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Environmental sustainability of run of the river hydropower projects: A study from western Himalayan region of India

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ABSTRACT

Run of the river (RoR) hydropower projects are generally considered more environmentally sustainable as compared to their reservoir based counterparts. Further, impacts of these projects are supposed to be in proportion to their installed capacity. Large numbers of this category of hydropower projects in different size ranges are coming up in Himalayan regions. Un-sustainable construction/operation practices adopted during development and/or running of these projects are posing an environmental threat to this fragile and youngest mountain range of the world. This research paper presents a public perception cum data collection study on the environmental impacts of small and large RoR hydropower projects located in western Himalayan region of India. A structured questionnaire was designed to collect the primary data pertaining to intangible impacts while secondary data was collected to analyse tangible environmental parameters. The study concludes that every environmental impact of SHPs is not 'small' as compared to LHPs. Ignoring the environmental impacts of SHPs may not be a good practice.

1. Introduction

Hydropower is acknowledged as one of the important renewable and sustainable energy resource. It is a cheaper and greener substitute for fossil fuel based electricity production and thus believed to restrain Green House Gases (GHGs) responsible for climate change [1–4]. It accounts for about 18% of the total world electricity production as in 2012 [5].

A number of reservoir based multipurpose hydropower projects have been developed globally in the past for example Three Gorges Project (22,500 MW) in China, Itaipu hydroelectric power plant (14,000 MW) at the border of Brazil and Paraguay, Guri Power Project (10,400 MW) in Venezuela etc. [6]. These projects were promoted as icons of social and economical development. However, their negative environmental impacts also started emerging with the passage of time. The most noted environmental impacts are deforestation, emission of GHGs from the reservoirs, biodiversity loss, species extinction, forest areas flooding, habitats destruction, farmland loss, alterations in the water regime, water bodies morphology, fish fauna impact etc. [7–10]. Majority of these impacts have been attributed to the construction of huge dams, formation of gigantic storage reservoirs behind the dams and submergence of huge area due to reservoir formation.

In view of negative environmental impacts associated with reservoir based large hydropower projects (LHPs), run of the river (RoR) mode of hydropower generation is considered more environmentally sustainable [11,12]. In this mode, water is diverted to the power house and it rejoins the main stream after electricity generation. Fig. 1 shows sketch of a typical RoR project. In view of either small size or complete absence of storage reservoir, environmental impacts of RoR hydropower projects are somewhat different from that of their reservoir based counterparts. Furthermore, environmental impacts of hydropower projects are generally considered proportional to the project size [14,15].

1.1. Literature review

Social, economic and environmental aspects of hydropower generation have been the favourite topic of many researchers. However, most of the research studies had been undertaken in the context of reservoir based hydropower projects only. Comparatively lesser numbers of researchers have forayed into the impacts associated with RoR projects. This study is a noble attempt to bridge this gap in the context of environmental impacts. Table 1 lists some research studies which had reported positive and negative aspects

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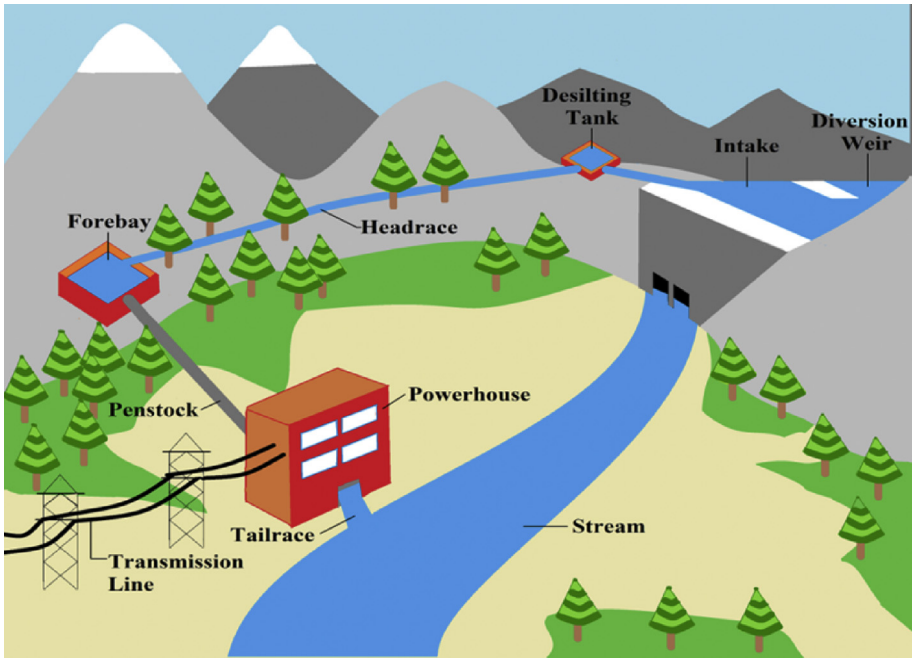

Fig. 1. A typical Run of the River (RoR) project [13].

of RoR hydropower projects.

It can be construed from Table 1 that main positive aspects of RoR projects are production of electricity without significant submergence and comparatively less construction/operating cost. In view of small reservoir size or complete absence of reservoir, these types of projects are supposed to be more environmentally sustainable in comparison to their reservoir based counterparts. On the other hand, less availability of water for consumptive use in the diverted stretch and more vulnerability to large flow fluctuations have been the main negative aspects.

There are only a few research studies mentioned in Table 1 e.g. Lata et al., 2013 [25], Diduck et al., 2013 [28] and Kumar and Katoch, 2015 [29] which have undertaken public perception studies with respect to RoR hydropower projects. Besides these studies, Sharma et al., 2007 [31] carried out a public perception survey to assess the man-made and natural hazards in the surrounding of two hydropower projects (Parbati Stage-II and III) in Kullu valley of Himachal Pradesh, India. Thoradeniya et al., 2007 [32] identified the social and environmental impacts of a mini hydro project in Ma Oya basin in Sri Lanka through consultation of stakeholders of the area. However, these research studies involved either large or small RoR hydropower project(s). In the present study, the authors have collected and compared public opinion about environmental impacts from large as well as small RoR projects.

In the present scenario, RoR large hydropower projects are also under criticism in view of unsustainable construction and operational practices resulting into many environmental hazards. This is happening despite provision of Environment Impact Assessment (EIA) for large projects i.e. having installed capacity more than 25 MW as per Indian classification [16,17]. Keeping in view these problems, now the focus has been on RoR small hydropower projects [18]. The main objectives of the present study are to:

- collect public opinion about environmental impacts of RoR hydropower projects
- collect and compile data about tangible environmental indicators of RoR hydropower projects
- compare the environmental impacts of small and large RoR hydropower projects based upon the collected public perception and tangible environmental indicators.

2. Methodology

To achieve the objectives outlined in the 'introduction' section,

Table 1
Positive and negative aspects of RoR hydropower projects.

Positive aspects	
• Few social and environmental impacts as compared to reservoir based hydropower project of equivalent installed capacity.	[11,19–26]
• Production of electricity without significant submergence due to small size of the reservoir. Hence, reservoir related problems (e.g. relocation of people, health impacts and reservoir induced seismicity) are less.	[2,11,12,20,25,27]
• Involve less construction/operating cost, less civil engineering work and less GHG emissions.	[2,11,12,25,26]
• Less interference with fish migration and are less prone to sedimentation as compared to large reservoirs based projects.	[2]
Negative aspects	
• Less availability of water for consumptive use (water supply and irrigation) in the diverted stretch, dust emissions, air pollution, noise, soil erosion, landslide, excavation debris, health problems, impact on aquatic life, destruction of natural habitat, aesthetic impacts, change in chemical composition and physical characteristics of water (pH, temperature, suspended solids, etc.), impact on trees or farm land,	[19,20,24,25,28,29]
• Drying up of natural drinking water springs, reduction in sub-soil moisture, impacts on agriculture and horticultural productivity, cracks in nearby houses due to vibrations caused by blasting, fracturing and fissuring of underground strata	[27–30]
• Deforestation, disruption of local flora and fauna and disturbance to hill slopes	[29]
• More vulnerable to large scale flow fluctuations (power production mimics river flow profile), less capacity to manage flash flow events	[8,20,26]
• Impact on fishing, hiking and other recreational facilities, opposition from local communities	[25]