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Renewable Energy Matters: Small Hydel Power and Sustainability in India

Madhu N. Rao

The world population crossed seven billion in 2011 and currently stands at 7.3 billion (http://www.census.gov/popclock/?intcmp=home_pop). Energy plays a critical role in the development of any country, be it environmental, economic or social. In spite of technological advances to promote better and more sustainable practices of energy production, the developing world lags behind in the ways it uses energy. As developing countries such as India move to increase their capacities for energy production, the ways in which they do so becomes ever more critical and their projects demand careful planning. Here, the skills and insights of geographers can help.

Need for New Energy Sources

The three major sources of renewable energy are solar, wind and hydro. India is a major energy producer as well as a major consumer. India ranks as the sixth largest producer and fifth largest consumer of energy in the world.

It is predicted that by 2030 India will be the most populated country in the world. Shockingly, however, more than one half of India's 1.2 billion people do not have access to continuous or uninterrupted power supply. Achieving energy access and doing so with clean energy is critical to the empowerment of the "bottom of the pyramid," which

includes the rural poor, women and children. The inadequate and skewed distribution of primary energy reserves such as coal and oil, and the need to address the challenges of ecological degradation and global warming has made renewable sources of energy such as hydro-electric (hydel) power an attractive option to meet the energy needs of a rapidly growing economy. While India is endowed with rich hydropower potential (it ranks fifth in the world), less than 25% of this potential has actually been developed. The government aims to double the country's hydel capacity and thereby meet 6% of national energy needs by 2030.

The Hydel Solution

Recognizing the urgent need for energy development, the Indian government has, through the Ministry of New and Renewable Energy, encouraged private investment, both domestic and foreign, to build small hydro-power (SHP) projects of up to 25 megawatts (MW) capacity with the estimated potential to generate 20,000 MW of power. At India's first Renewable Energy Global Investors' Meet and Expo in New Delhi on February 15, 2015, inaugurated by Prime Minister Narendra Modi, the New and Renewable Energy ministry was given a mandate to oversee small hydel power projects of up to 25 MW,

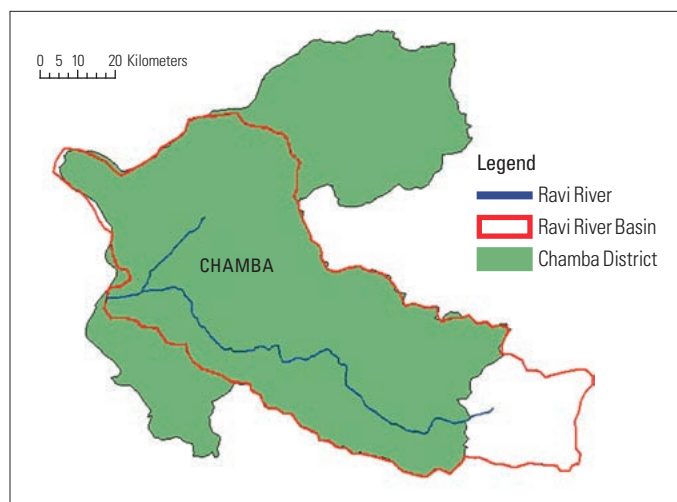


Figure 1. The Chamba District and the Ravi River Basin.

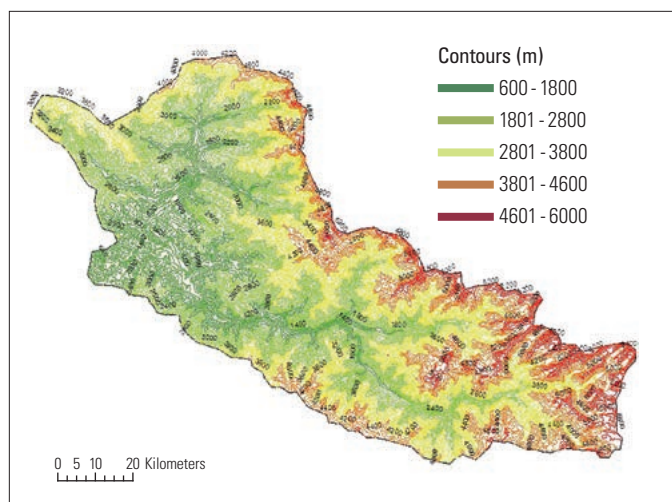


Figure 2. Contour Map of the Ravi River Basin.

while the Ministry of Power in the Indian government was made responsible for large hydro projects. With India's new push for renewable energy in wind, solar and water, a draft document on the National Mission for Small Hydro was put forth at the Meet and Expo setting a target of 5,000 MW for small hydel power by 2022. Small hydel projects are further classified thus: "Micro Hydro" (up to 100 kilowatts [kW]); Mini Hydro (101 kW to 2,000 kW [or 2 MW]); and Small Hydro (2,001 to 25,000 kW [or 25 MW]).

Incentives to Promote Hydel

With a view to motivate entrepreneurs (particularly those in small- and medium-sized enterprises) to contribute to hydel power development, the Renewable Energy ministry has offered new incentives and programs of financial support to small and mini hydel projects with capacities of less than 25 MW. Subsidies are provided through the Indian Renewable Energy Development Agency, Ltd., about Rs 50 million (or about \$755,500 USD) for the first MW plus Rs 5 million (or about \$75,550 USD) for each additional MW. The subsidies are disbursed in four installments with 25% offered at the time of the award of work orders and the signing of contract agreements.



Figure 3. Study Area: Chamba District, Himachal Pradesh, India.

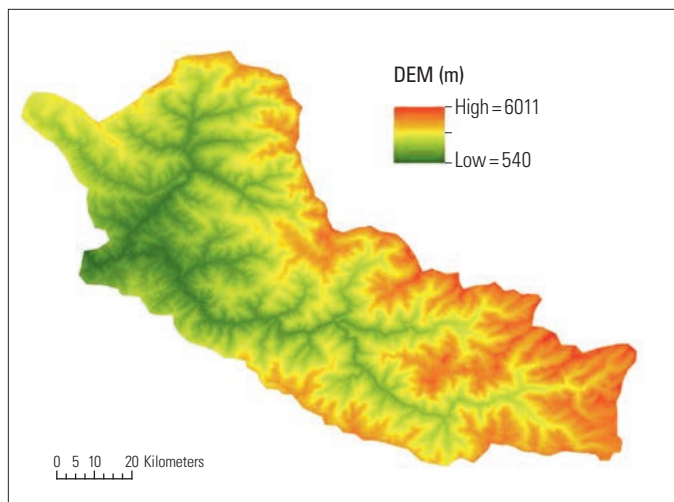


Figure 4. Digital Elevation Model, Ravi River Basin.

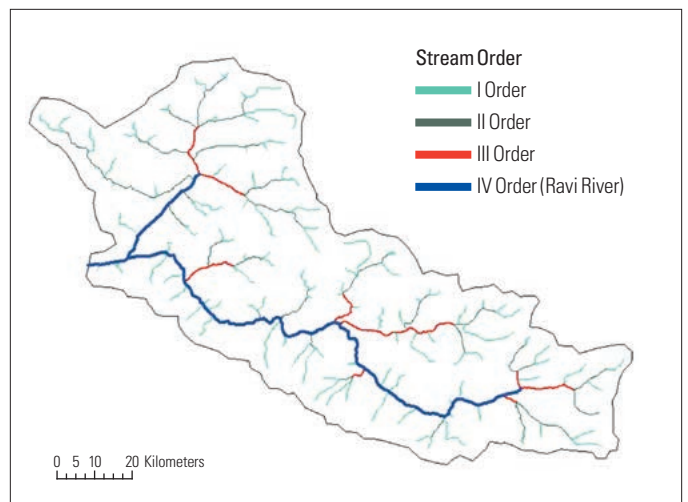


Figure 5. Stream Order Map, Ravi River Basin.

Hydel power projects will transform rural landscapes in India into models of sustainable development. By supplying power to households, they discourage denuding of forests for conventional fuel and they generate local employment opportunities, and thereby reduce outward migration of rural people to urban areas in search of livelihood.

Arunachal Pradesh, Jammu and Kashmir, where mountain slopes facilitate the run-of-the-stream model, a model that does not require construction of expensive dams and has a smaller environmental footprint. By improving the remote and inaccessible regions, SHP projects play a crucial role providing uninterrupted power supply and a better quality of life to local residents through direct employment in areas where development and industrialization have not yet taken hold.

Hydel Development in Himachal Pradesh

The state of Himachal Pradesh, in the northwestern region of India, has in its five river basins a vast hydel power potential of about 23,000 MW, of which about 750 MW are available for exploitation by small- and medium-sized enterprises under the small Hydel sector. The provincial government has therefore encouraged private investment in small hydel power projects by streamlining procedures to minimize the bottlenecks and by expediting contractual agreements with private firms. With a view to promoting development and sustainability in rural areas, the provincial government has instituted a hydel power policy by which 1-1.5% of the final cost of the hydel projects would be transferred to a Local Area

The next 30% is given after a project achieves 25% progress, a third instalment of 35% given when 50% progress is achieved, and the remainder (10%) is disbursed at completion of the project, which demands successful commissioning and performance testing, along with three months of power generation. To expedite the production of power, the Indian government has encouraged private enterprises to take up hydel

power projects on a “BOOM” (build, own, operate and manage) basis. As a result of all these policy measures in recent years, SHP projects have mushroomed in the mountainous regions of India, where natural run-of-the-river streams can be harnessed for power production in a cost-effective manner.

About 50% of the SHP potential of the country lies in the Himalayan states of Himachal Pradesh, Uttarakhand,

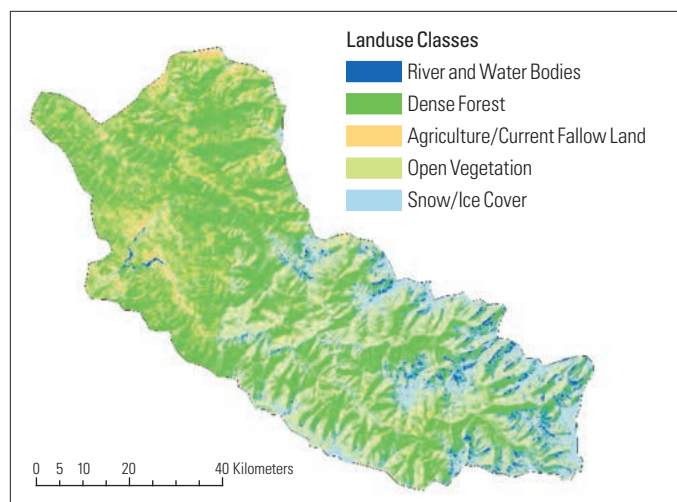


Figure 6. Land Use Classification Map of Ravi River Basin for 2000.

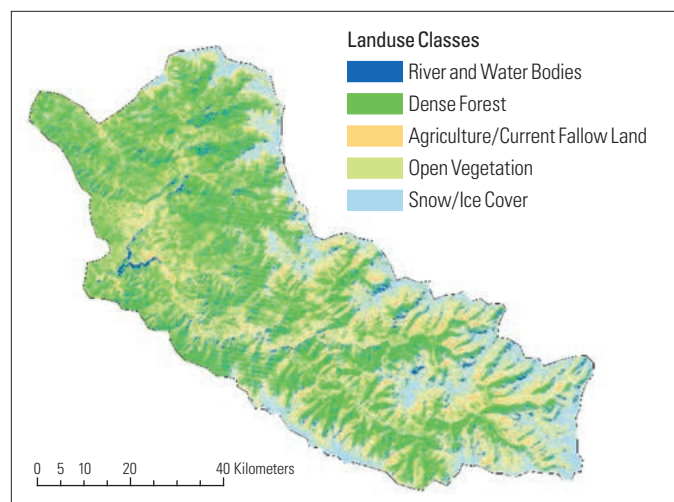


Figure 7. Land Use Classification Map of Ravi River Basin for 2005.

Development Fund. This fund provides a regular stream of revenue to generate income for the rural population, undertake welfare programs, and create infrastructure and community facilities on an ongoing basis over the life of the projects.

Remote Sensing and GIS Techniques

Here is the focus of my recent research, in which I have done preliminary groundwork for the examination of the impact of SHP projects on the sustainability or vulnerability of mountain ecosystems in Himalayan India, particularly in the Chamba district adjoining the Ravi River basin in Himachal Pradesh (Figure 3). The Ravi River, one of the five rivers flowing in Himachal Pradesh, was selected as a case study, and geospatial technologies, including remote sensing and geographic information system tools, were applied. Several sequential steps were necessary to take in order to comprehend the Ravi River ecosystem. First, in order to extract the Ravi River basin boundary, the available topographic and river basin information was examined to draw an approximate outline map of the basin (Figure 1). Next, in order to obtain the contours within the basin, ASTER (Advanced Spaceborne

Thermal Emission and Reflection Radiometer) global digital elevation model version 2 data sets were used. Elevation details of the study area were extracted (<http://earthexplorer.usgs.gov/>) to generate the Contour Map and Digital Elevation Model (Figures 2 & 4). Strahler's method of classification was used to generate stream ordering. The stream starting at the headwater is assigned number one to be recognized as a "first-order" stream. When two of these first-order streams come together, the resulting tributary is considered second-order. When two second-order streams join, the result is a third order, and so on. In this taxonomy, the Ravi River basin qualifies as a fourth-order basin (Figure 5).

Remote-sensing technology is a powerful tool for studying land-use and land-cover changes over time and across scales of analysis. Land use refers to what people do on the terrain (e.g., agriculture, industry, settlement). Land cover refers to the type of objects present on the landscape (e.g., crops, forest, water bodies, type of soil, wetlands, artificial entities such as buildings, roads). By generating a series of historical images, we can trace changes over time and quantify sustainability through socioeconomic and biophysical variables. Sequential

land-use/land-cover data classification provides one of the more valuable indicators of economic development and sustainability. The data for this is obtained from Land Satellite program (Landsat) launched by the National Aeronautics and Space Administration in 1972. These satellites record energy in multiple bands of the electromagnetic spectrum. The Multispectral scanners (MSS) of Landsat record the Earth's features that are of significant value for change-detection studies. Certain regions or bands of the electromagnetic spectrum record the spatial attributes of objects on the terrain. The United States has progressed from Landsat MSS launched in 1972 to more advanced scanning systems now. The Landsat Thematic Mapper records seven bands. The Earth Resources Data Analysis System (ERDAS) remote-sensing software tool was used to retrieve information on biophysical parameters for the years 2000, 2005 and 2010, and the images were classified into homogeneous categories for further analysis and interpretation. Using ERDAS Imagine, a technique called "supervised classification" was used and four land-use classes were identified in the Ravi River basin. The area was broken down into these main classes: River and Water Bodies, Dense Forest, Agriculture/Current Fallow, Open Vegetation, Snow/Ice Cover

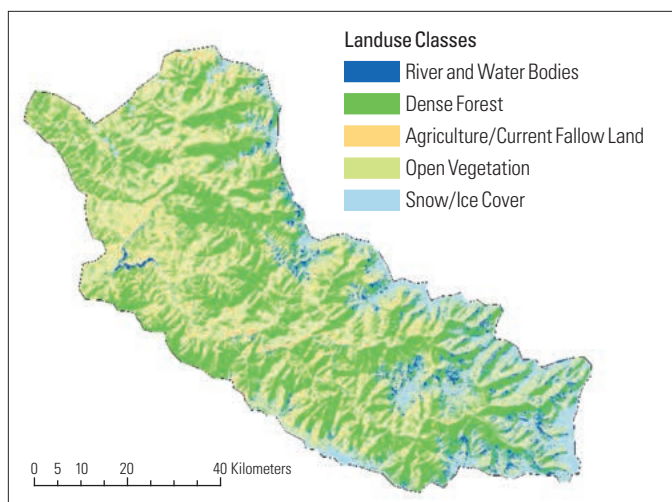


Figure 8. Land Use Classification Map of Ravi River Basin for 2010.

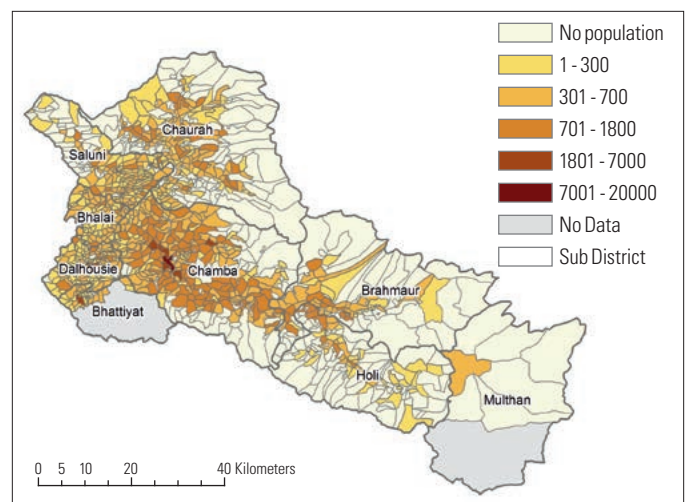


Figure 9. Population by Villages, Ravi River Basin, Chamba, Himachal Pradesh, India.

land, Open Vegetation, and Snow/Ice Cover (Figures 6, 7 and 8). The study results reveal significant changes over time in the ways that land in the Ravi basin were used. The temporal changes of land use are presented below.

LANDUSE CLASSES	2010	2005	2000	1989
River and Water Body	265	410	260	262
Dense Forest	1547	1638	1938	2021
Agriculture Land	678	702	655	614
Open Vegetation	2214	1837	1900	1825
Snow Cover	280	367	218	264

Table 1. Area of Various Land Use Classes in the Ravi River Basin (in square kilometers) compared over time

The figures in the table above make it clear that the area under open vegetation has increased in the last five years while decline of the forest land is also apparent. For the year 2005, the area designated as river and water body is much greater than in other recorded years. This could be the result of heavy rain and stagnant flood waters that had accumulated just before the satellite photo was taken.

Gathering these basic data breaking down land use practices is only a starting point, a baseline that we need to have to measure real change once hydroelectric development is instituted. But if we are going to be able to forecast how hydro-electric power production will intervene on life in the Ravi basin, we need also to know where its people actually live. And so, using data from the most recent district census of India (2010), all villages in Chamba district were digitized, coded and mapped (Figure 9). Two immediate patterns emerge: villages cropped up wherever there was land feasible for agriculture; and population clustered along the areas adjoining the Ravi River.

Toward Sustainable Rural Development

These findings are a critical first step for any assessment of how hydro-electric power development in Himalayan India

emissions and global warming, maintain ecological balance and biological diversity, and arrest water pollution.

The implementation of hydel projects, however, is a complex undertaking and if not properly managed and controlled, can lead to serious negative impacts on the environment and the local economy. Care needs to be exercised so as not to upset delicate ecosystems and endangered species throughout the Himalayan region. With their multifarious impacts and benefits, these mini-hydel projects can contribute to a more environmentally friendly and sustainable rural development model in India. But they must be developed with

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will progress and help us gauge the sorts of real impacts it will have on both ecosystems and the ways they shape human lives. Hydel power projects will transform rural landscapes in India into models of sustainable development. By supplying power to households, they will discourage denuding of forests for conventional fuel and they generate local employment opportunities, and thereby reducing outward migration of rural people to urban areas in search of livelihood. The emergence of ancillary small-scale industries increases labor productivity and enhance the standard of living of rural people. Done right, hydel can also control greenhouse gas

a comprehensive knowledge of the land and water they are using. And that's where geographers, trained in the techniques of land-use analysis, can help.



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