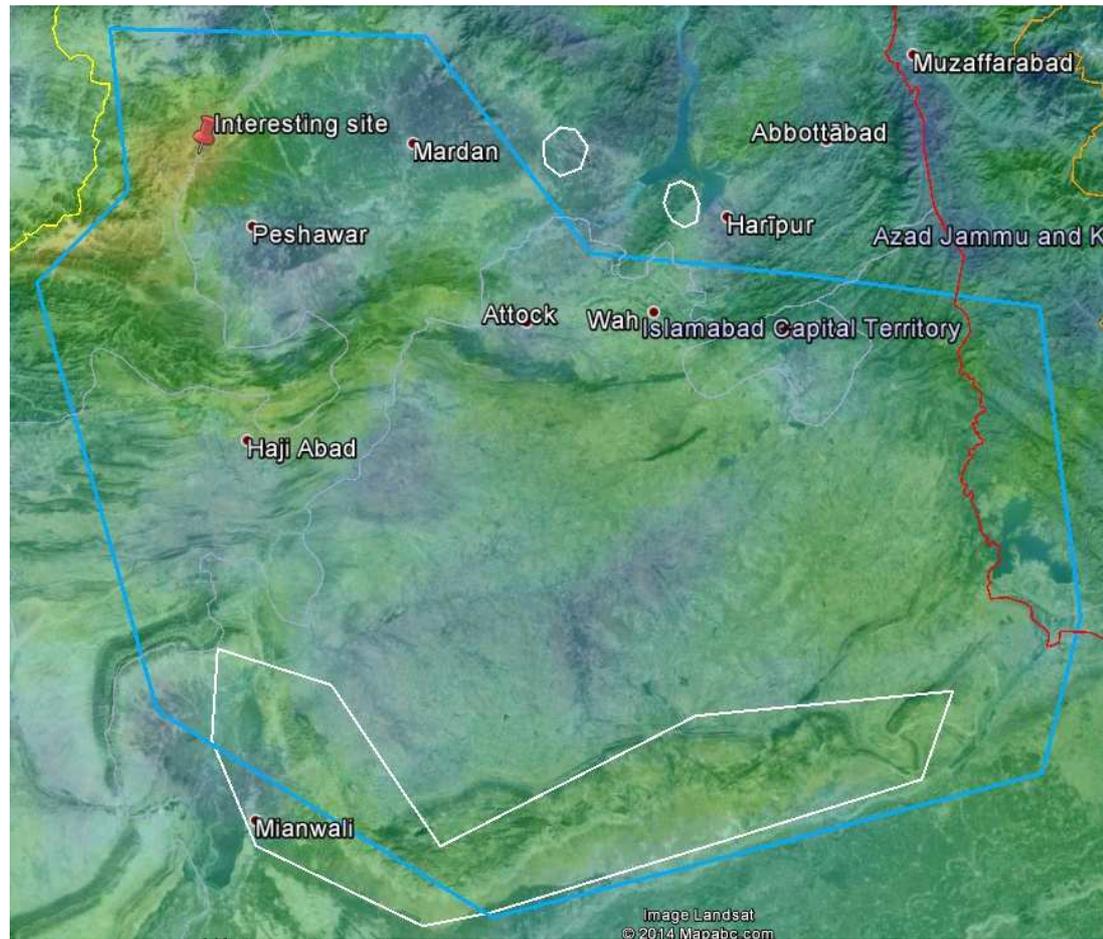


Figure 12: Identified potential sites in VR7 zone (Islamabad – Peshawar – Northern Punjab)

4.8 ZONE VR8: NORTHERN KHYBER PAKHTUNKHWA AND BALTISTAN

This is a very difficult zone for validation of the wind map, due to very complex topography. Only very few zones seem possible with reasonably flat terrain. However, these are not located in very windy areas.

4.9 ZONE VR9: EASTER SINDH

This zone was not investigated because of the change in methodology when it was realized that the Desktop study would not be possible to implement.

4.10 ZONE VR10: EASTERN PUNJAB - BAHAWALPUR

Derawar Village: very open area, easily reachable by road, very flat and homogeneous area, rather good wind potential.

Areas near many other villages would also be possible as long as the villages are small and easily accessible.

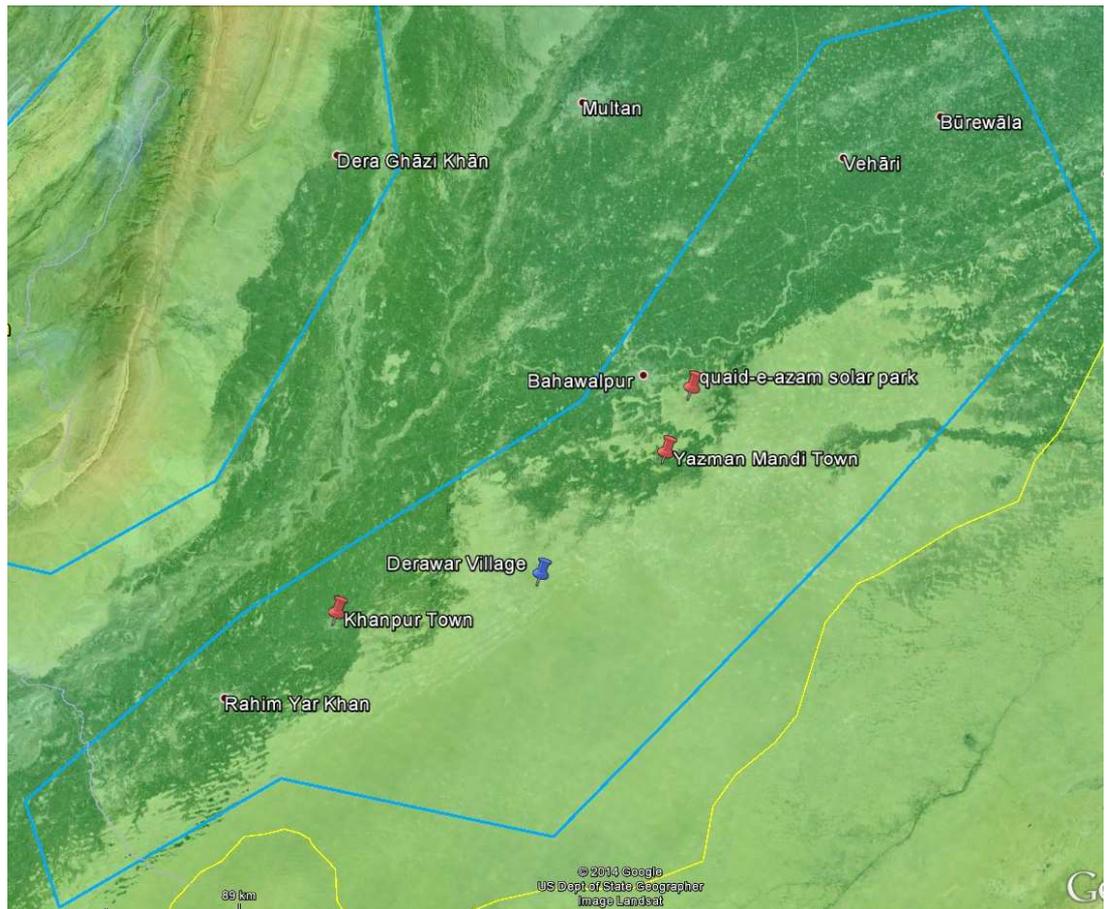


Figure 13: Identified potential sites in VR10 zone (Eastern Punjab - Bahawalpur)

5 RESULTS: LONG LIST OF SITES

As described in the Methodology section, the benefit of the desktop study (presented in Section 4) was limited by the availability and potential use of sites for the project. To solve this problem, a more pragmatic approach was used: the local government representatives were contacted and visits to publicly owned sites were organized.

Finally, the site identification analysis resulted in a long-list of 44 sites to be visited, which are listed and illustrated in Table 1 and Figure 14 below. Site visits will provide additional information in terms of logistics and validation process, and, from a technical point of view, the capacity to erect wind measurement mast and ensure appropriate security at and on the way to each of the sites.

Table 1: Selected long-list of mast locations

Province	Site
Khyber Pakhtunkhwa	UET Jalozai Campus
Khyber Pakhtunkhwa	Preimer Sugar Mill, Mardan
Khyber Pakhtunkhwa	Misri Banda Village, Nowshera
Khyber Pakhtunkhwa	Do Nali, Haripur
Punjab	Q A Solar Park, Bahawalpur
Punjab	Gath Bairi, RYK
Punjab	Chakri, Chakwal
Punjab	Quaidabad, Khushab
Punjab	Mpur, BMP Post, Rajanpur
Punjab	Pull Chak Shakari, Rajanpur
Punjab	Karari Wala Rest House, Muzafargarh
Punjab	Anari, Near Bahria Town, DGK
Punjab	Kot Chajji, Jand, Attock
Punjab	Taunsa Barage
Punjab	Kala Gojran, Jehlum
Punjab	Solar Park NUST, Islamabad
Punjab	UET Balkasar, Chakwal
Punjab	Rakh Warhal Forest, Chakwal
Punjab	Wild life Check Post, Chakwal
Punjab	Khar Cho Daf, Ground, DGK
Punjab	BMP Post, DGK
Punjab	Near Rest House, Islamabad
Punjab	Shahbaz Pur, Pindigheb, Attock
Punjab	Water Storage, Islamabad
Punjab	Hill Top, Islamabad
Punjab	Public Park, Islamabad

Sindh	Shahabad, Thatta
Sindh	Tandu Ghulam Ali, Badin
Sindh	Mataru Khan Village, Mirpur Khas
Sindh	Zahidabad, Mirpur Khas
Sindh	Sataar Goth, Umarkot
Sindh	Site 1, Kandhari, Sangharh
Sindh	Site 2, Kandhari, Sangharh
Sindh	30 km SuperHighway
Sindh	Farm 2, Mirpur Khas
Sindh	Jati, Thatta
Sindh	Location1, Farm 1, Mirpur Khas
Sindh	Location 2, Farm 1, Mirpur Khas
Sindh	PMA, Karachi
Baluchistan	BUIITEMS, Quetta
Baluchistan	Watra, Harnai
Baluchistan	Allah Dad, Kachh, Ziarat
Baluchistan	Kaust, Harnai
Baluchistan	Khur. Kachh, Ziarat

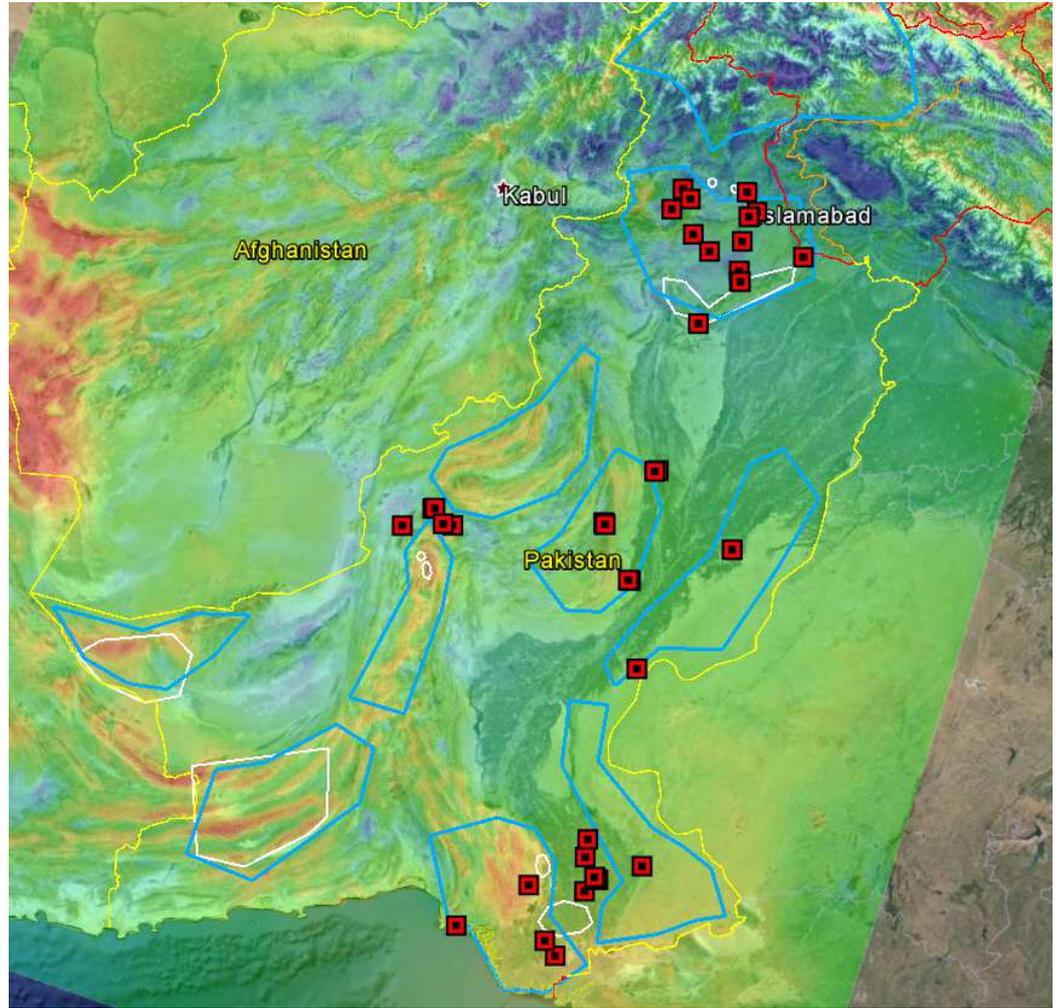


Figure 14: Similar to Figure 1 and showing the location of the sites to be visited (several site markers are hidden by others).

QUALITY INFORMATION

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