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A Review on Assessment of Environment Impact of hydro-projects in Himachal Pradesh

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Abstract—. India is the 7th largest hydroelectricity producer globally, accounting for 3.3% of total hydroelectricity and ranking 5th in exploitable hydroelectric energy. Himachal Pradesh, rich in water resources, generates 25% of the gross hydropower produced. The expansion of hydropower and the associated risks to the environment have both favourable and unfavourable consequences on the environment, despite the fact that hydropower is a very efficient renewable energy source. The state has numerous hydropower projects, including Bhakra Nangal Dam, Nathpa Jhakri Dam, Chamera Dam, Karcham Wangtu Hydroelectric Project, Salal Hydroelectric Power Station, and Rongtong Hydroelectric Project. These projects provide a substantial contribution to India's position as a prominent hydropower producer. Nevertheless, it is essential to exercise appropriate oversight over environmental and social consequences. Thorough Environmental Impact Assessment (EIA) and active involvement of the community are crucial for the appropriate construction of hydropower projects. The involvement of state governments and regulatory organizations is essential in supervising and controlling these projects to ensure sustainable growth.

Keywords— *Adverse Impacts, Hydropower Projects, Environmental Impact Assessment, Environmental Effects.*

1. INTRODUCTION

An environmental impact assessment (EIA) is a thorough examination of the possible favourable and unfavourable effects that a project's environmental impacts might have. A number of aspects are considered in this evaluation, including environmental, social, and economic ones. The purpose of the assessment is to make sure that the potential environmental impacts are considered by those making the decision to go forward with the project [1]. According to U.N. Environment Programme (UNEP) definition, an EIA is a pre-decisional and pre-commitment procedure for methodically determining, assessing, and reducing a project's environmental effects. Thus, it also functions as a means to ensure that projects are carried out with thorough regard for environmental factors. An EIA often leads to the development of an EMP, which provides detailed information on the actions to be taken to minimize and monitor any negative effects. EIAs are mandatory in the majority of developed nations for planned (hydropower) projects that surpass a certain scale.

The Indian Himalayan rivers have significant potential for hydropower production, with 20463.5 MW of hydropower capacity in five river basins. Himachal Pradesh, a rapidly developing state in India, depends on agriculture, tourism, cement, and hydropower as key drivers of its economic expansion. India has a total hydel capacity of 23,000 MW, which accounts for 25% of the country's overall hydel potential. Currently, hydropower projects have already used 8,368 MW, and there are plans to exploit an additional 3,805 MW. Although the Indian government recognizes hydropower as a crucial renewable energy source, it lacks the necessary resources and capabilities to efficiently and promptly develop these projects [2]. Incentive packages enhance the profitability of hydropower investments by effectively reducing costsWhile increasing hydropower capacity promotes economic growth, it also exacerbates environmental problems and causes disputes over the distribution of water and land resources. Long river sections vanish because of the repeated diversion of rivers into head race tunnels, which dries out a significant portion of the riverbed. This calls into question how well India's present Environmental Impact Assessment (EIA) system assesses and mitigates environmental problems. There is a dearth of research examining the intrinsic constraints of the legislation and the possibilities of alternative assessment instruments to enhance environmental decision-making for hydropower development in India. The majority of research focuses on assessing compliance with current EIA procedures.

2. ENVIRONMENTAL IMPACT ASSESSMENT

The methodical process of assessing a proposed development project's environmental effects—both positive and negative—is known as an environmental impact assessment, or EIA. Its goal is to ensure that these effects are properly taken into account during the project design process. All relevant facets of the ecological, social, economic, and human environments may be affected by these outcomes.Hence, the research necessitates an interdisciplinary approach and should be conducted within the initial stages of a project's viability. A research examined the EIA of a Himachal Pradesh (HP) hydropower project in

light of recent natural disasters in Uttarakhand. The Supreme Court of India has ordered a complete EIA evaluation for hydropower projects on the Bhagirathi and Alakhnanda rivers and in mountainous locations. Due to the conditions, an EIA study for a conventional hydropower project in Himachal Pradesh, India was done [3]. The essay examines a hydropower project's EIA and recommends remedial steps.

An Environmental Impact Assessment (EIA) is a crucial tool for figuring out if a proposed project, program, or policy will harm or help the environment. Reducing negative impacts on the environment and encouraging decision-makers to consider these effects are the primary goals of environmental impact assessments (EIAs). Screening for the need of an EIA should be the first order of business. Based on factors like size, location, and possible environmental effects, projects are screened. Scoping is the process of defining the parameters of the assessment, such as the methods to be employed and the environmental aspects to be taken into account. Stakeholders and the public are often involved in identifying issues and concerns to be addressed in the assessment. Baseline investigations are performed to determine the current environmental conditions in the project area. These studies evaluate variables such as the quality of air and water, biodiversity, socio-economic circumstances, and cultural heritage. This stage entails forecasting the probable ecological consequences of the proposed project, drawing on the baseline data and project plans [4]. Various situations may be taken into account, and modeling or other analytical methods can be used to evaluate the effects. Based on predicted repercussions, mitigation techniques try to lessen or eliminate environmental damage. These steps may include alterations to project design, adoption of optimal methodologies, or remuneration for inevitable consequences. An Environmental Management Plan (EMP) describes the project's management strategy to guarantee adherence to environmental laws and minimise impacts during the phases of building, operation, and decommissioning. Making decisions about whether and under what circumstances to move forward with the project depends on the EIA's conclusions, which include projected consequences and suggested mitigation strategies. To keep tabs on the project's environmental performance and make sure it complies with all regulations and mitigation strategies, monitoring programs are set up once the project is authorized and put into action. To mitigate the effects of unanticipated outcomes, modifications may be made based on monitoring data. Sustainable development and environmental management often use environmental impact assessments (EIAs) to discover a compromise between fostering economic growth and safeguarding the environment. It is required for certain types of projects in many nations' laws and regulations.

3. ENVIRONMENTAL ASPECTS LINKED TO HYDROELECTRIC PROJECTS

Hydroelectric projects, while providing significant benefits in terms of renewable energy generation and water resource management, also have environmental impacts that should be carefully considered [5]. The environmental impact of hydro-projects can vary depending on factors such as the size and type of the project, its location, and the specific technologies used. Here are some common environmental considerations associated with

Habitat Alteration and Loss: Natural ecosystems may be altered or lost as a result of the building of dams and reservoirs. Flooded areas can submerge terrestrial ecosystems, affecting plant and animal species, disrupting migration routes, and potentially leading to the loss of biodiversity.

Water Quality: The alteration of river flow and the creation of reservoirs can influence water quality. Changes in temperature, sediment transport, and nutrient cycling may occur, impacting aquatic ecosystems and the organisms that depend on them.

Fish Migration and Spawning: Dams can obstruct the natural migration of fish and disrupt their spawning patterns. Fish passages, such as fish ladders or lifts, are sometimes implemented to mitigate these effects, but their effectiveness can vary.

Sedimentation: The trapping of sediment behind dams can lead to downstream erosion and affect riverbed morphology. This can impact aquatic habitats and the organisms that depend on stable riverbed conditions.

Altered Flow Regimes: Hydroelectric projects can alter natural river flow patterns. This may affect downstream ecosystems, including floodplains and wetlands, and impact the flora and fauna adapted to specific flow regimes.

Social and Cultural Impacts: Hydro-projects can have social and cultural implications, especially if they result in the displacement of local communities. The construction of dams and reservoirs can lead to the loss of agricultural land, cultural sites, and traditional livelihoods.

Greenhouse Gas Emissions: Although hydroelectric power is regarded as a clean and renewable energy source, methane, a strong greenhouse gas, can be released as organic matter breaks down in reservoirs. A number of variables, including water temperature, depth, and nutrient availability, affect how much of these emissions occur.

Geological and Seismic Risks: The construction and operation of dams can sometimes induce geological and seismic risks. Changes in water levels and reservoir-induced

seismicity may occur, potentially leading to landslides or earthquakes.

To minimize the environmental impact of hydro-projects, Before beginning construction, it is crucial to carry out comprehensive environmental impact assessments (EIAs), put mitigation plans in place, and integrate sustainable practices. Advances in technology and improved project design can also help address some of the environmental challenges associated with hydroelectric developments.

4. THE EFFECTS OF HYDROELECTRIC DEVELOPMENTS IN HIMACHAL PRADESH

The rugged landscape and plentiful water resources of the northern Indian state of Himachal Pradesh have led to a proliferation of hydropower plants [6]. These projects have social and environmental implications in addition to their contributions to the state's energy production and economic growth. Important factors to think about while assessing the effects of hydro-projects in Himachal Pradesh are as follows:

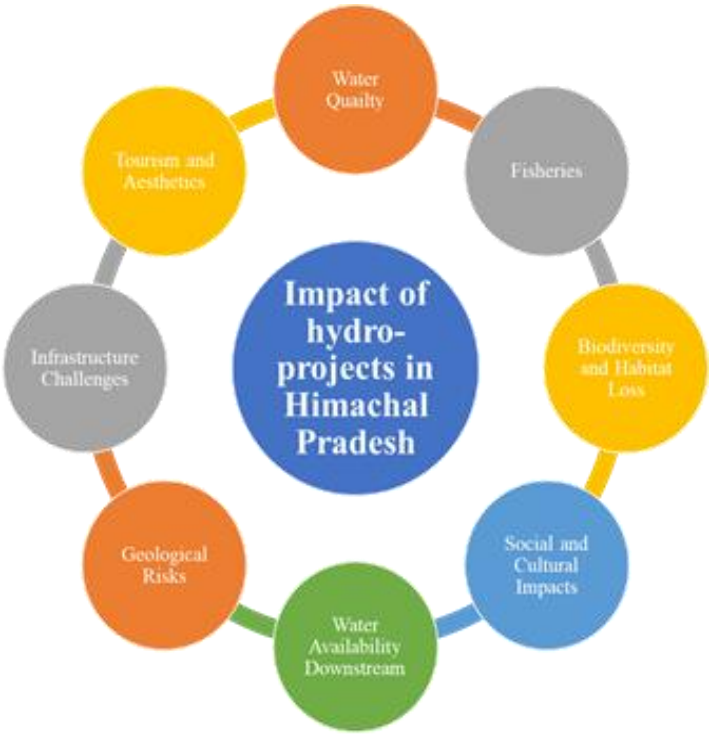

Fig.1 Impact of hydro-projects in Himachal Pradesh

Biodiversity and Habitat Loss: Building dams and reservoirs in Himachal Pradesh may cause land to become submerged, which could cause natural habitats to disappear or change. This may have an effect on the local wildlife and vegetation, which could result in a decrease in biodiversity

Fisheries: Hydro-projects in the region may disrupt river ecosystems and impact fisheries. Changes in water flow, temperature, and sedimentation can affect fish migration patterns and spawning, influencing the livelihoods of communities dependent on fisheries.

Water Quality: The alteration of river flow and the creation of reservoirs can influence water quality. Changes in sediment transport and nutrient cycling may affect aquatic ecosystems, impacting both water quality and the organisms inhabiting the water.

Social and Cultural Impacts: Communities may be uprooted as a result of dam building, which will have an effect on their customs, farming methods, and cultural heritage. Adequate compensation and resettlement measures are crucial to address these social concerns.

Tourism and Aesthetics: One of the main draws for visitors to Himachal Pradesh is its breathtaking scenery. The construction of dams and reservoirs has altered the landscape, which may have an effect on tourism by reducing the area's aesthetic appeal.

Infrastructure Challenges: The development of hydro-projects often requires extensive infrastructure, including roads and transmission lines. The construction and maintenance of such infrastructure can have localized environmental impacts, including habitat disruption and soil erosion.

Geological Risks: The mountainous terrain of Himachal Pradesh poses geological challenges. Dam construction and reservoir filling can induce seismic activity and landslides, necessitating careful geological assessments and mitigation measures.

Water Availability Downstream: Changes in river flow patterns can affect water availability downstream. Local communities and ecosystems reliant on consistent water flows may be impacted, potentially leading to conflicts over water resources.

It's important to note that Himachal Pradesh has been proactive in conducting environmental impact assessments (EIAs) for hydro-projects and implementing measures to address concerns. The state government, along with environmental regulatory bodies, plays a crucial role in ensuring sustainable and responsible development of hydroelectric projects while mitigating adverse environmental and social impacts [7]. Ongoing monitoring and adaptive management are essential to address emerging issues and improve the overall sustainability of hydro-projects in the region.

5. SEVERAL HYDRO-PROJECTS HIMACHAL PRADESH

Himachal Pradesh, a mountainous state in northern India, is known for its abundant water resources and has been a significant contributor to hydroelectric power generation in

the country [8]. The state's terrain and rivers make it well-suited for the development of hydroelectric projects. Several hydro-projects have been established in Himachal Pradesh over the years. Here are some notable ones:

Bhakra Nangal Dam: Although the Bhakra Nangal Dam is mostly situated in the adjacent state of Punjab, it also has a substantial influence on Himachal Pradesh. The dam, built on the Sutlej River, is among the biggest in India and serves several functions, including as irrigation, flood management, and hydroelectric power production.

Nathpa Jhakri Dam: Located on the Sutlej River in the Kinnaur district, Nathpa Jhakri is one of the largest hydroelectric projects in Himachal Pradesh. It has an installed capacity of around 1,500 megawatts (MW) and plays a crucial role in meeting the state's electricity demand.

Chamera Dam: Chamera Dam is situated on the Ravi River in the Chamba district. It consists of three stages (Chamera I, II, and III) and has a combined installed capacity of over 700 MW. The project contributes to electricity generation and water storage.

Karcham Wangtoo Hydroelectric Project: The Kinnaur district is where you'll find this project situated on the Satluj River. It incorporates both dam and run-of-the-river components and has an installed capacity of around 1,000 MW.

Salal Hydroelectric Power Station: While primarily located in the state of Jammu and Kashmir, the Salal Hydroelectric Power Station has some impact on Himachal Pradesh as it is situated on the Chenab River, a trans-Himalayan river that flows through parts of Himachal Pradesh.

Rongtong Hydropower Project: The project is situated along the Rongtong River in the Lahaul and Spiti area. This is a small-scale hydropower plant that helps meet the energy demands of the local community.

Himachal Pradesh is now one of India's leading producers of hydroelectric electricity, thanks in large part to these and other projects. It is critical to manage the environmental and social implications of hydroelectric projects with care, despite the fact that they provide advantages in terms of renewable energy and economic growth [9].. The state government and regulatory bodies play a vital role in overseeing and regulating these projects to ensure sustainable development.

6. HYDRO PROJECT SCENARIO IN HIMACHAL PRADESH

Himachal Pradesh, located in northern India, is characterized by its mountainous terrain, snow peaks, crystal lakes, valleys, rocky ravines, flowering meadows, ancient shrines, and tourist spots. Himachal Pradesh has been actively pursuing hydropower development as a key component of its energy strategy [10]. Please note that the information provided here might have changed, and it is advisable to check the latest sources for the most current updates on the hydro power scenario in Himachal Pradesh. Himachal Pradesh has a substantial installed capacity for hydroelectric power generation. Major projects like the Bhakra Dam, Nathpa Jhakri Hydroelectric Plant, Chamera Hydroelectric Project, and others contribute significantly to the state's electricity generation. To maximize its hydropower potential, the state is developing and expanding hydroelectric plants. Current projects and those in the planning stages are expected to further enhance state's hydro power capacity [11]. Himachal Pradesh has encouraged the development of small and modest hydropower plants, which has further facilitated decentralized energy generation. To foster the development of such projects, the state government has provided subsidies and incentives. The area's ecological fragility necessitates the consideration of environmental considerations while approving and carrying out hydroelectric projects [12]. Environmental impact studies are typically required for such projects in order to identify and mitigate any adverse effects on the environment.

Various Environmental parameters that can be affected by hydro-projects:

Sr no.	Parameter	Description	Impact
1.	Water Quality	Effect on water purity and aquatic life	Moderate
2.	Biodiversity	Impact on local flora and fauna diversity	High
3.	Soil Erosion	Potential for soil erosion and sed	Moderate
4.	Deforestation	Extent of forest loss due to project development	High
5.	Habitat Disruption	Disruption of natural habitats and migration patterns	Moderate
6.	Greenhouse Gas Emissions	Contribution to climate change through emissions	Low
7.	Socio-economic Effects	Impact on local communities and livelihoods	Varies

7. CONCLUSION

Hydropower is a mature technology that harnesses the energy of water without causing its depletion. Renewable energy is very dependable and has little greenhouse gas emissions. However, the adverse social and environmental consequences resulting from some hydroelectric developments are occasionally subject to discussion. When it comes to electricity projects in particular, the In order to address environmental issues that surface during the course of a project's development, an environmental impact assessment, or EIA, is required. One way to achieve sustainable development in hydropower projects is to include environmental factors in the development planning process. The 100 MW Sainj Hydro Power Project's Environmental Impact Assessment is summarized in this publication. Several regions of Himachal Pradesh are home to the project that HPPCL is supervising. The project's effects on the environment are assessed using physical-chemical and socio-economic data. We endeavored to document the disparities in Environmental Impact Assessment (EIA) procedures between industrialized and developing nations.

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