



Assessing the impact of small hydropower projects in Jammu and Kashmir: A study from north-western Himalayan region of India



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ABSTRACT

Small hydro projects (SHPs) are considered to be more eco-friendly as compared to large reservoir-based hydro projects. Throughout the world, SHPs are found to be more socially acceptable when compared with large ones because of less displacement of the population of the area and minimum harmful effects on flora and fauna. But still, in the western Himalayan region, these SHPs are under the radar of environmentalists and local communities because these projects sometimes cause the long-term negative impact on the environment due to lack of proper planning. The unwanted blockages in the mainstream, ruthless drilling, blasting of mountains and adverse effects on the downstream of the river due to migration of fish species are some of the environmental impacts. This research article presents the study of SHPs development in Jammu and Kashmir (J & K), as it is one of the hydro-rich states in the northwestern Himalayan region of India. In this paper, three SHPs from J & K are taken for the case study. To find out various sustainability issues related to these SHPs, a detailed discussion with the project affected people, interaction with the technical staff of these projects and in-depth field survey was carried out.

1. Introduction

Due to increase in population and expanding industrialization, urbanization, modernization and salary development, the worldwide power utilization is relied upon and will keep on growing altogether in the coming years to come. As indicated by the global energy outlook 2013 by the United Nation Energy Data Organization, the current worldwide essential energy requirement is 1.60×10^{14} kWh and is anticipated to reach very near to 2.40×10^{14} kWh by 2040. It is normal that the global utilization of electricity will be multiplied in the coming 15–20 years. It is anticipated that China, India, Morocco and so forth will increase their electrical energy utilization to two-fold in the following one to two decades [1]. India is one of the fastest developing monetary forces of the world and is expected to become developed country by 2020. The globalization of Indian economy, because of strategy change in the late years have a stimulating effect on the different segments of the economy and is presently heading for balanced and quick development in the coming years. This rate of progress will be hard to manage because of foundation bottlenecks on account of financial constraints and energy availability in the country. Government under the foundation advancement system has started different measures, including setting up of a base money organization and looking for private investment for support ventures including

influence area. To limit the gap between real power required and aggregate energy produced, tapping of unutilized hydropower potential in a quick and time bound way exhibits both, an open door and also a tough undertaking [2,3]. Hydropower is turning into the fastest developing renewable energy source in the world. Hydropower system produces around 20% of the world's power, and it is helping in the generation of energy with minimum emission of greenhouse gasses [4,5].

Since the large hydro projects have social, economical and environmental negative impacts because of which in many countries the main focus is shifted towards the installation of new small hydropower projects [6]. Especially after the oil emergency of 1973, enthusiasm for small hydropower projects (SHP) has been restored [7]. The global small hydropower potential is nearly about 173 GW [8]. The establishment of small hydropower potential is assessed to be 75 GW in 2012. Afghanistan, Bangladesh, Bhutan, India, Iran, Nepal, Pakistan and Sri Lanka have the small hydropower potential evaluated at 18,077 MW, and of which only 3563 MW has been developed [8,9]. Table 1 shows the benefits which are highlighted by the other researchers throughout the world related to small hydro projects. So, it is evident from the Table 1 that these kind of hydropower projects are very popular among developing nations like India, Pakistan, South Africa and China, and as well as in the developed countries like Germany, Europe, and United

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Table 1

Shows the small hydro projects current status in different countries all over the world.

Author	Important points related to the development and planning of SHPs
Xingag et al. [42], Chang et al. [43], Zhou et al. [44]	<ul style="list-style-type: none"> ● The demand of energy in China is increasing at a very rapid pace because of its enormous population and fast growing economy. The government of China is also searching for more reliable, sustainable and environmental friendly resources of energy to overcome the energy demand. The government is also paying attention towards the adverse impact of energy sources on the life of local people. ● The country is having enormous potential of Small Hydro Projects (SHPs) throughout its area. It is also estimated that these SHPs fulfill 80% (till 2014) of the energy demand of its renewable energy. These kinds of SHPs are considered to be more socially acceptable in China as compared to the large hydropower projects. So these type of projects are very popular in the country and also getting due attention from the government because of the benefits of displacement related issues which are minimum in such projects and less construction period when compared with large hydro projects.
Mishra et al. [45] Gupta et al. [46], Reddy et al. [10], Mishra et al. [47], Hoffken [48], Nautiyal et al. [49]	<ul style="list-style-type: none"> ● The hydropower potential in India is very huge and rank 5th position in the world. Because of Himalayan region in north India the topographic conditions are perfect for the installation of large as well as the small hydro power projects in the region. The overall potential of SHPs in India is estimated to 15 GW. The capacity of power generation ranging from 2 MW to 25 MW falls under the category of SHPs and below 2 MW come under the category of Mini Hydro Projects (MHPs). ● In various states of India, the state governments are promoting the SHPs and registering them under the Clean Development Mechanism (CDM) to get special financial benefits from the centre government but till date only small portion of the available hydro-potential is harnessed. This may be because the locations of these projects which are very remote and even some becomes economically not feasible. This is the main reason that during invitation of bids for these projects no power developer shows interest for their construction in such regions. But nowadays the state governments are paying particular attention to the development of these projects in their respective states and offering exclusive benefits to private developers for the construction of SHPs in such remote places.
Mainali and Silveira [50]	<ul style="list-style-type: none"> ● In Nepal, these SHPs can play a crucial role in locations where the grid connectivity is not present. Constructing these kinds of SHPs along with the small grids in the remote areas of Nepal will results in a permanent source of energy for the remote locations where the central grid connectivity is not economically possible.
Bahadori et al. [51]	<ul style="list-style-type: none"> ● In Australia the local people prefer Mini Hydropower projects because of less water needed for generation purpose and having less adverse effects on the local environment. No reservoir is constructed for these projects where as in the large hydro projects huge reservoirs and dams have to be built for the generation. Especially in Australia where MHPs are more viable as the rivers/streams are having smaller capacity and therefore the large hydro power projects are not feasible. Moreover in the case of MHPs the construction cost, installation time, and the payback period is very less as compared to large projects.
Taele et al. [52]	<ul style="list-style-type: none"> ● Various research studies have been carried out on the potential of SHPs in the Lesotho country and concluded that this source of renewable energy can play a vital role in the development of its rural areas. Till 1990 a total potential of 20 MW have been identified for the mini hydro power projects from 22 different sites. This source of renewable energy will reduce the dependency of Lesotho on the fossil fuels.
Spänhoff [53]	<ul style="list-style-type: none"> ● In Germany, there is feasibility for the installation of only a few numbers of more SHPs and MHPs. The installation of new run of the river large hydropower projects has almost been exhausted in the country.
Zimny et al. [54]	<ul style="list-style-type: none"> ● In Poland, the power generation through SHPs is only 0.6% of the total generated power. The SHPs potential is still needed to be explored in the country, as there is tremendous potential of SHPs in this part of the world which can be achieved only if proper financial support is given by the government. In Poland, 30% of the power supply is coming from large hydropower projects.
Kaunda [55]	<ul style="list-style-type: none"> ● After having the proper survey and pre-feasibility reports, the researchers come to the conclusion that Malawi is having an enormous potential of hydropower projects. The installation of these kinds of projects can play a significant role in rural electrification and nation's development.
Panić et al. [56]	<ul style="list-style-type: none"> ● Serbia government is taking necessary steps to encourage SHPs installation in rural areas because of its advantages and to make the people of Serbia less dependent on fossil fuels for power generation. The installation of more SHPs will help the country to become self-dependent in the field of energy requirement and reduce the import of power from outside. The life cycle or working period of these projects are also very large i.e. up to 50 years on an average.
Tristán et al. [57]	<ul style="list-style-type: none"> ● In the developed countries, the SHPs are considered as one of the most reliable source of renewable energy when compared to other sources. In Europe where most of the large hydro power projects were already installed and are ecologically less stable, the SHPs can be considered as the future for power generation to meet their energy demand.
Bakis & Demirbas [58], Dursun and Gokcol [59]	<ul style="list-style-type: none"> ● Turkey has a tremendous potential for small and large hydropower projects but till date, only one-third of the hydro potential is harnessed by the power developers in the country. Because of the advantages of SHPs to society and local environment, it has emerged as an important source of renewable and cleaner energy in the country. Some of the benefits of SHPs are low investment cost and less construction period, moreover the topography of the country is also more suitable for the development of SHPs.
Martins et al. [60]	<ul style="list-style-type: none"> ● In Brazil, the total number of SHPs which were registered to clean development mechanism is increased to 339. Most of these projects are in operations and remaining projects are expected to start soon in the near future.
Kaunda et al. [61]	<ul style="list-style-type: none"> ● Sub-Saharan African country is facing a massive power crisis in the remote areas where the grid connectivity is not present. Also for the main grid to reach the places which are so remote in Sub-Saharan African is not possible and this is one of the biggest challenge for the government. The researchers also feel that to adopt the non-grid connectivity technologies is the only solution by which this energy crisis can be solved. In this region, the potential of SHPs exists and can be utilized to overcome the power shortages. But these SHPs were site specific, and there is an urgent need to conduct the pre-feasibility survey by the local government to identify the locations where these projects can be installed and economically viable. These kinds of studies have not been performed so far in this region so, if the necessary information and data become available, then it can play a paramount role for the development of such kind of projects in Sub-Saharan African country.
Yi et al. [62]	<ul style="list-style-type: none"> ● In Korea, there are large numbers of SHP sites present which are not harnessed by the power developers so far

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