Development and Implementation of Renewable Energy Potential Geospatial Database Mapping in India for Cloud SDI Using Open Source GIS

Rabindra K. Barik, K. Muruga Perumal, P. Ajay-D-Vimal Raj and S. Rajasekar

Abstract India is owing to the substantial gaps amongst the established energy demand and mounted power capacity, with the conclusion that the per capita energy consumption in India is one of the lowermost in the world. The opportunity for development in India's energy system is huge. Renewable energy presently makes up a slight share (0.36%) of total main commercial energy supply, whereas 96.9% of such supplies come from fossil energies and 2.76% from hydro and atomic resources in India. The present research paper primarily proposed the renewable energy potential scenario in each and every state of India by taking different aspects with the clarification to the developed energy demand in future of India. Secondly, it has also developed the renewable energy potential geospatial database in India with the help of open-source GIS software further implementation in cloud SDI (Spatial Data Infrastructure) Model for better visualization and mapping of potential sites. Present paper has used Quantum GIS 2.14.3 open-source GIS software for the geospatial database creation. The developed geospatial database has been successfully viewed and implemented with Quantum GIS 2.14.3 as thick client environment for sharing of various factors, i.e. wind, small hydropower, biomass power and solar which are associated with the renewable energy potential scenario in India.

Keywords Renewable energy · GIS · Open-source · Geospatial database

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S. SenGupta et al. (eds.), *Advances in Smart Grid and Renewable Energy*,
Lecture Notes in Electrical Engineering 435, https://doi.org/10.1007/978-981-10-4286-7_41

1 Introduction

A large amount of electrical energy consumption in a country indicates increased activities in this power sector providing high relaxation in modern industrial and residential power applications. On the another side, the conventional method of power generation leads to increasing environmental pollutions and carbon footprints in our nation; at present, the main objective of any significant country is to increase power generation to meet pollution-free developed energy demand.

India is known as the fourth biggest electricity-using country after the orders of China, USA and Russia, respectively [1, 2]. And also it is noted as one of the fast-growing economics to meet the following major encounters of (a) fulfilling global warming mitigation through international protocols, (b) demanding the eradication of the un-electrified villages and (c) secured energy supply which is independent of fuel imports instability [3, 4].

As per statement of International Energy Agency (IEAI), India will be the second top country to rise in the global electrical energy demand by 2035 [1]. The major electricity production in India was obtained from fossil fuels such as coal (201,360 MW), natural gas (24,509 MW), nuclear power (5780 MW) and small quantities of crude oil (994 MW). India has the installed power of 288 GW as on 29 February 2016. Out of installed power, the 13% was only from various renewable energy resources such as solar, wind, mini hydro and biomasses. Figure 1 shows the installed electricity in India as on 29 February 2016.

2 Development of Renewable Power Group in India

The welfares of organizing renewable resources are providing uncontaminated energy, whereas dropping trust on fossil energies, thereby dipping CO_2 productions. Using renewable energy to complement the energy desires and to shrink

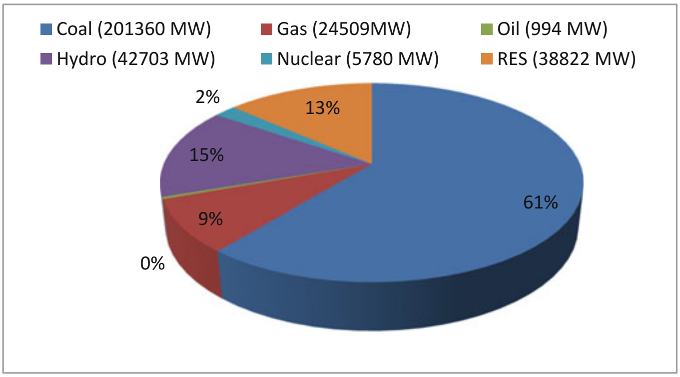


Fig. 1 Installed electricity in India as of 29 February 2016

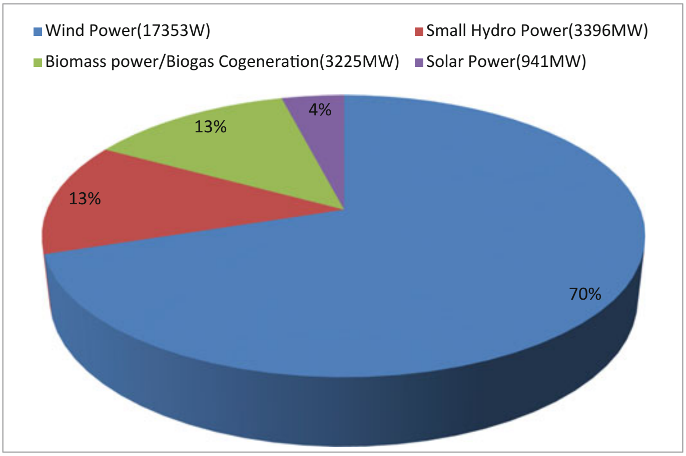


Fig. 2 Installed renewable electricity in India as of 29 February 2016

eco-friendly impact is an important goal of several nations round the ecosphere. Technical developments compact cost, and administrative inducements have complete some renewable resource such as solar and wind, additional economical in the market. Figure 2 shows the classification of renewable resource-based electrical power (counting off grid and on grid). Agreeing to the Ministry of Renewable Energy department, grid-connected renewable resources consist of solar, wind, minor hydro, industrial waste and bagasse cogeneration biomass power, etc. Amongst these, the major portion is 17 GW from wind mill, next 3.39 GW from mini hydro plant, 0.94 GW from sun energy and 3.22 GW from grid-connected bagasse and biomass [1–3, 5, 6]. The main objective of the present research work in renewable energy scenario of India is recommending suitable best configuration of hybrid renewable models for each renewable resource-rich regions of India and giving the solution to developed energy demand in future of our country [7, 8].

It has been observed that the sharing of suitable best configuration of hybrid renewable models' information for the analyst or decision-makers can be possible with the help of spatial technology with cloud computing environment for achievement of the main aim of development of Spatial Data Infrastructure (SDI) model.

3 Need of SDI Model for Renewable Energy Scenario in India

With the combination of mobile, Web and spatial technologies, it has been a greater potential for numerous functionality in terms of geospatial data allotment over Internet. It can offer a real-time and dynamic way to denote information through maps. So there is an urgent need to launch a well-organized SDI Model which is a geoportal where each and every participant can use, exchange and access spatial data for economic, social and ecological application [9]. Geospatial Web service is one of the key technologies required for development and application of SDI [10]. Design and implementation of SDI is used in cloud computing technology which is used for sharing the information about the renewable energy potential in India [11]. It enables the end user or data analyst to quickly look into the problem and get the information according to their need. Thus, the next section describes the details of related works which have been done with the Cloud SDI Model.

4 Cloud SDI Model

Cloud SDI Model delivers a platform in which organizations interrelate with technologies, tools and expertise to nurture deeds for producing, handling and using geographical statistics and data. SDI also defines the cumulative of technology, standards, strategies, policies and manpower required to attain, allot, sustain, process, use and reserve spatial data. The basic constituents of SDI have been observed as data, networking, public, policy and standards [12]. Further, SDI Model can be implemented through service-oriented architecture (SOA) or cloud computing technologies for better and efficient use. The SOA tries to construct dynamic, distributed and flexible facility system over the Web in order to see data and required services for development of SDI. Components in the service-oriented architecture-based spatial data infrastructure are geospatial Web services, i.e. structured collections of activities which are stateless, self-confined and independent upon the state of other services [13–15].

Likewise, Cloud SDI Model deploys a unique-instance, multitenant design and permits more than one client to contribute assets without disrupting each other. This integrated hosted service method helps installing patches and application advancements for user's transparency. Geospatial cloud is another characteristic embrace of Web services and SOA, a wholly established architectural methodology in the engineering [16]. Many cloud platforms uncover the applications statistics and functionalities via Web service. This permits a client to query/update different types of cloud services and applications data programmatically, along with the provision of a standard mechanism to assimilate different cloud applications in the software cloud with enterprise SOA infrastructure [17–19, 22]. Figure 3 illustrates the system architecture for Cloud SDI Model [20].

It has been shown from the system architecture of Cloud SDI Model where geospatial databases are a vital module in data layer in Cloud SDI Model. Thus, next section has been emphasized on the geospatial database creation.

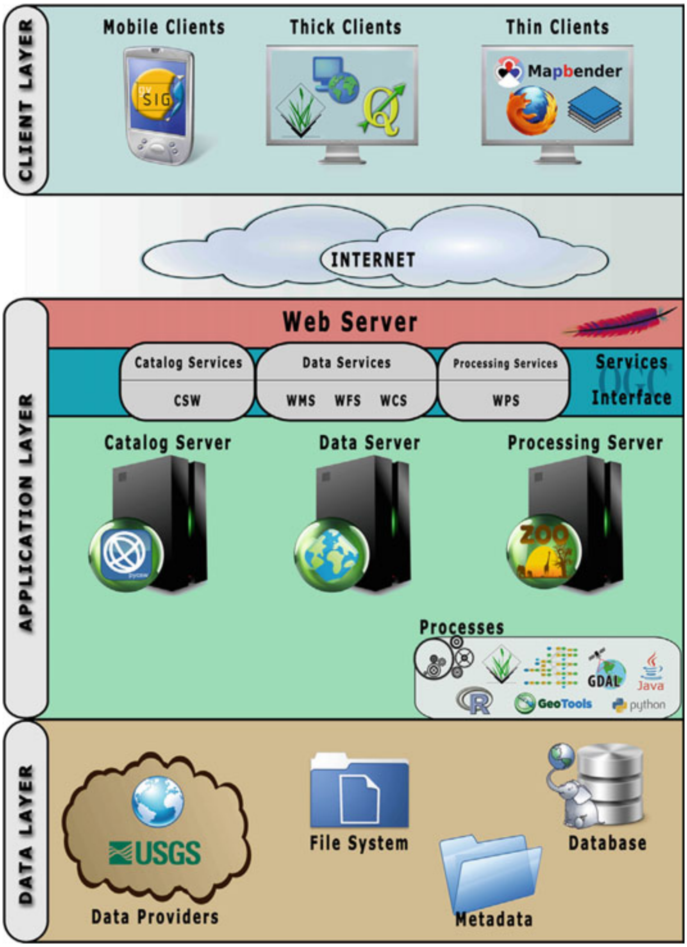


Fig. 3 System architecture for cloud SDI Model

5 Geospatial Database Creation for Renewable Energy Potential

The creation of geospatial databases for renewable energy potential in India is significant and tedious assignment where efficacy in geospatial related project depends upon. Integrated geospatial database creations include stages such as inputs of data on spatial and non-spatial attributes, and its authentication by connecting with same set of data. Geospatial database delivers a platform in which organizations interrelate with technologies to nurture actions for handling, spending and generating geographical data [20]. The development of geospatial database supports in various administrative and political levels through these decision-making functions. Quantum GIS 2.14.3 has been selected for creation of geospatial database.

6 Objective of the Present Research Work

The aim of the present research work is to use Quantum GIS 2.14.3 which has been utilized for geospatial database creation and also broadly used for development of geospatial database for renewable energy potential in India. It has also proposed a robust software engineering methodology approach for the development of geospatial database with the help of Quantum GIS 2.14.3. Thus, the next section describes about the methodology adopted for the geospatial database creation for renewable energy potential in India.

7 Methodology Adopted for Geospatial Database Creation for Renewable Energy Potential in India

For creation of geospatial database, the prime emphasis has been on the real-world approach to discover and spread the thought of geospatial database creation for renewable energy potential in India. The established geospatial database has to provide a proficient means of allocation of geospatial and non-spatial data in Cloud SDI Model. The prototype is based on object-oriented software engineering (OOSE) proposed by Jacobson's method to combine the time-critical nature and strong user focus [21, 22]. Figure 4 represents the fully win–win procedure model for creation of geospatial database creation.

The procedure model of geospatial database creation is recurring or frequent in nature, and each operation improves the study and strategy steps through assessment and testing of a completed component. In complete component, Quantum GIS 2.14.3 open-source GIS software has set up geospatial database for renewable energy potential in India with the help of political map of India. Quantum GIS 2.14.3 is also used for integrated geospatial database creation. The geospatial

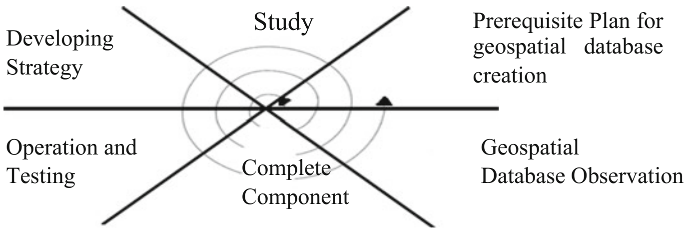


Fig. 4 Spiral model for geospatial database creation renewable energy potential in India

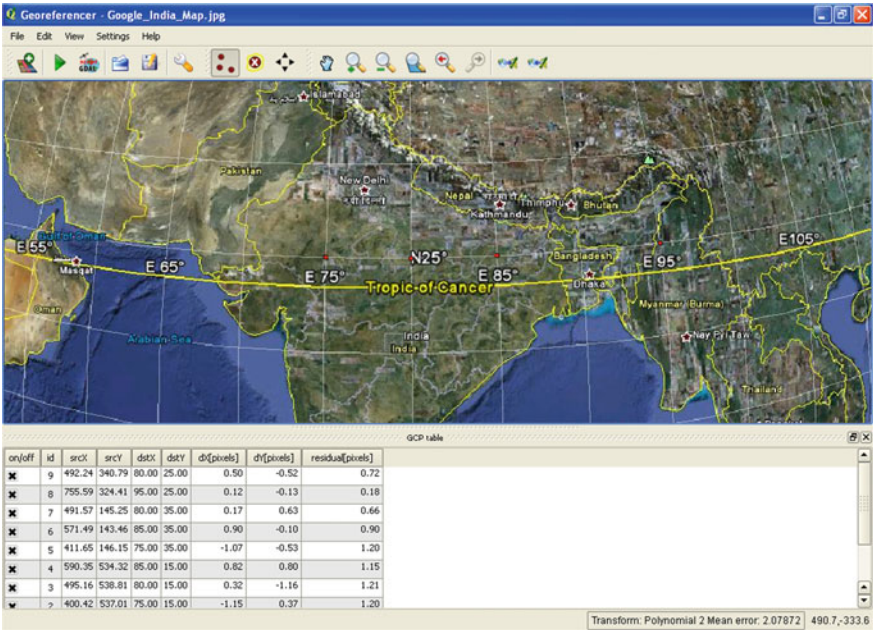


Fig. 5 Georeferencing: map of India

database for renewable energy potential in India has been nominated to illustrate the capabilities of developed framework. Geospatial database for renewable energy potential in India has been prepared by Quantum GIS Ver. 2.13.4. Initially, the base image of India has been downloaded from the Google Earth. The downloaded image is georeferenced with the help of Georeferencer Tool in Quantum GIS Ver. 2.14.3. For georeferencing the base map of India, 10 numbers of GCPs have been taken. The GCPs have been selected at the intersection of latitudinal and longitudinal lines. For universal coordinate system, WGS-84 with EPSG: 4326 coordinate reference system has been chosen. Now, the image is ready for georeferencing. After georeferencing, the generated image is used to extract the thematic maps. Figure 5 shows the snapshot of georeferencing of Indian map in Georeferencer Tool from Quantum GIS Ver. 2.14.3.

In the present application case study, the entire renewable energy potential in India has been taken. These have been categorized into the different layers with schema definition. Figures 6 and 7 show the layer name with respect to schema definition and instant of the database.

After schema definition, two thematic layers have been created. First layer has been developed as renewable energy potential in India and second layer has been created which indicates the whole India State Boundary. For these two layers, WGS-84 with EPSG: 4326 coordinates reference system has been chosen. The Indian state boundary has been created by on-screen digitization process in

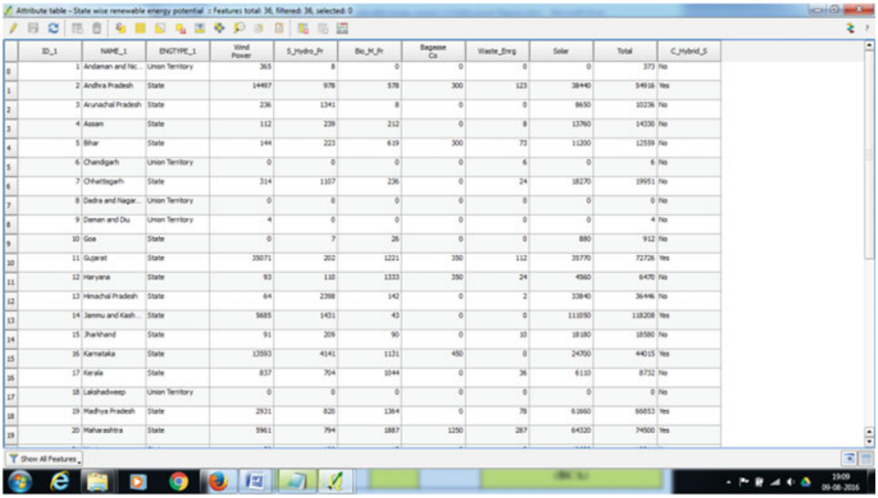
Renewable energy potential in India

Sl. No	States/ UTs	Wind Power	Small Hydro Power	Biomass Power	Bagasse Co-Gen.	Waste to Energy	Solar	Total	Chance to Hybrid system

India State Boundary

UID	State Name	State Capital Name

Fig. 6 Schema definitions for renewable energy potential in India



Attribute table - State wise renewable energy potential :: Features total: 36, filtered: 36, selected: 0

	ID_1	NAME_1	ENGTYPE_1	Wind Power	S_Hydro_Pr	Bio_M_Pr	Bagasse Co	Waste_Enrg	Solar	Total	C_Hybrid_S
0	1	Andaman and Nic...	Union Territory	365	8	0	0	0	0	373	No
1	2	Andhra Pradesh	State	14497	978	578	300	123	38440	54916	Yes
2	3	Arunachal Pradesh	State	236	1341	8	0	0	8650	10236	No
3	4	Assam	State	112	239	212	0	8	13760	14330	No
4	5	Bihar	State	144	223	619	300	73	11200	12559	No
5	6	Chandigarh	Union Territory	0	0	0	0	6	0	6	No
6	7	Chhattisgarh	State	314	1107	236	0	24	18270	19951	No
7	8	Dadra and Nagar...	Union Territory	0	0	0	0	0	0	0	No
8	9	Daman and Diu	Union Territory	4	0	0	0	0	0	4	No
9	10	Goa	State	0	7	26	0	0	880	912	No
10	11	Gujarat	State	35071	202	1221	350	112	35770	72726	Yes
11	12	Haryana	State	93	110	1333	350	24	4560	6470	No
12	13	Himachal Pradesh	State	64	2398	142	0	2	33840	36446	No
13	14	Jammu and Kash...	State	5685	1431	43	0	0	111050	118208	Yes
14	15	Jharkhand	State	91	209	90	0	10	18180	18580	No
15	16	Karnataka	State	13593	4141	1131	450	0	24700	44015	Yes
16	17	Kerala	State	837	704	1044	0	36	6110	8732	No
17	18	Lakshadweep	Union Territory	0	0	0	0	0	0	0	No
18	19	Madhya Pradesh	State	2931	820	1364	0	78	61660	66853	Yes
19	20	Maharashtra	State	5961	794	1887	1250	287	64320	74500	Yes

Show All Features

Fig. 7 Instance of the database for renewable energy potential in India

Quantum GIS 2.14.3 in ESRI shape file format. From the Spatial Converter Tool, two thematic layers, i.e. renewable energy potential in India and India State Boundary, have been generated.

It has been observed that overlaying analysis of various vector data and raster data of particular area has been performed. Initially, the developed geospatial databases have been opened with Quantum GIS 2.14.3 and performed some join operations. The desired overlay operation has been done with stand-alone application and is known as thick client operation. Finally, these layers have been overviewed with India State Boundary. Figure 8 shows the snapshot of two layers in Quantum GIS 2.14.3.

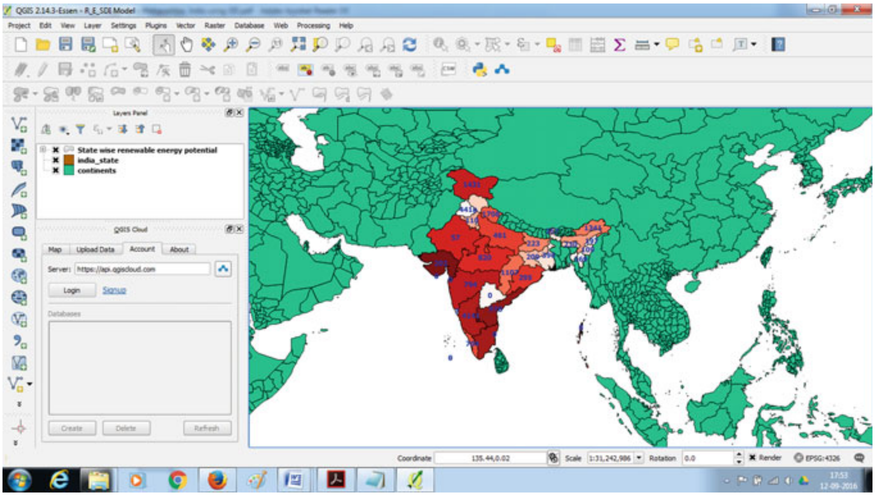


Fig. 8 Integration of renewable energy potential geospatial database

8 Concluding Remarks

The present research endeavours to link the information between the real merits and demerits of open-source GIS software via comprehensive exploration and evaluation of particular aspects correlated with functionality and complete execution. It is recognized as competent for delivering vigorous proficiencies to form the geospatial database creation for renewable energy potential in India. In regard to the creation of geospatial database, Quantum GIS 2.13.4 software invented as appropriate. However, the core emphasis of the current research is to cultivate the renewable energy potential geospatial database particularly at national level and further it will implement for Cloud SDI Model. Therefore, the database which has been established is analytical and does not include complete structures. This geospatial database may be made more ample in forthcoming studies. Currently, it has been planned to extend for other national level, and the equivalent may be deployed on the cloud environment in imminent studies.

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