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Harnessing the Flow, Navigating the Impact: Hydropower, Society, and Environmental Justice in Nepal

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Abstract: Hydropower has emerged as the foundation stone of Nepal's national energy strategy, operated by a global push for renewable energy and the vast hydropower capacity of the country. However, while hydroelectric is promoted as a permanent solution for the challenges of energy and development, it is often the result of adverse social and cultural consequences for local and indigenous communities. This research critically evaluates the effects of two big dams—Upper Karnali and Arun-3—through a mixed-methods design that combines survey answers of 85 affected households and 25 stakeholder interviews with NGOs(Non-Government organisation), developers, and policymakers. Quantitative analysis indicated that 47.1% of the respondents have "other" sources of income, and most mentioned negative (41.2%) or neutral (44.1%) overall effects after displacement. ANOVA(Analysis of Variance) tests ($F = 0.275$, $p = .892$) revealed no significant difference in total effect based on source of income, whereas Chi-square analysis ($\chi^2 = 15.495$, $df = 6$, $p = .017$) indicated a significant relationship between sense of belonging and desire to stay at original location. Thematic and discourse qualitative analysis pointed out universal discontent with pay, restricted procedural participation, and lack of recognition for lost culture. Word cloud and sentiment network visualisations illustrated a stark dichotomy between institutional discourses—driven by regulation, development, and compliance—and community discourses centred on loss, resistance, and justice. Based on the findings, the research concludes that existing hydropower governance in Nepal is not procedurally, distributive, or cognitively just and urges a transition toward inclusive, participatory, and culturally sensitive development approaches that are consistent with the tenets of environmental justice and sustainable transition.

Keywords: Hydropower Displacement, Environmental Justice, Socio-economic Impact, Indigenous Communities, Mixed-Methods Research. Sustainable Development

1. Introduction

The global energy landscape is undergoing rapid changes as countries try to reduce their dependence on fossil fuels and embrace cleaner, renewable energy sources. Among the array of renewable options, hydroelectric has emerged as a fundamental pillar in this field, which is due to its ability to provide large-scale, reliable, and low-carbon electricity [1]. By 2023, the hydroxide calculated more than 60% of the world's renewable power generation, especially in Asia, Latin America, in the energy portfolio and parts of Sub-Saharan Africa. Its appeal is not only in its carbon mitigation capacity, but also in its role in energy security, grid stability, and socio-economic development through rural electrification, employment generation, and infrastructure expansion. These characteristics have deployed hydroelectric power as a strategic priority for both development and decarbonisation for many lower and medium-oriented countries [2]. Nevertheless, a more complex and frequent choice is fought under

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its "green" veneer. Large-scale hydroelectric projects, especially damage to dam construction and river turns, are often accompanied by significant environmental and social costs. Displacement of local communities, disintegration of aquatic ecosystems, and disadvantage of cultural heritage sites are periodic results[3]. Critics argue that the stability of hydropower is eliminated, and that projects often reproduce or increase existing inequalities, especially affecting the indigenous and rural population. This has been described by scholars as "contradiction of stability": while hydroids are manipulated as a clean energy source, their implementation often reduces the main principles of the environment and social justice. This tension is particularly acute in the global south, where the state-led development agenda intersects with the donor-managed financing model and where the voice of the affected communities is often marginalized[4].

Anywhere this contradiction is not more pronounced than Nepal, a Himalayan nation is endowed with immense hydroelectric capacity - the highest at more than 80,000 MW, the highest of which is tapped by only a fraction is tapped. Hydropower Nepal's development has been central for ambitions, both as a source of domestic energy and an export object in regional power markets [5]. Accurate prediction of water availability is essential for managing Nepal’s diverse and vulnerable water systems. Sustainable practices depend on reliable data and advanced simulation techniques [6].In the last two decades, the country has seen an increase in hydropower projects, many of which are funded by foreign donors such as the World Bank and the Asian Development Bank, or supported by neighbouring powers like India and China. These projects are postponed as vehicles for sustainable development, foreign investment, and regional cooperation[7]. However, they are also sites of deep social and ecological competition, especially where project implementation includes the displacement of marginalized populations, the redistribution of landscape, and a lack of real consultation with affected communities. The research focuses on two symbolic matters in Nepal: the Upper Karnali Hydroelectric Project and the Arun-3 Hydropower Project. The Upper Karnali project supported by the Asian Development Bank and the World Bank shows how the major infrastructure is rationalized through national development imperative, while simultaneous involuntary displacement, livelihood disruption and local resistance between indigenous communities are triggered by local resistance[8]. Conversely, the Arun-3 Project-Freedom-funded and developed by India-Highlights Transboundary Energy Diplomacy, where geopolitical interests often override the sounds of local stakeholders, and environmental assessment is more shaped by ecological calculus at ecological discretion[9]. Both cases provide rich land for the rule of hydropower governance and stability, development, and justice in Nepal.

While the hydroelectric sector has received important scholarly and policy attention - especially in relation to technical viability, energy production capacity, and environmental assessment - a notable zero in research that extends social justice dimensions of hydropower development, especially in the global south[10]. In areas such as Nepal, where large-scale hydroelectric projects rely on donor financing, state-run development goals, and a historically marginalized rural and indigenous population, the socio-political dynamics of such interventions are particularly complicated [11]. Current studies often give privileges of metrics with engineering and environmental effects, while informing the affected communities how affected communities experience displacement, how governance structures facilitate or force meaningful participation, and the perceptions of justice and resistance are expressed on the ground. Important domains of procedural inclusion, distribution equity, and local identity recognition are unattainable from a sociological and political ecological point of view. The paper addresses the interval by deploying a justice-oriented analytical lens, focusing on two symbolic hydroelectric projects in Nepal-Apar Karanali and Arun-3. The study attempts to understand the living experiences of affected communities, evaluate the structure of governance, and analyse the prudent constructions of justice and resistance within a comprehensive context of Nepal's hydroelectric expansion. These objectives are addressed through the following research questions:

- What are the socio-economic and cultural impacts of hydropower-induced displacement on indigenous and rural communities in Nepal?

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- To what extent are affected communities meaningfully included in the governance, consultation, and decision-making processes related to hydropower planning and resettlement?
- How are narratives of justice, marginalization, and resistance constructed and communicated by communities, NGOs, and media actors in the context of large-scale hydropower development?

By connecting with these questions, the paper contributes to the more fine understanding of the social-environmental effects of the hydroelectric, which is beyond the binary stories of clean versus dirty energy or development vs. protection. This stability is located in hydropower within extensive literature on infections, environmental justice, and political ecology, offering insight to those who are theoretically grounded and empirically rich. This paper also underlines the need for more inclusive, partnership and justice-focused energy policies, especially in areas where the environmental regime is entangled with donor impact and the North's colonial state-building agenda.

2. Theoretical Framework

The study is based on a quarterly theoretical structure integrating environmental sociology, political ecology, and environmental justice to thoroughly analyse the complex social-environmental dynamics of hydropower development in Nepal. From the perspective of ecological sociology, it is attracted to the criticisms of techno-optimism and risk society thesis, stating that large-scale infrastructure projects, while implicated as a permanent solution, often produce new forms of risks and uncertainty for the marginalized population. Political ecology focused on the power disparity, resource control, and the role of state and donor institutions in shaping the results of development, especially in post-colonial contexts where external financing and national interests often override local preferences. Environment justice provides an ideal and analytical lens to assess equity in hydroelectric rule, emphasizes three main dimensions: distribution justice (cost and proper allocation of benefits), procedural justice (inclusion and transparency of decision -making processes), and recognition justice (diverse identity and diverse identity, respects and respect for knowledge systems). Together, these framework enables a holistic understanding of how hydroelectric projects affect not only ecosystems, but also the claims of social structures, governance systems, and justice.

2.1 Ecological Modernization Theory (EMT) and Its Application in Hydropower Development

According to Ecological Modernisation Theory (EMT), economic growth and environmental protection go hand in hand. If we use the right technology, security and privacy can actually work together. Innovative changes, reforms in institutions and market-based approaches. Hydropower is commonly included in this type of system. Considered an example of sustainable infrastructure—making it possible to reduce carbon emissions in energy systems, boosting the success of the economy [12]. Many times, governments, development banks and private investors choose EMT. Present hydroelectric power projects as important for reducing emissions (SDG 13) and providing clean energy access (SDG 7) and economic growth (SDG 8); they are especially necessary in regions that suffer from energy poverty[13]. From An EMT would consider hydropower technology to be clean, efficient and easy to grow. Innovations in It is believed that turbine design, managing sediment and controlling environmental flows are enough to handle ecological impacts. Measures like environmental impact assessments (EIAs) and multi-stakeholder processes are included in institutional reforms[14]. It is believed that using consultations and public-private partnerships helps ensure projects follow sustainability and its standards. In addition, there are carbon markets and international climate finance mechanisms (for example, the Green Climate Fund) are used more often to finance infrastructure, since the idea of “green growth” support[15]. However, critical scholars and some activists point out that EMT mainly relies on a technical and apolitical view of sustainability. The issues related to the environment and society are turned into engineering or governance problems. This perspective tends to overlook the big structural and power differences that often exist. For example, Nepal, which is known for it’s because they depend on hydropower, many countries have constructed large dams which have often brought negative effects[16]. Moving away indigenous and marginalised communities, with little or no proper help or

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compensation planning. They regularly suffer the loss of their homes, jobs and even their ancient traditions. Destruction of land and sacred water sources which results in the loss of culture and mental trauma. Also, institutional Many of the approaches valued by EMT, such as environmental governance frameworks, are not truly embraced by communities. EIAs do not always look into all the details, and consultations may be carried out mostly for show. Relying on experts to decide, this model believes that problems can be solved by technology and does not consider cultural ways of thinking that reject treating nature as a commodity. In other words, EMT focuses on the future by blending growth and care for nature, but its views can hide the social and cultural effects of projects such as hydropower. It usually highlights technology and downplays matters of justice, representation and accountability. As a result, any use of EMT in hydropower development should be matched with careful attention to environmental justice, political ecology and the opinions of communities so that the clean energy transition is good for the environment and society[17].

2.1.1 Risk Society

The "Risk Society" is a concept developed by German sociologist Ulrich Beck, how the unexpected results of modern industrial and technological progress have created a new set of social and environmental challenges. Unlike traditional societies, which were mainly related to distributing funds, risky societies focus on the production, distribution, and management of rapid risks-especially those that stem from man-made technologies and modernization processes [18]. These risks, such as climate change, biodiversity loss, and technical hazards, are global, systemic, and often irreversible, with consequences that are difficult to control or predict. Bake emphasizes that these risks are not basically "natural", but are manufactured as a result of political, economic, and technical decisions. In addition, because traditional institutions - Governments, regulatory bodies, and international organizations - often lack the equipment to address these emerging risks equally, they require a process of "reflective modernization", which leads to evaluation of societies and improves the systems that generate these risks. Building on Beck's foundational theory, [19] provide a concrete application of the risk society framework within the context of hydropower development in South Asia, particularly Nepal. Their study examines how hydropower projects, while promoted as clean and sustainable energy sources, often produce new forms of environmental and social risk that disproportionately affect marginalized groups. The authors argue that the discourse of risk is not neutral; rather, it is actively shaped by institutional, political, and economic actors who seek to frame certain risks (e.g., lack of development or energy scarcity) as more pressing than others (e.g., displacement, loss of biodiversity, or cultural erosion). In this context, risks are not just technical problems to be solved but deeply political issues embedded in power relations [20].

For example, Local communities are not usually included in the planning and building of hydropower projects in Nepal, as the process is mostly directed from above. Domestic and foreign investors think hydropower is important for expanding the economy, feeling secure about energy sources and fighting climate change, whereas the people living near these projects are troubled by environmental harms, job losses and fragmentation of communities. The projects show that modernization projects may actually lead to new risks and difficulties that current governance bodies are not prepared to handle. They ask for risk governance that acknowledges traditional knowledge, shares out risks and rewards equally and upholds fairness in processes. Therefore, when they look at hydropower's politics with the help of risk society, [21] point out the limitations of reliance on experts and underline the significance of thinking things over when taking environmental decisions. It agrees with Beck's theory that, in modern days, we need to find ways to make sure that everyone, not just a few, are involved in defining, measuring and managing risks.

2.2 Political Ecology

Political ecology provides the essential perspective to explore how environmental concerns are entangled with political, economic, and social institutions. Emerging from geography and anthropology, political ecology is critical of the prevailing discourses on environmental management that tend to

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neglect historical and political contexts. It scrutinizes how power relations and institutional structures influence access to and control over natural resources[7]. For hydropower, political ecology deconstructs the socio-political mechanisms involved in dam building, water management, and land appropriation. It discloses that hydropower development is hardly ever technologically or politically neutral but is, rather, intensely political and involves the relocation of indigenous people, the changing of local livelihoods, and reallocation of land and water rights. Political ecology assists in shedding light on how state and corporate agendas propel hydropower development and exclude impacted communities[22]. It also brings into view the agency of resistance movements and environmental activism in pushing back against prevailing energy paradigms. Political ecology thus allows for this research to interrogate who gets to decide, who gains, and who loses from hydropower projects. Political ecology provides an important lens through which to analyse environmental changes, not only focussing on ecological dynamics but also on strong relations, political-economic systems, and historical trajectories that show how to use natural resources and who benefits. This structure challenges the technical and political illustration of development projects such as hydroelectric, arguing that these interventions are deeply political functions that can reproduce social inequalities and environmental injustice [23].

2.2.1 Power and Discourse in Hydropower Development

One of the central principles of political ecology is the role of discourse – stories and language used by powerful actors to justify environmental interventions. In terms of hydroelectricity, governments and international donors often frame large dam projects required for national development, energy security and climate mitigation. These major narratives put the hydroidal as "clean" and "green" solutions while often calming or handing over alternative approaches, especially to indigenous people, displaced communities and environmental workers. For example, in countries such as Nepal and Ethiopia, hybrids have been promoted as a symbol of modernity and self-sufficiency, which increases concerns about social displacement, biodiversity loss and cultural eradication. Political ecological criticisms show these discourses how they mask business and normalise exclusion practices in the name of progress[24].

2.2.2 Resource Access and Control

Political ecology also investigates who receives profit and who loses access to important resources – such as water, land and electricity – as a result of hydroelectric development. Large dams typically include local ecosystem and reconstruction of resource flow, leading to changes in natural property control. While the Elbraks, private investors and urban populations often benefit from increasing power supply or revenue, rural and indigenous communities often have to face restricted access to rivers, fisheries and agricultural lands that they depend on to survive. For example, dam construction with Trans Boundary Rivers such as Arun or Karanli has reduced traditional irrigation systems, reduced access to water for farming, and excluded electrical benefits, especially in remote areas. These results not only reflect environmental effects but also compete with the politics of ownership, rights and justice.

2.2.3 Multi-Scalar Governance and Neocolonial Dynamics

Another significant contribution to political ecology focuses on multi-scalar rule – how the global or national decision scale affects local environments and communities. Hydropower projects are not local in nature; they are located within the international financial circuits, geopolitical agendas and regional energy markets. Institutions such as the World Bank, Asian Development Bank and bilateral donors (e.g., China or India) greatly affect the priorities, funding and governance processes of these projects[25]. Such external drivers often compromise local autonomy and pour the dynamics of asymmetrical power, with the conditions and minimal resort to the conditions and affected communities. Political ecology has described it as a process of neo-colonialism in which the discourse of stability and growth continues resource extraction and marginalises under global capitalism. Overall, political ecology makes it clear that hydropower growth is not only a technical or environmental concern but a deep political process. It highlights the dynamics of the underlying power, the displacement of

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indigenous knowledge, and the silence of marginal approaches that go with such an initiative in general. In comprehensive political-economic processes hydroelectrically, this lens decides "green" and calls for an inclusive, justified and responsible manner to create durable energy infections [26].

2.3 Environmental Justice Theory

Environmental justice (EJ) theory offers a normative and analytical basis for assessing the justice of environmental decision-making and outcomes. It arose in reaction to the overexposure of marginalized groups to environmental risks and has developed over time into an extensive area that deals with distributive, procedural, and recognitional justice. Distributive Justice addresses the fair allocation of environmental advantages (e.g., electricity, economic growth) and disadvantages (e.g., relocation, environmental damage[27]. In the case of hydropower, EJ theory questions whether energy from dams actually benefits communities at or near the dams or benefits essentially urban and industrial places. Procedural Justice focuses on bringing involved stakeholders into decision-making forums. It is critical of top-down hydropower planning that marginalizes local opinions and sidesteps democratic processes. Recognitional Justice discusses the recognition of cultural identities, historical contexts, and local knowledge systems. For most rural and indigenous communities, rivers are not just resources but also sacred objects that are a part of cultural identity and spiritual practice. Through application of environmental justice theory, this study examines how hydropower projects reproduce or counteract structural inequalities. It evaluates available mechanisms for community participation, compensation, and redress, and examines how effectively these reconcile with justice and equity principles[28].Indigenous communities are at the forefront of resisting environmental degradation, linking ecological harm with social injustice. Their struggles highlight the transformative potential of eco-justice movements.

2.3.1 Environmental Sociology

Environmental sociology provides significant insights into complex differences between society and environment, especially in terms of technical interventions such as hydroelectric development. Three central concepts- techno-optimism, risk society, and stability contradictions framework to analyse how technical solutions are considered and implemented, and their broad social and environmental implications[29]. Techno-optimism symbolizes the belief that technological progress can effectively address environmental challenges without the need for significant changes in social behaviour or structures. This perspective often outlines large-scale infrastructure projects, including the development of hydropower, where technical solutions are preferred on socio-political ideas. However, dependence on technical-easement can reduce the potential risks and to marginalize the knowledge and needs of the local communities. [30] examined this phenomenon among Midwestern farmers, finding that higher levels of techno-optimism correlated with reduced support for climate change adaptation measures, suggesting that faith in technology may delay necessary behavioural and policy changes. Similarly, critiques have emerged regarding the promotion of techno-optimism by influential figures in Silicon Valley [31]where technological advancements are often pursued without adequately addressing issues of inequality and environmental harm. These critiques underscore the need for a more nuanced approach that considers the socio-political dimensions of technological solutions [32].

2.3.2 Socio-Technical Systems Theory

Socio-technical systems theory offers a systems-level framework for examining how technological infrastructures co-evolve with societal institutions, practices, and values. Hydropower systems are more than technical artefacts but rather compound assemblages of engineering, regulation, finance, and social relations. The theory focuses on the mutual shaping of technology and society, acknowledging that technological choice is driven by social norms and, reciprocally, reworks social dynamics [33]. In the case of hydropower, socio-technical theory serves to unpack the myth of technological neutrality. It highlights how dams' design, construction, and operation represent ideologies in power—like modernization, progress, and control by the state. The theory also explores problems of path dependency, whereby current technological systems limit future options and innovation. For instance,

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large-scale development of hydropower can lock in centralized energy systems at the expense of decentralized and community-based options. In addition, socio-technical systems theory facilitates examination of stakeholder networks, governance arrangements, and institutional frameworks that intermediate hydropower development. It examines how various actors—engineers, policymakers, financiers, NGOs, and communities—engage in the hydropower system and how they determine interests and values that shape project outcomes. This systems approach is important for capturing the complexity and interdependence of social and technical elements in hydropower governance[34].

2.3.3 Sustainable Development Paradigm

The continuous development paradigm provides an essential structure to balance environmental leadership, economic progress and social welfare in the discovery of human and planetary health for a long time. In terms of hydropower, this approach emphasises that energy production should only be beyond increasing power generation capacity to incorporate widespread environmental and social impacts. The alignment of hydropower with the United Nations Sustainable Development Goals (SDGs) underlines its versatile role and the complications involved[35]. For example, SDG 7 emphasises the importance of inexpensive and clean energy, where hydroelectric acts as an important renewable source, which helps many countries achieve their renewable energy goals and reduce dependence on fossil fuels. However, hydroelectric projects also interact intimately with SDG 6, which worries about clean water and hygiene. Large dams and reservoirs essentially change the flow of natural water and affect the quality of water, demanding strong, integrated water resources management to prevent negative downstream effects on ecosystems and human communities. With regard to climate action (SDG 13), hydropower provides a means of reducing greenhouse gases through low-carbon electricity generation and thus contributes to the global fight against climate change [36].However, this advantage must be balanced against possible ecological trade-offs as brought out by SDG 15, focusing on terrestrial ecosystems and biodiversity. Construction of dams tends to cause fragmentation and loss of habitats, posing a danger to wildlife and biodiversity, which makes environmental planning and mitigation a delicate issue. Finally, the paradigm also considers social equity as evident in SDG 10, where fair distribution of hydropower benefits is of paramount importance. This involves ensuring that displaced and marginalised communities benefit from the energy produced through fair compensation and access to the power, avoiding increased exacerbation of original social disparities. In conclusion, taking a sustainable development perspective makes it clear that hydropower developments need to be conceived and operated in an integrated manner, weighing energy requirements against environmental conservation and social equity to deliver genuinely sustainable results [37].

a) Distributional Justice

Distributive justice addresses uneven allocation of environmental benefits and is a burden as a result of hydroelectric projects. While such projects are often promoted as renewable, low-carbon energy sources, they profit-like electricity use, economic returns, and better infrastructure – usually directed to export to urban populations, industrial users, or neighbouring countries. Conversely, cost restoration, loss of agricultural land, decline of river ecosystems, and reducing access to water are reduced – the villagers living near the dam sites are unevenly borne by the communities of indigenous or marginalised communities. For example, in the Arun-3 and Upper Karnali projects in Nepal, the local population was transferred to the reservoirs and the infrastructure of the dam, but many of them did not get just compensation, nor did they benefit from electricity access or employment opportunities. This uneven distribution enhances important concerns about inter-state equity and whether hydroelectric development actually performs good work for the public or confirms existing socio-economic inequalities [38].

b) Procedural Justice

In the field of environmental governance, procedural justice means paying attention to fairness, openness and including all parties in making decisions. It also looks at how decisions concerning the placement of power stations, reviews of environmental impacts and giving compensation are handled,

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as well as who is able to be involved in those choices. State agencies, foreign investors and development banks often make HPS development decisions top-down. It is common for local communities and those who will be directly affected to be left out of the decision-making during EIAs, feasibility studies and benefit-sharing agreements. These consultations are sometimes just forms without real discussion or approval by the public. Lack of involvement in decision-making often makes people distrust the project and sometimes encourages opposition and disputes. Procedural justice guarantees that all parties, with special attention to vulnerable populations, can speak up, gain information and affect the decisions that matter to their surroundings and income[39].

c) Recognition Justice

Besides providing resources and following processes, recognition justice is concerned with recognising different identities, cultures, knowledge systems and histories. Hydropower projects often break recognition justice when builders and planners do not respect how indigenous and local people connect spiritually, culturally and traditionally to local rivers, forests and land [40]. For some indigenous communities, rivers are thought to be sacred, providing their identity and role in their universe. Development frameworks that think of rivers only as resources for economic growth ignore their cultural meanings and contribute to maintaining Asian colonialism. Often, more complex ecological knowledge stored within indigenous and local communities is overlooked when technocratic planning is in place. It means acknowledging people's different traditions, giving them an economic role in guiding care for nature and opposing schemes claiming that development must be the same for everyone. Without recognition, even well-intent environmental policies can result in symbolic violence and intense margins. Together, three dimensions of environmental justice – deformity, procedural, and recognition – form a broad structure for evaluation of the equity and validity of hydroelectric development. Applying this structure enables the hydropower to be seen only as a technical or economic undertaking, which is to understand it as a deep social and political process, with intensive implications for human rights, cultural existence and democratic participation[41].

2.4 Integration of Theories

Although each of the theoretical perspectives is unique in its contribution, their combination gives a broader picture of the intricacies surrounding hydropower development. Political ecology places emphasis on power and resistance; environmental justice on equity and inclusion; socio-technical systems theory on complexity and co-evolution; and the sustainable development paradigm on normative advice.

Through their synthesis, research can:

- Graph the political and institutional landscape of hydropower development.
- Assess justice dimensions at planning, implementation, and impact levels.
- Examine the interface between social structures and technical systems.
- Evaluate alignment with sustainability principles and objectives.

The integration of several theoretical approaches provides a rich and finer understanding of complex dynamics involved in hydropower growth. While each theory provides different insight, their joint application allows researchers to capture the versatile nature of the region. For example, political ecosystems attract attention to forms of underlying strength relationships and resistance, which shape hydroelectric projects, stating that some actors and interests dominate the decision-making processes, while groups of margins can compete or oppose these developments. The environmental justice theory especially complements it by focusing on issues of fairness, equity and inclusion, ensuring who takes advantage of who benefits, who tolerates costs, and whose voices are heard; they remain central throughout the plan and implementation stages. The socio-technical system theory adds another layer to emphasise the complexity and co-development of social and technical elements and shows how infrastructure, technology, institutes and communities interact and adapt over time. Meanwhile, the sustainable development paradigm provides ideal guidance, designing the discussion to balance

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economic development, environmental protection and social equity in accordance with global stability goals. By synthesising these approaches, researchers can effectively map the political and institutional landscape of hydropower development, seriously assess justice dimensions in different stages – planning, implementation, and effects – and find out how social structures and technical systems differentiate together. This integrated structure facilitates comparative studies in various cases or comparative studies in regions, showing how local references have been mediated and shaped widespread global trends that affect energy policy and environmental regimes. Ultimately, this overall approach equips scholars and physicians with a broad toolkit, which includes ways to analyse and guide hydroelectric growth, which are relevant, grounded, and aligned with stability mandates.

The integrated framework also enables comparative analysis of various case studies or geographical locations, emphasizing how local determinants intermediate global trends for energy policy and environmental governance.

2.4.1 Operationalization in Research

The theoretical perspective will guide the research design, such as research questions, choice of case studies, data collection techniques, and analysis approaches. Qualitative techniques like interviews, document study, and participatory observation will be applied to capture perspectives from various stakeholders. Analysis will be based on the following thematic lenses:

- Governance and Power Relations: Who are the decision-makers, and how do they shape decisions?
- Justice and Equity: How are the benefits and burdens shared, and who participates in decision-making?
- Technological Systems and Practices: What are the socio-technical processes of hydropower projects?
- Sustainability and Trade-offs: How do hydropower projects fit with or diverge from sustainability objectives?

The theoretical structure that underlines this research fundamentally shapes the overall research design, which affects the creation of research questions, selection of case studies and the choice of data collection and analysis methods. Given the complexity of hydropower development and its social-environmental implications, qualitative methods are best suited to detect diverse stake views. Techniques such as semi-composed interviews, document analysis, and participant observation enable the researcher to collect relevant data rich in policy makers, community members, developers, and non-governmental organisations or those affected by hydropower projects. Data analysis will be conducted through the thematic lens obtained from the integrated theoretical structure, which ensures a comprehensive examination of major issues. First, the regime and power relations will be investigated to identify the major decision-makers and their impact on the results of the project, reflecting the political ecological perspective that leads the dynamics of power forward [42]. Secondly, justice and equity questions will assess how the benefits and burdens are distributed among the stakeholders and the limit of community participation in decision-making processes; how to align with environmental justice concerns will also be assessed. Third, the socio-technical system theory indicates the analysis of interaction between technical infrastructure and social practices, focusing on how hydropower projects develop within the complex network of actors and institutions[43]. Finally, stability and business bounds will be evaluated by checking whether and how the hydroelectric initiative highlights energy production, environmental protection and tension between social welfare and deviations or distractions from sustainable development principles. This layered analytical approach allows for the overall understanding of hydropower development, which captures its versatility in governance, justice, technology and stability.

The framework guarantees that the research transcends superficial analysis to capture the underlying causes of social and environmental conflict, distinguish opportunities for reform, and contribute to

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more equitable and sustainable energy futures. Hydropower is at the nexus of energy transition, ecological responsibility, and social justice. At a time when the world is increasingly demanding renewable energy, it is also increasingly in need of critical, multi-disciplinary scholarship that interrogates the complex consequences of energy infrastructures. This theoretical framework offers a strong basis for such research. Through the synthesis of political ecology, environmental justice theory, socio-technical systems theory, and the sustainable development paradigm, the study will produce rich insights into the governance, equity, and sustainability of hydropower projects. Overall, this synthesis seeks to contribute to more inclusive, accountable, and ecologically responsible energy policies that acknowledge the voices and rights of all stakeholders, especially those most impacted by hydropower development.

3. Methodology

The study appoints a mixed-method research structure that integrates both quantitative and qualitative approaches to examine the socio-economic, cultural and governance effects of hydropower development in Nepal. The quantitative component includes a domestic survey (N = 85) using the project site, displacement status, gender and ethnicity, with descriptive data, with data, cross-symbols, curry tests, and data analysed via ANOVA. The qualitative component includes 25 semi-corresponding interviews with key stakeholders – members of the community, NGOs, developers and policymakers – as well as EIA, NGO reports and document analysis of media sources. Qualitative data was analysed using thematic coding and discourse analysis. The study focuses on Upper Karnali and Arun-3 hydropower projects, which have been selected for their scale, displacement effects, foreign donor participation and community resistance. Data sources include surveys, interviews, field notes and official project documentation. Analytical devices such as SPSS and NVivo were used, supported by visualisations such as word clouds, emotion networks and stakeholder clustering, to increase interpretation and present significant conclusions.

3.1 Research Design

Data is gathered using both qualitative and quantitative methods in this study to give a full overview of what happens in the environment with the construction of hydropower plants. Structured surveys on affected groups, policy-makers and stakeholders are used in the quantitative component to get data about their views on the advantages, consequences and availability of resources. It makes it possible to spot patterns and trends in larger groups. In comparison, the qualitative side uses interviews, study of documents and thematic and discourse analysis to investigate detailed ideas, knowledge that comes from the area, shifts in power and questions about justice in hydropower planning and implementation. Because of this dual process, knowledge from quantitative work can be better understood and supported by information from qualitative work. Using various types of data allows the study to look at governance structures, participation, fairness and the costs and benefits of sustainability from actual evidence and personal accounts.

3.2 Case Selection

For the purpose of this study, two carefully picked hydropower projects in Nepal were chosen: Upper Karnali Hydropower Project in the west and Arun-3 Hydropower Project in the east, because both represent the central topics in this research. These examples differ in how they were built, involved many foreign donors, had major effects on local society and the environment and met with strong opposition from local people. His project in the Midwestern Karnali region is supported by international institutions such as the World Bank and the Asian Development Bank (ADB). The region houses mainly Tharu, Dalit and indigenous hill people. Here, people experience a high level of poverty, have little in the way of infrastructure,, and the environment is quite vulnerable. Because people felt poorly consulted and many were forced to leave and the money they lost was low, the project is ideal for analysing the

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problems of engaging people in decision-making, doing justice and respecting indigenous people when development comes from non-governmental sources.

Instead, the Arun-3 Hydropower Project in Sankhuwasabha district, eastern Nepal, is funded and carried out by India's Satluj Jal Vidyut Nigam (SJVN) following a bilateral deal between Nepal and India. Here, a national energy strategy is giving priority over what locals care about in the region. People have also openly opposed Arun-3, mostly due to issues involving buying land, damaging the environment and ignoring voices from local communities during decision-making. Both mountains have rich ecological areas, high levels of biodiversity,, and locals there share a strong bond with the environment and rivers. Because of their choice, it is easy to study how hydropower development works differently in different regions. The examination of these two different but closely related cases gives a lot of valuable material to study the mix of development, justice, power and resistance in Nepal's hydropower sector.

3.3 Data Sources

To cover all the aspects of hydropower development in Nepal, the study depended on many different types of data. The use of several kinds of data enabled us to validate conclusions and get an in-depth understanding from many angles. Data was obtained by talking to groups affected by displacement, to key stakeholders, to official project documents and to what was observed in the field to study the varied challenges and impacts of the Upper Karnali and Arun-3 hydropower projects. The main types of data used were household surveys, interviews, reading through documents and watching things in the field.

3.3.1 Quantitative: Household Survey

A planned questionnaire with 15 targeted items was given to families rendered homeless because of the selected hydropower sites. We wanted to find out about the effects of migration on income and jobs, on the use of services like healthcare, education and electricity and on groups' traditions. The questionnaire included questions about the survey's participants' thoughts on how their quality of life measures up after they were displaced. Those most affected by the development projects were selected specifically as the participants in the survey. From the data, trends could be seen that allowed us to spot typical problems and also regional differences in the situation of displaced people.

Each of the four main groups—(1) those who had been displaced, (2) NGO workers, (3) members of the development team and (4) government officials—was interviewed. These interviews looked closely at the way people and communities are involved in hydropower project management and how certain systems are put in place for transparency, compensation, justice and the expression of resistance. A list of ten structured questions was asked in every interview to ensure equal treatment,, and this left space for answers that were not specific. Qualitative information revealed the personal stories and opinions of staff that many official documents of the project do not present.

3.3.2 Document Analysis

To get a clearer picture of the policy and regulatory framework, a large variety of secondary materials was examined. Such information consisted of Environmental Impact Assessment (EIA) reports, compensation and resettlement guidelines, news articles, materials from NGOs and project promotional brochures. Transcripts or short summaries from public consultation and grievance hearings were looked at if they existed. It gave me a clearer idea of how different groups—government, project developers and civil institutions—approached hydropower projects and how what politicians said often didn't match the results seen on the ground.

3.3.3 Field Observations

When possible, the team went on site visits to observe non-intrusively the land involved in the project and where those relocated live. They observed and reported on real details of the infrastructure,, such as housing, clean water availability, sanitation and the state of the roads. The team also looked at community collaboration, the involvement of the public and their normal daily habits following the

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disaster. What people did and said was used to confirm or challenge survey and interview results, making the analysis more complete.

3.4 Data Analysis

3.4.1 Sampling Technique

To catch both elaborate personal experiences and broad community-level trends, this study employed a mixed sampling strategy for objective samples for qualitative data and stable sampling for a quantitative survey. The objective sampling enabled the selection of major informers – such as displaced individuals, NGO representatives, developers and policymakers – based on their relevance and direct participation in hydropower projects. Stratified sampling was ensured in major variables such as project location, displacement conditions, gender and ethnicity in the survey component. This approach increased the depth and diversity of insight, allowing fine analysis of hydroelectric effects on the affected communities in Nepal.

Personal sampling is a strategic and deliberate method used to select participants in qualitative research who have specific knowledge, experiences or roles that are important to address research questions. In this study, objective sampling was done to identify and recruit key stakeholders associated with Upper Karanli and Arun-3 hydropower projects. These participants include members of the displaced community, who have directly experienced social and environmental consequences of hydropower development; representatives of non-governmental organisations (NGOs) who advocate for affected populations or environmental protection; hydropower developers involved in project planning and execution, which includes regulatory framework and donor agency officials, such as local activities and funding priorities; and those who mediate between communities and state institutions.

Table 1: Sample Distribution based on Interview

Stakeholder Group	**Number of Interviews**	**Gender (M/F)**	**Affiliation/Type**
NGO Representatives	10	5 / 5	Human rights, environmental NGOs
Hydropower Developers	6	5 / 1	Project managers, engineers, CSR heads
Policymakers	5	4 / 1	Ministry officials, donor agency reps
Local Leaders/Ward Reps	4	4 / 0	Village leaders, ex-VDC officials
Total	**25**	**18 / 7**	–

Table 1 outlines the distribution of 25 interview participants across four key stakeholder groups: NGO representatives, hydropower developers, policymakers, and local leaders. The sample ensures institutional diversity and gender representation, with participants drawn from both national and local contexts. These interviews provided critical insights into governance practices, community engagement, and justice discourses surrounding the hydropower projects.

The selection of cases was meant to guarantee that the research covered a broad range of perspectives and knowledge related to the main themes, for example, how well community consultation works, how fair the compensation and complaint processes are, experiences of change and resistance and the

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intricate power structures around policy making. Purposive sampling allows us to study the details of social life for those affected by hydropower projects, things that would be difficult to access with random sampling. The main aim of this approach is to provide detailed insights that help us grasp the social and political situations around hydropower governance. Especially in this case, it is important to use purposive sampling to include those less often heard, such as groups like indigenous peoples and rural areas, and to set their views against the perspectives of those carrying out and funding major projects. By providing a contrast, it makes visible the conflicts and tensions in hydropower projects and gives a full picture of justice, power and sustainability issues. In the end, purposive sampling helps the research demonstrate the wide range of stakeholder experiences, which plays a key role in creating useful policy suggestions and research contributions.

3.4.2 Sample Distribution

Different regions and social groups were carefully chosen in the household survey with stratified sampling so that their unique experiences and opinions about hydropower development could be included. The process required grouping the target population into meaningful subgroups and, after that, picking samples from each group. The main layers in this analysis were the project site (Upper Karnali versus Arun-3), whether families were settled within the construction zone or affected in another way and demographic variables like gender, ethnicity (such as Tharu, Magar, Rai, and Limbu) and primary employment type (agriculture, wage labour, and business).

To include all important stakeholders, the sample was selected from two main hydropower project regions in Nepal: Upper Karnali and Arun-3. Displaced community members were interviewed in 85 household surveys to study their social and economic changes. Besides, interviews were also held with 25 important stakeholders, such as NGOs, developers, policymakers and local leaders, to discover their understandings of governance, justice and resistance. The sample was organised to match differences in geography, ethnicity, gender and the roles played in the institutions, which gave the research depth and covered a wide range of aspects by mixing methods.

Table 2: Sample Distribution based on Survey

Project Site	**Number of Respondents**	**Gender (M/F)**	**Ethnic Groups Represented**
Upper Karnali Project	45	28 / 17	Tharu, Magar, Dalit
Arun-3 Project	40	25 / 15	Rai, Limbu, Brahmin, Chhetri
Total	**85**	**53 / 32**	–

Table 2 presents the distribution of 85 domestic survey respondents in two hydroelectric project sites: Upper Karnali (45) and Arun-3 (40). The sample includes a balanced gender representation and diverse ethnic groups such as Tharu, Rai, and Limbu. Respondents were chosen to reflect varying social and geographical contexts primarily affecting rural families. The argument behind using stratified samples was to ensure the proportional representation of these important subgroups, which are likely to have different experiences of hydroelectric effects. By tying the sample, the study can effectively compare and contrast social, economic, and cultural effects between two project sites, which may vary in scale, governance, and environmental context. Additionally, stratification has been allowed by the state of displacement of how direct vs. indirect displacement affects domestic goods, compensation experiences, and access to services. The inclusion of demographic stratification further enabled the identification of inequalities based on ethnicity and gender, such as inequalities in compensation satisfaction or cultural loss, which are often masked in collected data. This approach strengthened the analytical clarity and legitimacy of quantitative data by allowing site-specific insights and systematic patterns in diverse

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populations. It also ensured that marginalized and weak groups – often excluded from official plans and assessments – were involved in meaningful research. Eventually, stratified sampling provided a strong structure to the socio-economic impact of hydropower projects with a strong structure and more accuracy in evaluating distributional justice.

3.4.3 Data Analysis

Two different but companion techniques were used to study both the numbers in datasets and the opinions gathered from interviews. These findings were then combined to give a full picture of hydropower's effects.

3.4.4 Quantitative Analysis

Analysis of the survey, which included data from 85 participants, helped reveal patterns and connections in the data.

a) Descriptive Statistics

The descriptive statistics showed the first summary of variables such as household income, access to public services, participation in cultural activities and perception of displacement. Frequencies, percentage distributions, average (mean) values and measures of variation (standard deviations) were determined to explain the sample and display its typical trends. A simple example is the calculation of the mean household income ($\bar{x}$):

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

where x_i represents income of household i and n= 85 is the sample size.

b) Likert Scale Scoring

To make it easier for analysis, Likert scale answers (starting at 1 for very dissatisfied and reaching 5 for very satisfied) on compensation satisfaction, restoration of living and continuity of culture were coded as numbers. Mean scores and medians were used to express the overall levels of satisfaction and variance, and standard deviation helped to show how much the participants agreed or disagreed with each other.

c) **Cross-Tabulation**

The research used cross-tabulation to compare responses from different project sites (Upper Karnali versus Arun-3), different genders and different ethnic groups to look for any similarities or differences in their experiences. Mathematicians put the answers into tables that showed the numbers of each answer for each individual pair, so it was easy to spot patterns.

d) Chi-square and ANOVA Tests of Independence

To see if observed patterns in categories (categorical variables) were statistically meaningful, Chi-square tests (χ^2) were used. As an example, if we want to check if satisfaction with resettlement is related to ethnicity, the null hypothesis (H0) is that there is no link between ethnicity and satisfaction. It is calculated by:

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

where O_i is the observed frequency in cell i and E_i is the expected frequency under (H_o) . The resulting χ^2 value is compared to a critical value from the Chi-square distribution with appropriate degrees of freedom to determine statistical significance, typically at α=0.05.

ANOVA (analysis of variance) is a statistical method that is used to determine whether there are significant differences between the means of three or more independent groups. In this study, the

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ANOVA was implemented to assess whether the satisfaction and overall impact scores of the livelihood are quite different in various categories such as compensation adequacy and income sources. The process involves calculating the middle group variance (differences between the group) and compare with the group variance (variability within each group). An F-statistic arises to determine whether the differences of the group are statistically important, indicating the level of importance with a uniform p-value. In this case, the results showed non-mating consequences (e.g., F = 0.275, P = .892), suggesting that the variation in livelihood satisfaction and alleged effect was not strongly affected by group classification, and any difference was observed due to chance.

3.4.5 Qualitative Data Analysis: Thematic Coding of Interviews and Documents

For qualitative data analysis in this study, thematic coding was used. This enabled systematic identification, classification, and interpretation of emergent key themes in interview texts and documentary material such as Environmental Impact Assessment (EIA) reports, policy reports, NGO documents, and media reports. The coding was initiated with open coding, where line-by-line transcripts of 25 semi-structured interviews with displaced members of the community, NGO officials, hydropower developers, policymakers, and local leaders were read. Preliminary codes were assigned to text segments indicating ideas, perceptions, and concerns surrounding displacement, governance, participation, justice, and resistance. Axial coding was then performed to sort these preliminary codes into broad thematic categories. For example:

- Phrases such as "no prior notice", "we were not consulted", and "decisions were already made" were grouped under Procedural Exclusion.
- Sentences such as "ancestral land lost", "compensation delayed", and "livelihood disrupted" were grouped under Distributional Injustice.
- Remarks such as "We protested", "NGOs helped us speak up", and "The media ignored us" were compiled under Resistance and Voice.

Additional key themes included:

- Recognition and Cultural Loss: covering spiritual and symbolic value of rivers and land.
- Power Asymmetries: referencing the dominance of state and donor narratives over local knowledge.
- Environmental Misalignment: highlighting discrepancies between EIA claims and actual ecological consequences.

The theme with the findings of the document analysis was also cross-satisfied, where the official reports and the media were investigated to prepare the strategies of the discourse (e.g., the projects were depicted as "national development" vs. communities that prepared them as "threats to survive"). This enabled the identity of opposite stories and the power of power between institutional actors and the affected population. A predetermined coding not only helped reveal the depth and complexity of stakeholder experiences but also aligned empirical data with the theoretical framework of the study – especially around the principles of environmental justice, political ecology and sustainable development. This method allowed research to go beyond surface-level summary and instead created a fine, multi-operated understanding of social-psychosocial effects of hydropower development in Nepal.

4. Finding and Analysis

The results of this study present a comprehensive analysis of the socio-economic, cultural and governance influences of hydropower development in Nepal, which focuses on the Upper Karnali and Arun-3 projects. Drawing from both quantitative survey data and qualitative interviews, findings show how displaced communities experience large-scale infrastructure results. Survey data highlights the average change in income, access to services, livelihood stability and cultural continuity between

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affected houses. Meanwhile, qualitative insight offers a deep attitude on community participation, perception of justice and resistance stories. Standard reactions from NGOs, policymakers and developers depict a gap between institutional intentions and on-the-ground realities. The results are pragmatically conducted, aligning with three main research questions of the study and depicting both convergence and deviation between statistical patterns and individual experiences. Overall, the conclusions underline the complex difference between development goals and social equity in the developed hydropower landscape of Nepal.

Table 3: Household Income Source Data

Statistics		
Income Source		
N	Valid	34
	Missing	0
Mode		5

Table 3 analysis of income sources between surveyed houses (n = 34) shows no missing response, indicating complete data. The mode value of 5 suggests that most often the informed income matches the fifth category on the source survey, which can represent daily wages, labour or uniform business (depending on the original scale). This reflects a major dependence on informal or low-income livelihood options among the displaced families.

Table 4: Distribution of Household Income Sources

Income Source					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agriculture	2	5.9	5.9	5.9
	Business	8	23.5	23.5	29.4
	Daily wage labour	6	17.6	17.6	47.1
	Government job	2	5.9	5.9	52.9
	Other	16	47.1	47.1	100.0
	Total	34	100.0	100.0	

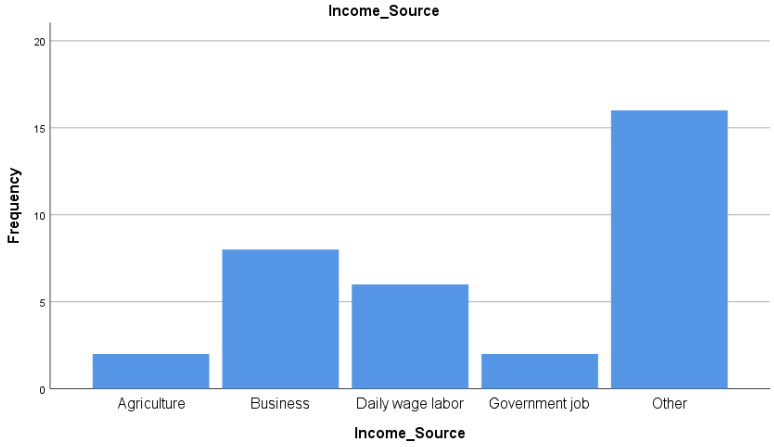

Figure 1: Distribution of Household Income Sources

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Table 4 presents the distribution of primary income sources among 34 surveyed families. The majority (47.1%) reported the "other" sources of income, followed by trade (23.5%) and daily wages labor (17.6%). Only a small ratio depends on agriculture (5.9%) or government jobs (5.9%), which highlights a change away from traditional or formal employment between displaced communities. The graphical representation of these findings is provided in Figure 1.

Table 5: Chi-Square Test

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.367[a]	4	.252
Likelihood Ratio	6.315	4	.177
Linear-by-Linear Association	1.328	1	.249
N of Valid Cases	34		

Table 5 results of the Chi-Square test indicate that there is no statistically significant connection between the tested variables, as shown with the P-Value of the Pearson Chi-Square value 5.367 with .252 (more than the 0.05 threshold). Similarly, the probability ratio (6.315, p = .177) and linear-by-linear association (1.328, p = .249) support the conclusion that the difference observed due to the opportunity is likely. With 34 valid cases analysed, these results suggest that the reactions in the categories may vary; they are not strong enough to establish a meaningful relationship between them under consideration.

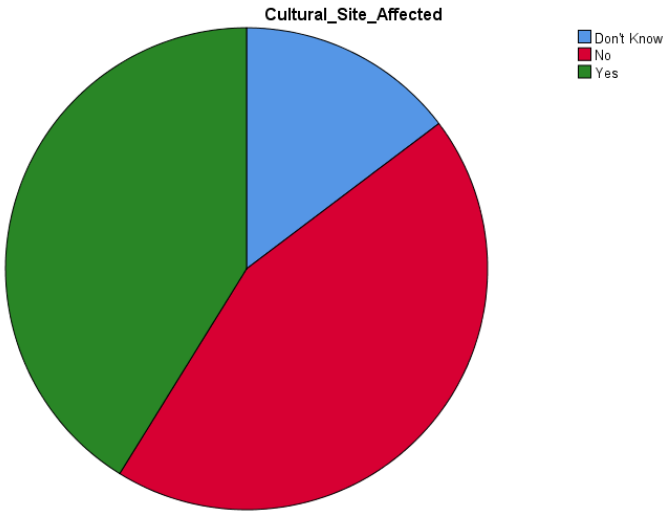

Figure 2 : impact of hydropower development at cultural sites.

Figure 2 presents the assumptions of the houses surveyed about the impact of hydropower development at cultural sites. Among 34 respondents, 44.1% stated that no cultural site was affected, while 41.2% reported that such sites were really affected. A small group (14.7%) indicated uncertainty by selecting "not address". These reactions reflect a community divided into its awareness or cultural disruption experience.

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Table 6: ANOVA Test

ANOVA					
Overall Impact					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.700	4	.425	.275	.892
Within Groups	44.771	29	1.544		
Total	46.471	33			

Table 6 ANOVA suggest that the difference in alleged overall impact in various groups is not statistically important, with an F-value of 0.275 and a P-value of 892. This indicates a high p-mind that any observed variation in the impact perception is likely to occur due to opportunity. Therefore, the type of income source or group classification does not significantly affect the overall evaluation of the effects related to the hydroelectrical effects of the respondents.

Table 7: Descriptive Statistics on Residency Duration and Access to Health Services

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Years In Area	34	1	4	2.41	.957
Distance Health Centre	34	1	4	1.94	1.071
Valid N (listwise)	34				

Table 7 provides descriptive data on two major variables: the year of residence in the area and the distance to the nearest health centre. On average, the respondents lived in the area for 2.41 units on a 4-point scale, indicating a moderate settlement period. The average value for the distance of the health centre was 1.94, which suggests relative proximity, although variation exists (SD = 1.071). These insights help to refer to the stability and service access of the displaced houses.

Table 8: Descriptive Statistics on Income Change and Perceived Overall Impact

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Income Change	34	1	4	2.88	1.343
Overall Impact	34	1	5	2.47	1.187
Valid N (listwise)	34				

Table 8 summarises domestic perceptions about changes in income and overall impact after displacement. The average income change score was 2.88 on the 4-point scale, which reflects a common perception of income declining or instability. The average score for overall impact was 2.47 on the 5-point scale, suggesting that most of the respondents saw the effects of displacement negatively.

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Table 9: Case Processing Summary for Livelihood Loss and Compensation Adequacy

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Livelihood Loss * Compensation Adequacy	34	100.0%	0	0.0%	34	100.0%

Table 9 shows that all 34 cases (100%) provided valid reactions to both variables: livelihood loss and compensation adequacy. There were no missing values to ensure complete data availability for cross-learning and further statistical analysis between these two indicators of displacement effect.

Table 10: Chi-Square Test

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.235[a]	2	.120
Likelihood Ratio	4.402	2	.111
Linear-by-Linear Association	4.084	1	.043
N of Valid Cases	34		

Table 10 Chi- test do not suggest any significant relations between the variables, as the Pearson Chi-Square (P = 0.120) and the probability ratio (P = 0.111) values are above 0.05. However, the linear-by-linear association (P = 0.043) suggests an important linear tendency between variables. The analysis was conducted on 34 valid cases.

Table 11: ANOVA test on Livelihood Satisfaction

ANOVA					
Livelihood Satisfaction					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.175	4	.294	1.359	.272
Within Groups	6.267	29	.216		
Total	7.441	33			

Table 11 ANOVA result for livelihood satisfaction shows no statistically significant difference between the groups, which has F = 1.359 and P = .272 (P> 0.05). This means that the level of livelihood satisfaction is not quite different based on the group variables used in the analysis.

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Table 12: Chi-Square Test Results for Livelihood Loss and Compensation Adequacy

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.309[a]	4	.366
Likelihood Ratio	4.735	4	.316
Linear-by-Linear Association	1.042	1	.307
N of Valid Cases	34		

Table 12 presents the results of the Chi-Square Testing investigating the relationship between loss of livelihood and alleged compensation. Pearson Chi-Square of 4.309 with P = .366 indicates that the relationship is not statistically important at 0.05 level. This shows that the perceptions of compensation adequacy are not significantly different among those who experienced the loss of livelihood and who were not there.

Table 13: Case Processing Summary for Sense of Belonging and Preference for Original Location

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Sense Of Belonging Prefer Original Location	34	100.0%	0	0.0%	34	100.0%

Table 13 suggests that all 34 respondents (100%) provided valid reactions to both variables: relatedness and feeling of preference to the original location. There were no missing cases that allowed for complete and reliable analysis of relationships between these two aspects of post-immunity community integration.

Table 14: Chi-Square Tests

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	15.495[a]	6	.017
Likelihood Ratio	17.076	6	.009
Linear-by-Linear Association	3.835	1	.050
N of Valid Cases	34		

Table 14 Chi-Square Test results reveal a statistically significant relationship between the Pearson Chi-Square Price of 15.495 and the P-Value of .017, which is below the 0.05 threshold between the variables analysed with a variable analysed. The probability ratio (17.076, p = .009) and linear-by-linear

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association (P = .050) support this importance. This suggests that the relationship between the variables is not due to chance and reflects a meaningful pattern within the data.

Table 15: Sense Of Belonging Prefer Original Location Cross tabulation

Sense of Belonging Prefer Original Location Cross tabulation			
			Total
Sense Of Belonging	Agree	Count	3
		Expected Count	3.0
	Disagree	Count	9
		Expected Count	9.0
	Neutral	Count	11
		Expected Count	11.0
	Strongly agree	Count	1
		Expected Count	1.0
	Strongly disagree	Count	10
		Expected Count	10.0
Total		Count	34
		Expected Count	34.0

This table 15 reflects the distribution of a sense of belonging to the participants for their original place. Each category (e.g., "Agreed", "disagree") is a count and a uniform expected count, which is no deviation from the expected distribution. The total number of reactions is 34, and the calculated calculation match is expected completely.

Table 16: Chi-Square Tests

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.096[a]	8	.526
Likelihood Ratio	8.030	8	.431
Linear-by-Linear Association	.126	1	.723
N of Valid Cases	34		

Table 16 Pearson Chi-Square Price is 8.096 with 8 degrees of independence and the importance of 0.526, which has no statistically significant relationship between the sentiment of the concerned and their preference for the original space. Similarly, the probability ratio and linear-by-linear unions also show non-mating results (p> 0.05).

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Table 17: Descriptives – Livelihood Satisfaction

Descriptives					
Livelihood Satisfaction					
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean
					Lower Bound
Adequate	8	1.75	.463	.164	1.36
Inadequate	10	1.70	.483	.153	1.35
Neutral	12	1.67	.492	.142	1.35
Very adequate	2	2.00	.000	.000	2.00
Very inadequate	2	1.00	.000	.000	1.00
Total	34	1.68	.475	.081	1.51

Table 17 presents descriptive figures of livelihood satisfaction in various categories of compensation adequacy. The overall median satisfaction score is 1.68 on a 2-point scale, where lower scores indicate dissatisfaction. The respondents evaluated compensation as "very insufficient"; among them, the lowest satisfaction (meaning = 1.00), while those who rated it as "very enough" were the highest (meaning = 2.00). Although the sample size for extreme categories is small, the trend suggests a positive relationship between perceived compensation adequacy and livelihood satisfaction.

Table 18: ANOVA tests

ANOVA					
Livelihood Satisfaction					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.175	4	.294	1.359	.272
Within Groups	6.267	29	.216		
Total	7.441	33			

Table 18 presents the results of the ANOVA tests assessing the difference in livelihood satisfaction in the categories of compensation adequacy. Analysis shows an F-value of 1.359 with P-Human of 272, showing that the differences seen in the level of satisfaction between groups are not statistically important. This suggests that the alleged adequacy of compensation does not affect the variation in the satisfaction of livelihood within the sample. The post test result based on the ANOVA is provided in the appendix.

Table 19: Descriptive Statistics for Perceived Overall Impact by Income Source

Descriptives					
Overall Impact					
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean
					Lower Bound

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Agriculture	2	2.50	2.121	1.500	-16.56
Business	8	2.75	1.389	.491	1.59
Daily wage labour	6	2.67	1.506	.615	1.09
Government job	2	2.00	.000	.000	2.00
Other	16	2.31	1.014	.254	1.77
Total	34	2.47	1.187	.204	2.06

Table 19 summarises the average score of alleged overall effects of displacement in different domestic income sources. Responsible in business reported the highest average impact score (2.75), followed by daily wages labour (2.67), while in government jobs they reported the lowest (2.00). Families with "other" income sources also reported a relatively low impact (2.31). Despite the variations, the overall median score in all groups was 2.47, which is usually negative to the neutral perception of displacement aftereffect. The overall impact and the test of homogeneity is presented in appendix.

Table 20 : Descriptive Statistics for Perceived Overall Impact by Income Source

Descriptives					
Overall Impact					
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean
					Lower Bound
Agriculture	2	2.50	2.121	1.500	-16.56
Business	8	2.75	1.389	.491	1.59
Daily wage labour	6	2.67	1.506	.615	1.09
Government job	2	2.00	.000	.000	2.00
Other	16	2.31	1.014	.254	1.77
Total	34	2.47	1.187	.204	2.06

Table 20 presents descriptive figures for the alleged overall effect of displacement classified by the primary income source of respondents. The highest average effects were engaged in business people (meaning = 2.75) and daily wages (meaning = 2.67), while in government jobs they are considered the lowest impact (meaning = 2.00). Agriculture-dependent respondents showed more variability, possibly due to the size of small samples. The overall mean in all groups was 2.47, which is usually negative, as a minor neutral view of displacement results in income categories. The overall impact and the test of homogeneity is presented in appendix.

Table 21: Case Processing Summary for Livelihood Satisfaction and Compensation Adequacy

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Livelihood Satisfaction Compensation Adequacy	34	100.0%	0	0.0%	34	100.0%

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Table 21 indicates that all 34 cases (100%) contained legitimate reactions for both livelihood satisfaction and compensation adequacy, including no missing data. This complete dataset ensures reliability for cross-tabulation and further statistical analysis between these two major variables.

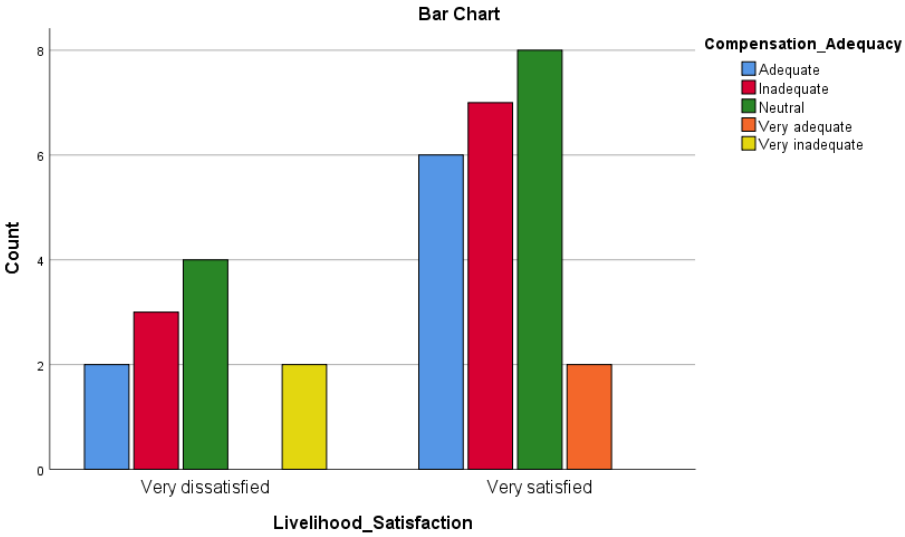

Figure 3: Compensation Adequacy

Figure 3 shows the relationship between "livelihood Satisfaction" (classified as "very disgruntled" and "very satisfied" on the X-axis) and "compensation_EDCassi" ("sufficient," insufficient, "neutral," very enough"," and "have been represented by different colours for"). For there are 2 respondents who consider compensation "adequate", 3 who consider it "insufficient", and 4 who consider it "neutral"; with 2, on the contrary, "very satisfied" with their livelihood, 6 responders considered compensation. Only 2 consider "very insufficient" with 2. It suggests a trend where high livelihood satisfaction is more correlated with a perception of adequate compensation, although a remarkable part of satisfied persons still considers compensation inadequate.

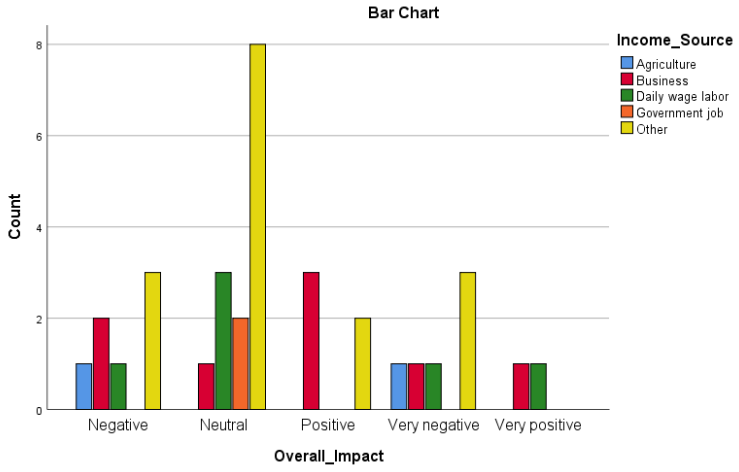

Figure 4: Income Source

Figure 4 reflects the distribution of various income sources at various levels of alleged overall impact among the chart respondents. For those reporting a negative effect, the most common income sources were business and others. Under the neutral impact category, with a remarkable presence of daily wage labour, other income sources were dominated. In cases of positive effects, business emerged as the most frequent income source, followed by others. The categories of very negative and very positive effects show limited but notable representation from agriculture and daily wages. Overall, the chart suggests

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that respondents who rely on other income sources are more often associated with neutral effects, while people engaged in business are more likely to report positive results.

Findings based on Thematic Analysis

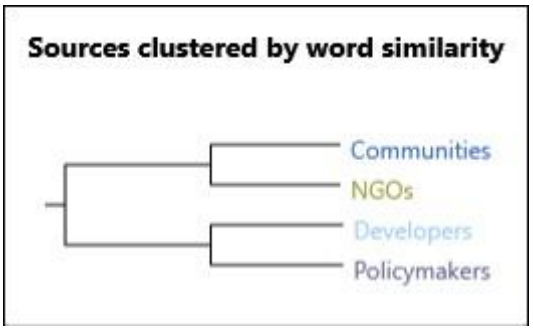

Figure 5: Source Clustered by Word

Figure 5 dendrogram cluster displays four stakeholder groups – community, NGOs, developers and policymakers – based on the similarity of their language use. The diagram suggests that communities and NGOs are aligned more closely in terminology, possibly reflecting shared concerns around justice, rights and participation. In contrast, developers and policy makers create a separate cluster, which focuses a shared focus on procedural, technical and institutional language. This view highlights the grassroots level and discretionary division between institutional actors in the hydropower discourse.

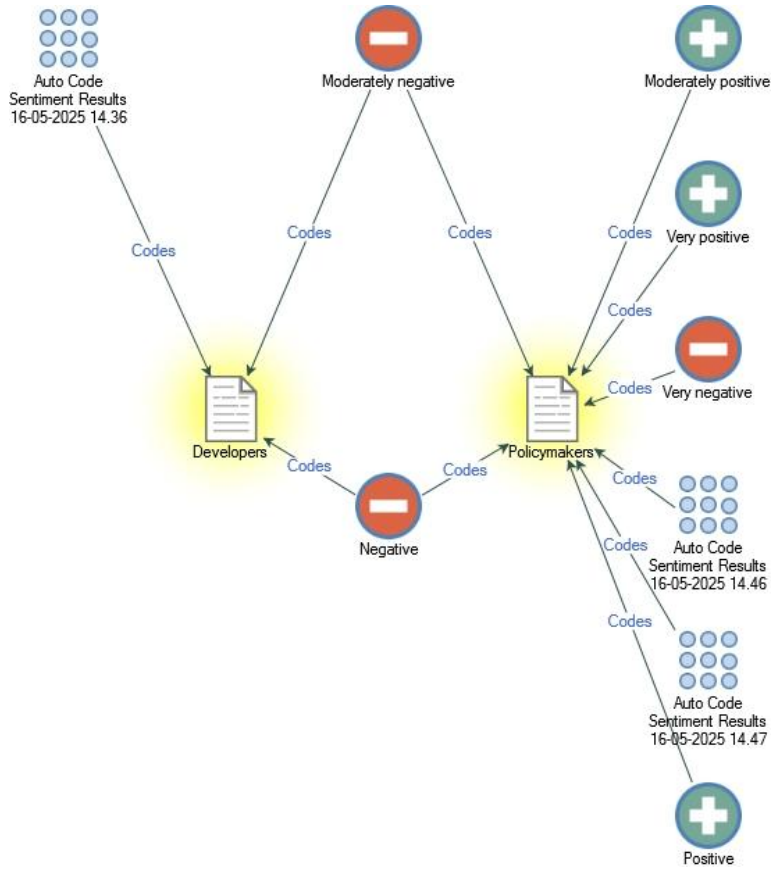

Figure 6: Sentiment Coding Network for Developers and Policymakers

Figure 6 presents a visual emotion coding map that connects developers and policy makers to various emotion categories based on auto-coded qualitative data. Both stakeholders are associated with a range of emotion codes, including many negative, negative and very negative ones, indicating a sufficiently

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significant response in the dataset. However, policymakers also show links of moderate positive, positive and very positive emotions, which show more mixed perceptions than developers. The diagram highlights complicated and often contradictory public sentiments towards institutional actors involved in hydroelectric rule.

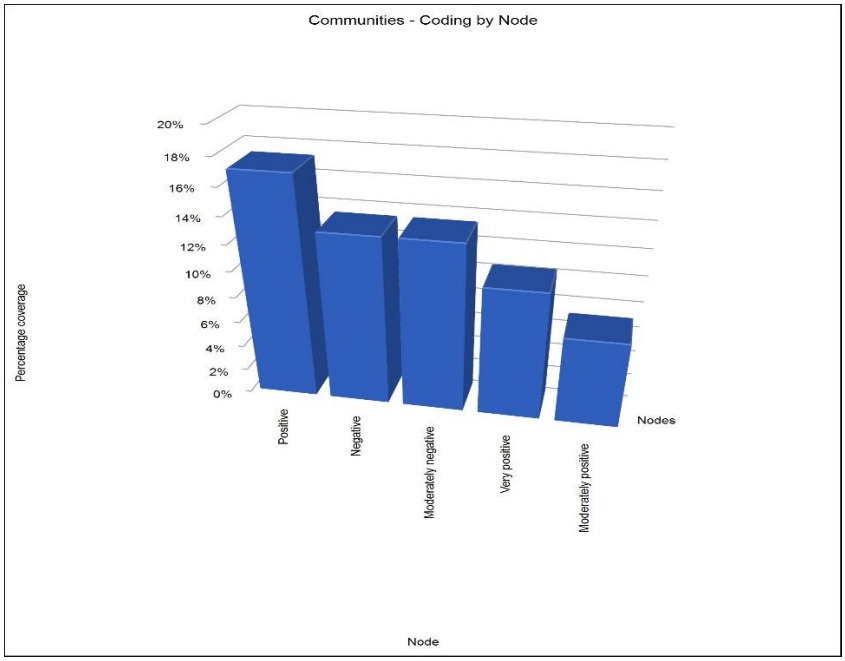

Figure 7: Communities Coding by Node

Figure 7 "Communities – Coding by Node, shows the percentage coverage" of" separate" node"s. The X-axis classifies various nodes as "positive", "negative", "minor negative, "very positive", and "minor positive ". The Y-axis reflects percentage coverage, from 0% to 20%. The graph indicates that the "positive" node has the highest percentage coverage (about 17%), followed by "negative" and "medium negative" (about 13%), then "very positive" (about 9%), and finally "minor positive" with the lowest coverage (about 6%).

(a) Community

(b)Developer

(c) NGO

(d) Policy

Figure 8: Word Cloud based on Thematic Analysis

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Figure 8 (a-d) collectively describe different approaches to hydroelectric development through clouds. Figure 8(a) reveals community concerns focused on land, loss, and lack of understanding, highlighting the subjects of exclusion, cultural erosion, and unknown rights. Figure 8 (b), from the point of view of developers, emphasises efforts to manage formal counselling, procedures and resistance and ensures profit through structured dialogue. Figure 7 (c) reflects NGOs' concerns around indigenous rights, justice and consent and emphasises the role of media and activism in addressing exclusion and violations. Figure 8 (d) (Policy and Governance Views) underlines the need for better mechanisms, accountability and communication to achieve inclusive development. Together, the figures describe the interdependent story of the development of a fragmented competition, where stakeholders often collide or are wrong.

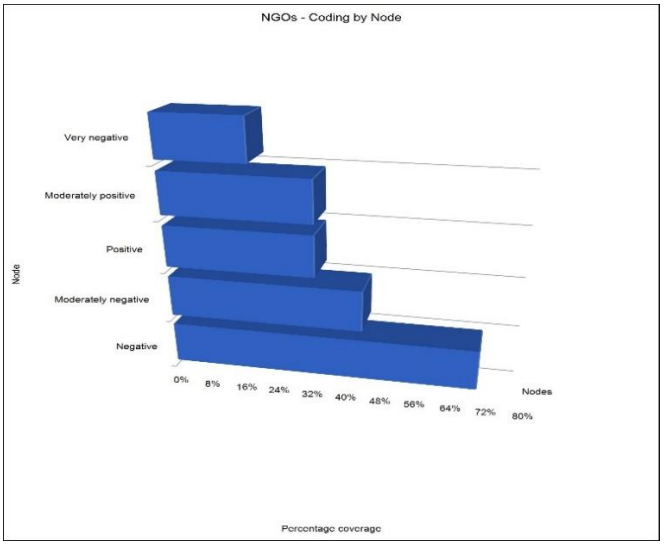

Figure 9: NGOs-Coding by Node

Figure 9 NGO presents a 3D horizontal bar graph called "NGO – Coding by Node", displaying percentage coverage of various emotion categories based on qualitative coding of interview data. The highest coverage is seen in the negative category, more than 64%, indicating a major important stance between NGOs. This is followed by slight negative emotions at about 48%. Both positive and moderate positive feelings fall below 32%, while very negative coverage is the lowest, less than 16%. These results suggest that NGOs mainly expressed concern and criticism about hydroelectric governance, community impact and justice procedures.

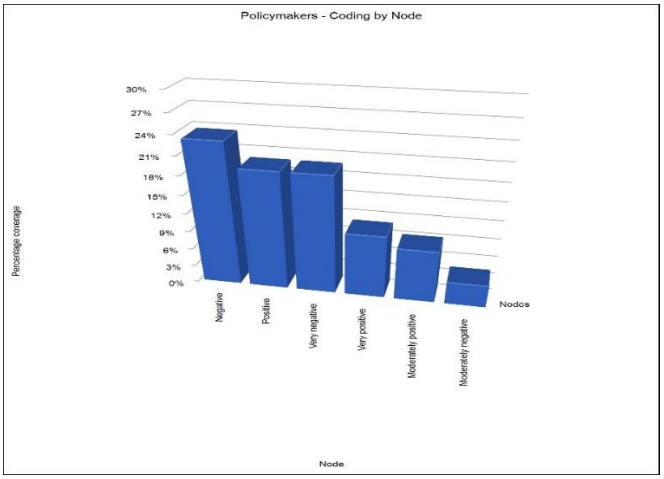

Figure 10: Policymakers-Coding by Node

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Figure 10 "policy maker – coding by node, displays "percentage coverage" for various "nodes" from the perspective of" policy maker's. The graph indicates that the "negative" has the highest percentage coverage, about 24%, with "positive" and "very negative" both closely around 18-20%. "Very positive" has quite low coverage, about 9%; "modest positive" and "minor" have lower coverage, 6% and less than 3%, respectively.

5. Discussion

The study examined the complex social, economic and governance influences of large-scale hydroelectric development in Nepal, focusing on the Upper Karnali and Arun-3 projects. Drawing on a mixed-method approach, research revealed a layered landscape, where the ambitions of national development and clean energy goals were intertwined with deep issues of displacement, exclusion, and justice. Quantitative conclusions from domestic surveys indicated that displaced communities experienced various degrees of disintegration. Income sources have shifted significantly, with traditional businesses in many homes, such as informal labour or infection, moving away from agriculture towards uncertain livelihoods. The average alleged overall impact score was moderately negative, with the highest dissatisfaction among people dependent on daily wages and business. However, the ANOVA tests showed that the difference in satisfaction of livelihood in compensation categories was not statistically important, suggesting that monetary compensation did not translate into alleged welfare or stability alone. A large proportion of respondents also reported effects on culturally important sites, underlining that non-physical loss is often ignored in development plans. Qualitative conclusions added depth into these patterns. Interviews with community members, NGOs and local leaders revealed a strong sense of procedural exclusion. Many participants were informed about the projects only after the major decisions were made; public consultations were described as symbolic or inaccessible. The subjects of humiliation, lack of recognition and cultural isolation were often, especially among indigenous groups. In contrast, interviews with developers and policymakers emphasise compliance with environmental. In addition, the cross-accommodation amidst the perceptions of livelihood loss and compensation portrayed a weak association, indicating that the justice difference may lie more in participation and recognition than in in economic restoration. Interviews and document analysis also revealed the central role of NGOs in raising community voices, lodging petitions and challenging project practices, while policy stakeholders acknowledged the limits of the current grievance redressed system and the need for better coordination. Clustering analysis has shown that communities and NGOs closely shared alliances and concerns, while developers and policy makers formed a separate group with technical language and procedural justification. This division not only reflects different preferences but also fundamentally different ways to understand justice, risk and responsibility. Together, conclusions confirm that hydropower development in Nepal is not only a technical or economic process but also a deep political and cultural one. Despite its branding as "green energy", large-scale hydroelectric often reproduces existing inequalities, displaces the weak population, and reduces traditional knowledge and location-based identity. The application of environmental justice and political ecological structure helped unpack these dynamics, while the sustainable development lens revealed the important trade-offs between energy goals and the good of the community. Research suggests that without meaningful community engagement, recognition of indigenous rights, and transparent governance mechanisms, hydroelectric risk changes the very forms of hydroelectricity injustice that it wants to address. Moving forward, energy infection in Nepal should be not only in environmental stability but also in social inclusion.

6. Conclusion

The study seriously examined the socio-economic, cultural and governance influences of hydroelectric development in Nepal on a large scale, singing the upper Karnali and Arun-3 projects as a case study. The findings revealed significant gaps between institutional claims of sustainable development and the

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living realities of displaced communities. Quantitative consequences showed that about half the respondents experienced negative or neutral effects, after the subsequent displacement, there was no significant improvement in livelihood satisfaction in the compensation categories. Qualitative analysis highlighted extensive dissatisfaction with compensation processes, exclusion from decision-making, and neglect of cultural and ancestral relations for the land. These findings underline the failure of the current hydroelectric rule to ensure environmental justice, especially in procedural and recognised dimensions. Future research should expand the geographical and demographic scope to incorporate more diverse population groups, including additional hydroelectric sites and more diverse population groups, including women, youth and ethnic minorities. Longitudinal studies are also required to assess long-term results of displacement and rehabilitation. Integrating GIS-based spatial analysis can provide deep insight into land-use changes and ecological effects. Policymakers should be encouraged to adopt a participation structure which prefers local knowledge, customary rights and culturally sensitive development schemes. By advancing justice-focused approaches, future hydroelectric development can be combined not only with clean energy goals but also with just and inclusive stability.

Conflicts of interest

There are no conflicts of interest.

Funding statement

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