CARTOGRAPHIC ILLUSTRATION OF ENERGY SOURCES

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Abstract. This article analyzes the average daily and annual solar radiation on the horizontal surface of Uzbekistan's territory. The technical potential and geographical distribution of wind energy resources in Uzbekistan have also been examined. A digital map has been created using a geospatial database. The methodology for developing alternative energy resource maps has been improved based on international experience and national research efforts. Furthermore, geodetic studies of energy facilities have been conducted.

Key words: database, electronic map, alternative energy, topographic survey, GPS device, CredoCAD software, AutoCAD software.

The initial stage of utilizing alternative energy resources at the national and local levels is closely related to the development of its geographic, cartographic, and geodetic foundations. This is due to the territorial, periodic, complex, and systemic characteristics of wind, solar, bio, and hydro resources. For example, while solar energy is widely used in Southern Europe, wind energy is more characteristic of Northern Europe. In Uzbekistan, with nearly 300–320 sunny days per year, solar energy is a primary resource. According to specialists at the Institute of Physics-Solar under the Academy of Sciences of Uzbekistan, the total potential of solar energy is 51 billion tons of oil equivalent (toe), while the technical potential is 177 million toe. However, the distribution of solar radiation across different surfaces varies depending on local conditions. Therefore, studying the geographic characteristics of alternative energy resources and developing their cartographic and geodetic foundations is of great importance.

A map was developed using data from the Global Solar Atlas (GSA) project, compiled by the World Bank. A map was developed using data from the Global Solar Atlas (GSA) project, compiled by the World Bank. The map is based on the database of average daily and annual solar radiation on Uzbekistan's horizontal surface from 1999 to 2018. The map data were obtained from satellite images with 15- and 30-minute intervals, while the terrain surface was provided with a nominal spatial accuracy of 250 meters. Due to the lack of highly accurate geodetic instruments, the data were modeled, with an error range of 8% to 61% (Figure 1).

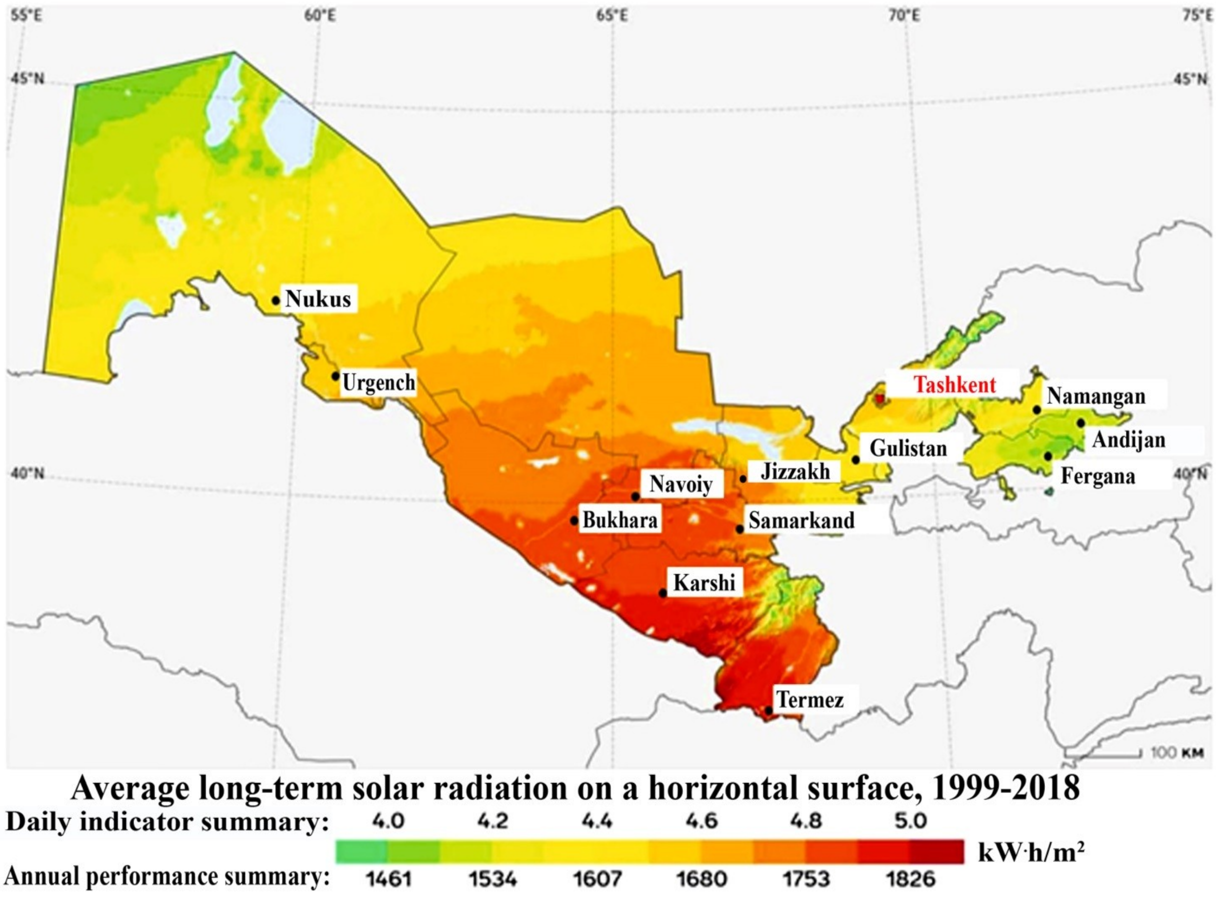

Figure 1. **Average daily and annual solar radiation on the surface of Uzbekistan, kWh/m^2**

The analysis of the map reveals that in Kashkadarya and Surkhandarya regions, the daily solar radiation on the Earth's surface ranges between 4.8 – 5.3 kWh/m², while in the northern Ustyurt, Kyzylkum, and Aral Sea regions, it decreases to 4.0 kWh/m² or lower. The annual solar radiation values follow a geographical gradient from 1,400 to 1,830 kWh/m² toward the north. Such variability corresponds not only to zonal, but also to the laws of zoning of solar radiation in altitude regions.

To reduce electricity and natural gas consumption for social purposes, it is planned to implement solar photovoltaic stations with a daily capacity of 54.3 kcal and a total capacity of 1.5 MW. Additionally, solar collectors with a daily capacity of 1.3 Gcal will be introduced for hot water supply and heating in social facilities.

The technical potential of wind energy resources in Uzbekistan exceeds 1 million GWh, with an installed capacity of approximately 520 MW. However, their geographical distribution varies significantly (Figure 2).

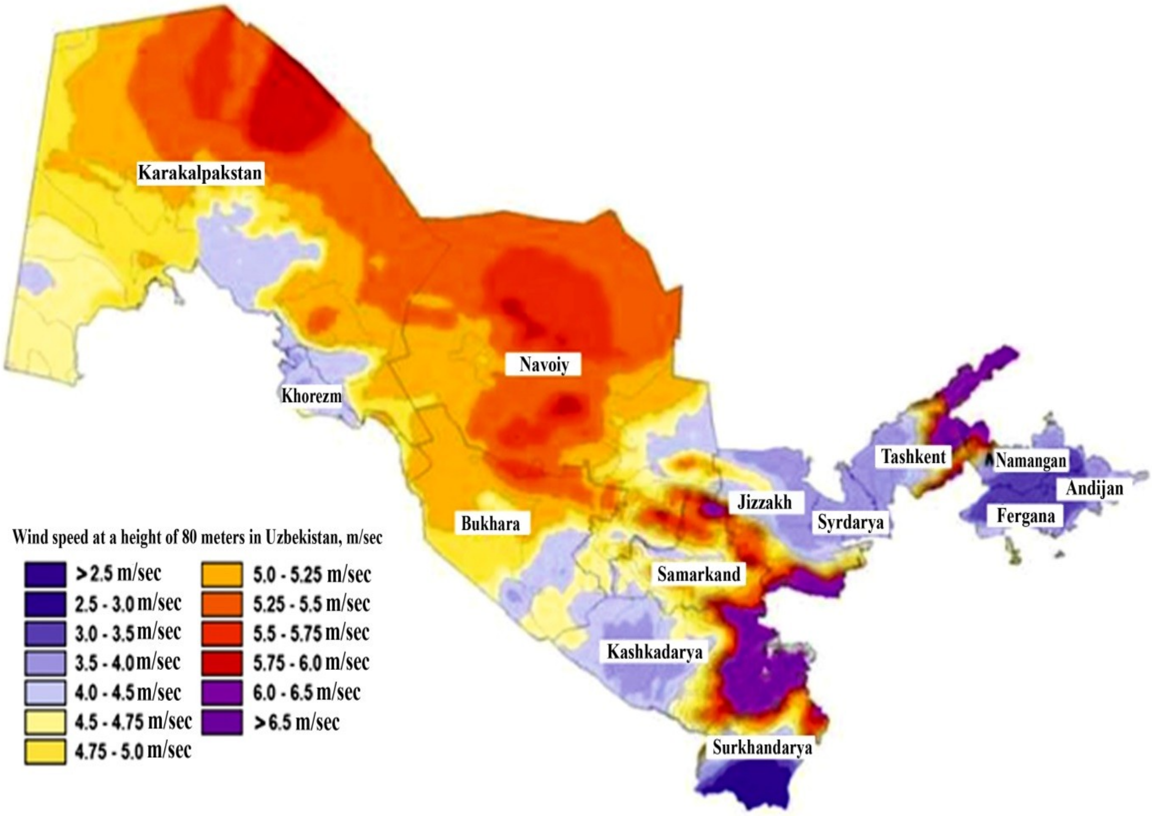

Figure 2*. Wind speed at a height of 80 meters in Uzbekistan*, m/s.

Unlike solar radiation intensity, wind energy is stronger at 80 meters altitude in northern regions and high-mountain areas, with speeds ranging from 5.5 m/s to over 6.5 m/s. Exceptions include the Bekabad-Khavos zone in Syrdarya, the Kokand-Yazyavan zone in the Fergana Valley, and the southern Surkhandarya region, where “Afghan winds” are prevalent.

To replace thermal power plants (TPPs) with renewable energy sources, the construction of wind power stations with capacities exceeding 100 MW is recommended, particularly to supply energy to social facilities in remote areas.

Between 2017 and 2019, the development of biogas energy in Uzbekistan focused on 726 large poultry and livestock farms, where biogas installations were introduced. The share of such facilities increased from 0.7% in 2017 to 11.2% in 2019, allowing for the annual production of up to 60.8 million m^3 of biogas. Additionally, 170,000 tons of eco-friendly organic fertilizers (in dry weight) were produced for use in farming.

The methodology for creating alternative energy resource maps is based on a five-stage process (Figure 3).

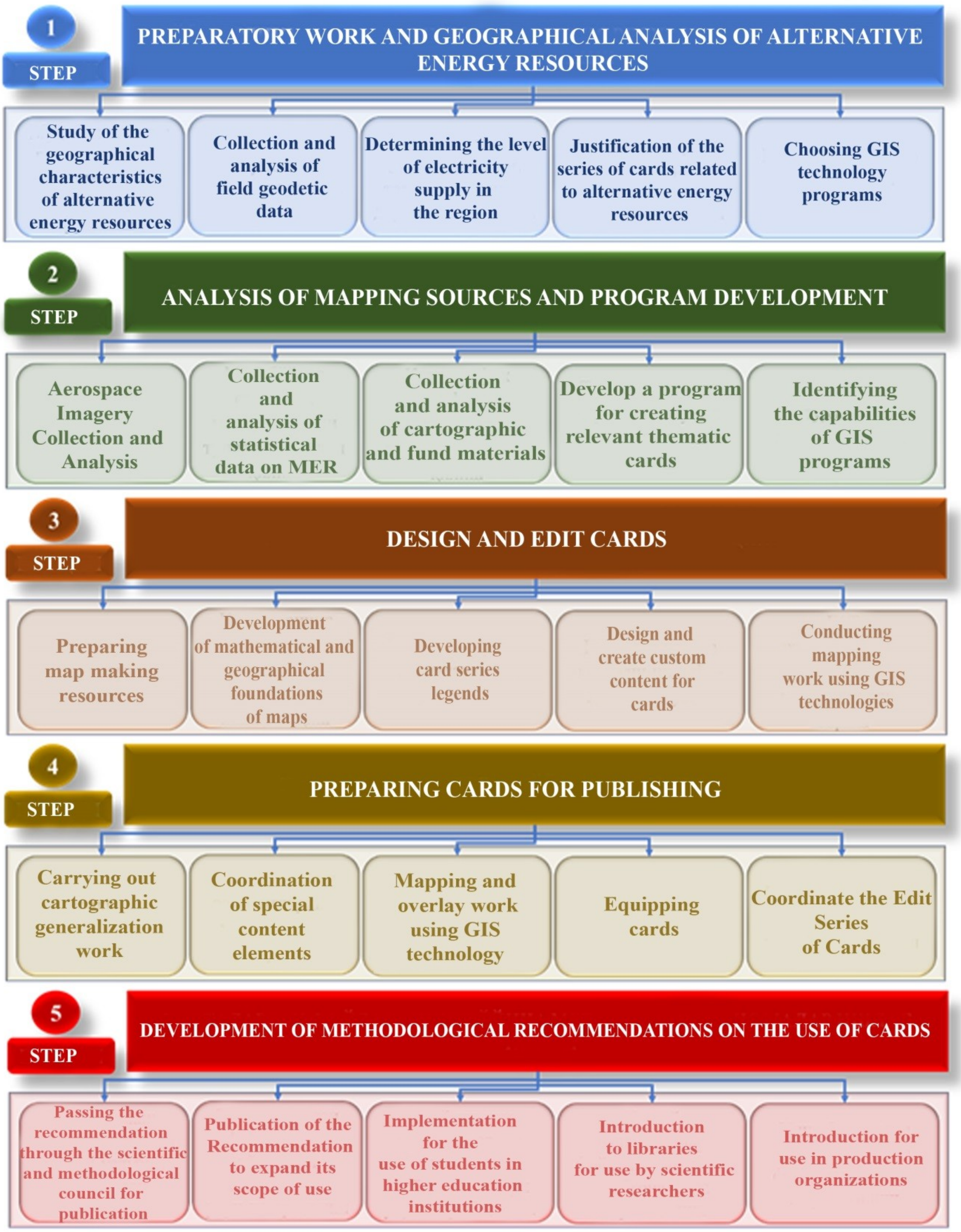

Figure 3. Methodology for creating maps of alternative energy resources

Data Collection and Analysis - the first stage involves gathering, analyzing, and classifying data to reveal the geographical distribution characteristics of alternative energy resources. This is followed by field geodetic data collection and analysis. The study assesses the electricity supply status of the research areas and selects GIS software based on the justification of alternative energy resource maps.

Cartographic Data Processing – This second stage includes the collection and analysis of aerospace images, preparation of geographic foundations, and statistical and cartographic data analysis. Thematic map creation software is developed, and the capabilities of GIS software such as ArcGIS, AutoCAD, and MapInfo are determined.

Thematic Map Creation – The third stage focuses on the design, compilation, and editing of thematic maps for alternative energy resources. This includes gathering map sources, developing mathematical and geographic foundations, and defining map legends. Thematic content is designed, and maps are created using GIS technologies.

Map Finalization and Publication – At fourth stage, cartographic generalization is performed, content elements are refined, and the maps are created using GIS technologies. The series of maps is edited and formatted for publication.

Methodological Guidelines for Usage – In the final fifth stage, guidelines for the practical use of the developed maps are prepared and distributed in an illustrative manner, following a specific sequence and detailed instructions.

After determining the patterns of territorial location of alternative energy sources using appropriate maps, a sequence of geodetic works, i.e. methodology, for surveying and construction of each selected facility is developed. These geodetic works will be carried out in 3 stages. In the first desk phase, data on alternative energy resource sites (Figure 4) will be collected, surveyed and a large-scale topographic base will be created. Then, geologic and lithologic surveys and studies were conducted on the geologic and lithologic base of the site where the energy facilities will be located.

Depending on the size of the plant to be constructed, a cross section of its deep layers is made and the mechanical stability of the rocks is determined. Geodetic surveys of energy facilities are carried out and methods of surveying for alternative energy sources are determined. Based on the results of the preparation, GIS Technologies was selected to carry out geodetic works.

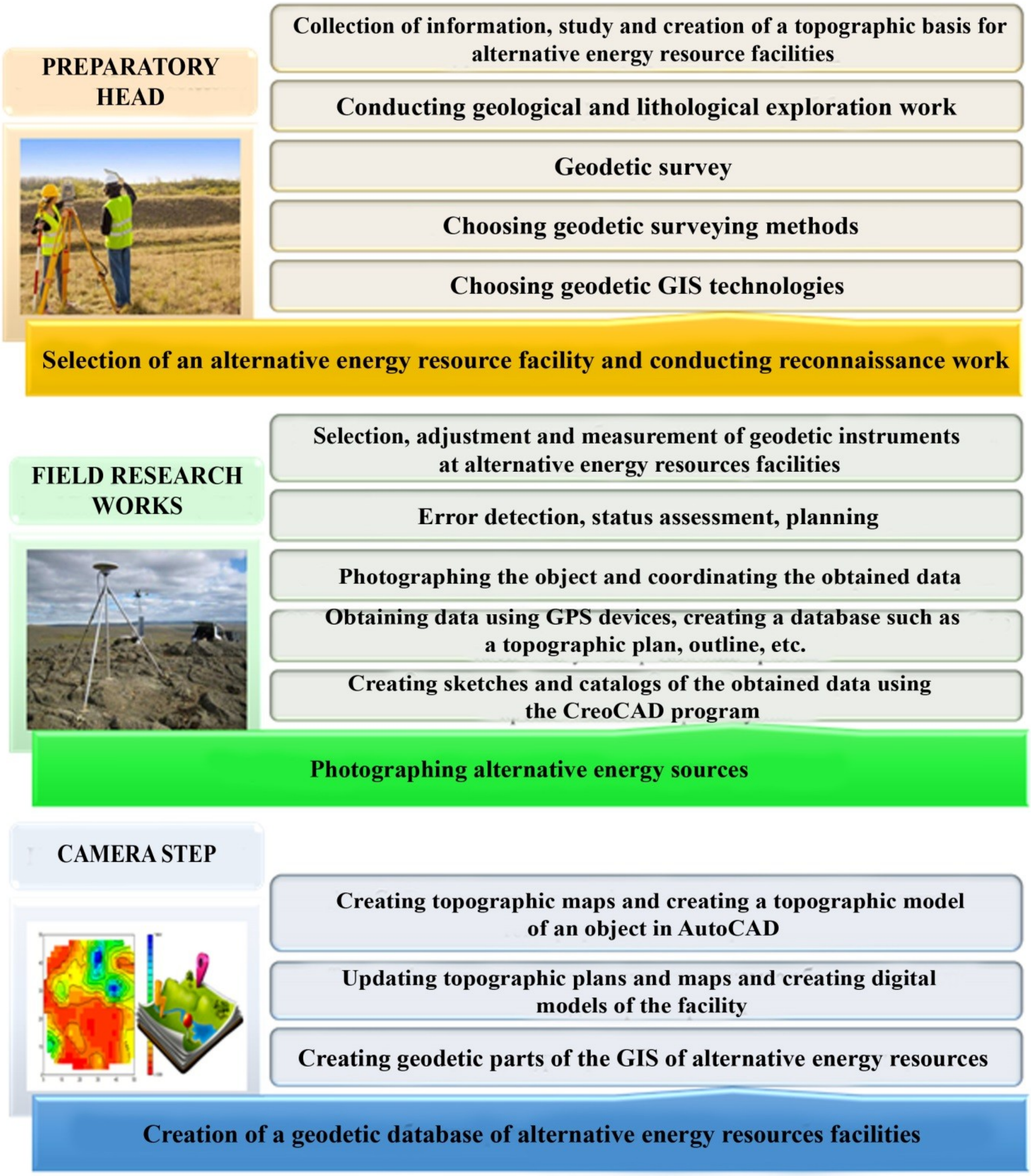

Figure 4. Methodology for conducting geodetic surveying work in the construction of alternative energy resources

After the preparatory stage is completed, field surveys are conducted, geodetic instruments are selected, set up and measurements are taken to accurately record the data required for measurements and design of alternative energy source stations at construction sites. Possible errors in surveying are identified and the real situation is assessed. The selected object is photographed and the obtained data are aligned according to a single criterion. Additional data are obtained using GPS devices, a large-scale topographic map of the area is made, and a database is created. Based on the obtained information, schemes and catalogs were created using CredoCAD program.

After completion of field work, large-scale topographic maps were created in camera using AutoCAD program and a topographic model of the selected object was created. By generalizing and coordinating the data, the previously made topographic plans and maps were updated, digital models of the object and geodetic basis of the geoinformation system of alternative energy resources were created.

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