ELSEVIER

Energy Policy 34 (2006) 3195–3205

ENERGY POLICY

www.elsevier.com/locate/enpol

Assessment of small hydropower potential using remote sensing data for sustainable development in India

Surekha Dudhani[a,*], A.K. Sinha[b], S.S. Inamdar[a]

[a]Bharati Vidyapeeth's College of Engineering, A-4, Paschim Vihar, Rothak Road, New Delhi-110063, India
[b]Galgotia College of Engineering, Greater Noida, Uttar Pradesh, India

Available online 28 July 2005

Abstract

India being a developing country has witnessed a rapidly growing energy needs owing to fast industrialization. Sustainable and qualitative growth for developing economics and habitat requires increased energy input from various resources while maintaining balance in the ecosystem during exploitation. Paper discusses state of the resource potentials, achievements and various issues related to the power generation in India. The growing concern over environmental degradation caused by fossil fuel based systems, opposition to large hydropower projects on grounds of displacement of land and population, environmental problems with nuclear fuel based systems and the ever-rising shortage of power highlights the need for tapping alternate energy sources for power generation. Amongst the alternate sources utilization of hydropower on a smaller scale (small, mini and micro hydropower) has become the thrust area for sustainable growth in the power sector. Hydropower is an economical and environmentally clean source of renewable energy abundantly available in hilly regions of India. Hydropower stations have an inherent ability for instantaneous starting, stopping, load variations, etc., and help in improving the reliability of power system.

Huge hydropower potential in India, yet to be explored is located at inaccessible mountainous region. However, development of this potential is challenging due to difficult and inaccessible terrain profile. Paper presents application of remote sensing data for identification and selection of probable site for hydropower projects. The algorithm for identification and assessment of water resources and its perennial is developed in Visual Basic (VB) platform and it is successfully applied for IRS-1D, LISS III Geo-coded False Color Composite (FCC) satellite image for plain as well as hilly and mountainous regions. Classification of satellite image in to different objects is modeled as the task of clustering based on the intensity of R-G-B values of pixels. Results obtained are presented and compared with the Survey of India Toposheets (53K/2, 53K/3 and 53J/16). Use of Remote sensing data provides a scientific method of hydropower identification and assessment.

Keywords: Small hydropower; Sustainable; Satellite image

1. Introduction

India being a developing country has witnessed a rapidly growing energy needs owing to fast industrialization. Primary energy demands are met largely from conventional energy sources; coal, oil, natural gas, hydropower resources, etc. Hydroelectricity represents a large-scale alternative to fossil fuel generation, contributing only very small amount to green house gas emissions and other atmospheric pollution. Hydropower is a renewable and sustainable energy source to meet global challenges (Frey and Linke, 2002) but developing the remaining hydroelectric potential in a sustainable way offers many challenges (Balsar, 2002). Information in detailed project reports based up on survey and investigations works for a potential site are not adequate and reliable at the time of actual implementation. (Yogendra Prasad, 2000).

Present task for the energy sector is to satisfy the growing demand for electric energy of the community

*Corresponding author. Tel.: +91 1125278443; fax: +91 1125278444.
E-mail address: surekhadudhani573@yahoo.com (S. Dudhani).

0301-4215/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2005.06.011

while conserving resources for the benefit of future generation. Sustainable and qualitative growth for developing economics and habitat requires increased energy input from renewable sources, while maintaining balance in the ecosystem during exploitation (Palanichamy et al., 1999). The growing concern over environmental degradation caused by fossil fuel based systems, environmental problems with nuclear fuel based systems, opposition to large hydropower projects on grounds of displacement of land and population, and the ever-rising shortage of power have highlighted the need for development of new and alternate energy sources such as, small hydropower, ocean energy, solar energy, biomass, biogas, wind power, etc. Of these small hydropower is the most attractive source of energy because of its inherent advantages such as, flexibility of utilization, pollution free generation and non-inflationary tendencies after completion.

The small hydropower technology is extremely robust and systems can last for 50 years or more with little maintenance. Small hydropower has a key role to play in meeting the challenges by reduction in carbon-dioxide (CO_2) emissions (Tondi and Chiaramonti, 1999). Even many countries have thought of making big business by establishing small hydropower projects (Moxon, 1999). There are many hilly or mountainous regions of the country where the grid will probably never reach, but which have sufficient hydro resources to meet basic domestic and cottage industry needs of the local populations.

In order to exploit the balance hydro potential to the full extent, it is necessary to adapt to new technologies such as Satellite image processing for planning, evaluation and implementation of hydro projects. Satellite Imagery has been available since the early 1970s, but is often overlooked as a powerful and cost effective tool in hydropower assessment and development. Potential uses of remote sensing is gaining importance in resource planning and management in various fields such as, ground water exploitation (Rao and Mohan, 1988), mapping of resources estimation of run off models, observation of water levels in channels (Al Khudhairy et al., 2002). Assessment of rural land use classification, (Adinarayana and Krishna, 1996; Chen and Stow, 2003). Attempt has been initiated to estimate soil erosion and slope profile of the land from the contour details (Mizukoshi and Aniya, 2002). The scope of the technology at present is limited to the study of area related parameters supported by field data. However, there are not many studies, which provide clearly the integrated application in hydropower development in particular hilly areas. In the proposed methodology the satellite image obtained from IRS-1D LISS-III is used for identification of water resources and neighboring objects such as forest/ vegetation, snow, inhabitation patterns, etc., which are the important parameters for selection of hydropower site.

Though commercially available softwares such as, ARC/INFO, MAP/INFO, GEOMEDIA, IDRISI, ERDAS Imagine, MIKE BASIN, etc. more powerful and have greater flexibility, their prohibitive cost prevents developing countries from deploying them at the end user level. This paper describes a methodology for extraction of information from the remote sensing data for mapping of water resources and its perennial for a plain as well as hilly and mountainous region in relatively more comprehensive and scientific method.

2. State of the power in India

2.1. Growth of installed generating capacity

Over the years the electricity supply in India has made significant progress. The installed capacity of the electricity supply undertakings (utilization) in the country over 50 years is increased from 1700 MW in 1950 to 108,207 MW in May 2003 and electrification of more than 500,000 villages is impressive in absolute terms (Power on demand by 2012). Efforts have been made to supply electricity to larger sections of population by way of rural electrification programmes. The growth in the installed capacity is shown in Table 1.

2.2. Resources for power generation

2.2.1. Coal

Coal-based thermal power stations are presently the mainstay of power development and this is likely to be in the immediate future also. India is endowed with 6% of coal reserves of the world. The coal reserves in the country as per the assessment carried out in January 2003, down to the depth of 1200 m stood at 240.78 billion tones. Bulk of the coal reserves are unevenly distributed in the country. Bulk of the coal reserves approximately to the extent of 73% lay in the Eastern Region in the states of Bihar, Orissa and West Bengal. Other states with sizable coal reserves are Madhya Pradesh (17.5%) and Andhra Pradesh (6.7%) and

Table 1
Growth of installed generating capacity (MW)

Year	Thermal	Hydro	Nuclear	Wind and others
1950	1153	559	—	—
1960	2736	1917	—	—
1970	7906	6383	420	—
1980	17562	11791	860	—
1990	45768	18753	1565	—
2003	76607	26910	2720	1736

Source: http://cea.nic.in.