Water Security in the Face of Climate Change in Bhutan

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This paper explores the intersection of climate change and water resources management in Bhutan, examining the current challenges, policy responses and future strategies to ensure water security in the face of a changing climate.

Bhutan's Water Paradox

Renowned for its pristine environment and unwavering commitment to environmental conservation, Bhutan is a global leader in sustainability practices. However, climate change poses growing threats to its water resources, revealing a striking paradox: while the nation is water-secure by global standards, local communities increasingly face acute water scarcity.

Bhutan grapples with a dual reality - "the problem of plenty" (underutilised resources) and "the problem of scant" (localised deficits). According to a 2018 Water Security Index, Bhutan boasts one of the world's highest per capita water availability - 94,500 m³ per person annually - thanks to its vast river networks and glacial reserves.

Despite this, reports of drying springs, declining agricultural water supplies, and reduced river discharges for hydropower highlight a troubling disconnect between national abundance and local scarcity.

While long-term hydrological data and comprehensive study of climate change impacts on the water sector in Bhutan remain limited, clear observable trends and scientific projections point to significant disruptions in the country's water systems. Rising temperatures, erratic rainfall and glacial retreat are disrupting traditional water systems.

Although Bhutan's macro-level water security remains robust, micro-level vulnerabilities - such as seasonal droughts, infrastructure gaps, and

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weak governance - are exposing communities to unexpected shortages.

Addressing this imbalance will require a better understanding of water resources and climate change impacts on them, current policies, and practices. Going forward, what innovative strategies could link national wealth with community-level resilience, ensuring that Bhutan's water security benefits all its citizens?

Water Resources in Bhutan

To assess Bhutan's water resources, we must first examine its precipitation dynamics, which vary dramatically across regions, due to extreme topographic, altitudinal differences, and associated micro climates.

Bhutan receives a high average annual rainfall of 2000 mm, but the amount varies significantly by region due to its rugged topography and altitude differences. The annual average rainfall differs as we move across different agro-ecological zones.

The southern foothills (subtropical) like Samtse, Chukha, and Sarpang receive an average rainfall of 2500 mm to 5500 mm. The central valleys (temperate) like Thimphu, Punakha, and Wangdue Phodrang receive an average rainfall of 1000 mm to 2000 mm. The high mountains (alpine) like Bumthang, Gasa, and Haa receive an average rainfall of less than 1000 mm.

The National Centre for Hydrology and Meterology (2023) states that the annual average rainfall was 1794.30 mm in 2023, indicating that the country as a whole received slightly below normal rainfall against the longterm average from 1996 to 2022.

Rain and snow accumulate in the watershed, forming different hydrological regimes and fresh water resources, broadly categorised as wetlands. The general categories of wetlands in our country are glaciers, lakes, vernal pools, rivers, streams, springs, and marshes.

This is a simplified version of the categories whereas, depending on the hydrological regimes and the associated aquifers, these can be further categorised into complex categories of wetland types. Wetlands in the watersheds create unique ecosystems that regulate the micro climate and can also function as sponges to soak in the precipitation and recharge the aquifers.

For ease of understanding, we can also broadly say that wetlands are the main sources of water in Bhutan, and a diverse network of wetlands in a watershed characterises a rich hydrological regime and a healthy watershed.

Bhutan fundamentally relies on strategically utilising distinct water sources for specific needs, a practice shaped by the country's diverse hydrological resources, socio-cultural beliefs, and varying demand patterns. Most of the available water is in the valley floor in the form of rivers, and the water scarcity is faced by settlements on the mountain slopes, which consider spring water as an ideal source for drinking water because of the community's traditional knowledge that springs have better quality of water.

So, for drinking water or domestic use and agriculture, mostly springs and streams are tapped, and for hydropower generation, rivers are dammed.

The impact of climate change on the water sector is not one-dimensional and therefore, there is a need to understand climate change impact on the food-water-energy nexus. The nexus approach helps us understand the multi-dimensional nature of the water sector and its impacts on livelihood and development in Bhutan. This warrants an in-depth study.

Climate Change Impacts

Climate change is profoundly impacting the water sector through shifts in precipitation patterns, rising temperatures and increased frequency of extreme weather events.

According to the World Meteorological Organisation (2023) the global mean near-surface temperature for the year 2023 was around 1.40 (1.28-1.52) °C above the 1850-1900 baseline, used as an approximation of pre-industrial levels.

The following are some of the prominent visible impacts of climate change on the water sector:

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Melting Glaciers and Glacial Lakes Outburst Flood (GLOF)

Melting glaciers and GLOFs cause a dual crisis - the rapid loss of its natural water storage and an increase in climate-induced disasters. Remote sensing studies show that the snow and ice coverage in the alpine regions of Bhutan has drastically changed in recent decades. Rising temperatures and changes in precipitation pattern have led to glacial retreat, resulting in reduced glacial ice surface area and volume.

The formation of supra-glacial lakes is on the rise and when there is a breach in the moraine dam, it causes the disastrous flooding called GLOFs. There have been recent reports of GLOF events in the country. Through inventories and ground truthing, the National Centre for Hydrology and Metrology claims Bhutan has 17 potentially dangerous glacial lakes of which the maximum are found in the Phochhu sub-basin of the Punatshangchhu watershed.

Flash Floods

High rainfall intensities for a prolonged period of time in fragile mountain slopes cause flash floods, threatening lives and livelihoods along rivers and streams. As the summer monsoon becomes more erratic and intense, water levels in the streams and rivers increase, they wash off the debris and create temporary dams in the narrow valleys, causing backwater flow.

As destabilisation of slopes is exacerbated, these temporary dams are breached, the accumulated volume of water with debris is released, causing disastrous floods. All river valleys in Bhutan are prone to this disaster. Every year, there are many reports of flash floods across the country. In 2024, Thimphu also faced a disastrous flash flood induced by prolonged high intensity of rainfall.

Drying Water Sources

Reports of water sources drying, especially springs and lakes, have been coming from across the Himalayas (Nepal, Sikkim, and Bhutan) for several years. Most reports have been anecdotal and have very little empirical evidence to support the claims that it is contributed by climate change.

However, in recent years, through various case studies and establishment of pilot sites in the country, there is increasing evidence that climate change is one of the factors causing it. The unintended consequences of weak water

governance, with poor water resources planning, no water budgeting and wrong interventions, have exacerbated the phenomenon.

Current Water Policies and Practice

Bhutan's water resources are governed by a combination of national policies, environmental regulations, and international commitments, all aimed at ensuring sustainable water management, while supporting socioeconomic development. The policies align with global commitments, like the Sustainable Development Goals, particularly SDG 6 - Clean Water and Sanitation - and the Paris Agreement, reinforcing its climate-resilient water governance.

The management of water in the country cross-cuts different sectors, departments and ministries. The key management practices include the hydropower sector, urban and rural water supply, watershed and wetlands conservation, disaster risk reduction, and climate adaptation.

Considering the diverse and cross-sectoral nature of water governance, the recent transformation exercise in the Royal Government of Bhutan created a new Department for Water in the Ministry of Energy and Natural Resources. The intention was to create a single department that oversees the management of water in the country and reduce the duplication in planning and implementing programmes and projects, to enhance efficiency.

However, there are still loopholes in the institutional transformation. The main caveat in water resources management has repeatedly been pointed out to be the lack of communication and weak collaboration amongst agencies that deal with water. This still exists even after the institutional reform.

The rural and urban water supply programmes are housed in a different ministry. The new department is entrusted with mandates but the human resources are weak. The water policies are strong but face weak implementation due to huge budgetary requirements and weak informed decision-making through science and research. Though the necessary changes have started, there is a long way to go for the water sector to become efficient enough to navigate and address the multiple and complex problems of water resources management in Bhutan.

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Going Forward

Bhutan's water future depends on transforming national abundance into equitable access through strong leadership, good governance, and informed decision-making. Many generic strategies are mentioned in various documents on water resources management in Bhutan, which are already being addressed through various interventions by the Department of Water. The following are a selected few strategies, often misunderstood by decision makers and donors, which is important to be highlighted.

Plan and Implement Localised Water Strategies

Water resources in mountainous terrain are complex and fragile, and understanding the unintended consequences of water recharge interventions is paramount. Planting trees haphazardly is often not a solution to the problem.

In mountain areas like the Himalayas, the high relief and complex geological structure play an important role in the formation of mountain aquifers. Hydrogeological mapping of the springs often reveals that the recharge area and the area of protection of the springs show a very sitespecific relationship. The extent and location of these recharge areas are governed by local geology and the rock structure.

Ideally, recharge areas should be demarcated based on the hydrogeology, after monitoring the site for a long period of time. Given the importance of aquifers in understanding springs, hydrogeological approach should be an integral part of any water-related investigation. This is particularly important when planning activities that can be carried out to improve recharge of the aquifers to restore water sources.

Simply put, precipitation in Bhutan vary dramatically across regions due to extreme topographic, altitudinal differences and associated micro climates. The hydrogeology, forest cover, and agricultural practices differ across the country. Traditional water use also differs, depending on water availability. These spatial diversity underscores why localised water strategies are essential for Bhutan's resilience.

Prioritise Surface Water Management Rather than Exploiting Ground Water

Surface water in Bhutan is not managed, considering the water balance in the watershed, causing a widespread understanding that surface water is scarce. We see some watersheds that are heavily exploited by different water user groups and for different purposes. Proper water budgeting in the watershed is rarely visible.

On the other hand, there is an increasing trend among decision makers to point out the exploitation of ground water as a possible solution to address water scarcity. This is risky and can cause serious water quality and quantity problems in the future.

Interventions should be made considering that ground water is an alternative fresh water resource that can deplete over time. It should be accounted as a reserve, not a resource we can exploit easily.

Groundwater science is complex and even developed countries with centuries-old data struggle to manage ground water. However, mapping ground water is important, and further research on ground water science is crucial to understand how we can use it efficiently and equitably.

Strengthen Water Governance

Water governance is multi-faceted and is a very important aspect of water resources management. Though an important facet of managing watersheds of major towns and settlements by locking it in as critical watersheds is a crucial step, management of water at the user interface is necessary.

The supply and demand for water is not managed well and priority is often given to the problems at the water source. Very few strategic behavioural change interventions exist to manage treated water. Towns and cities have not been able to reduce their non-revenue water rates and have not been able to impose proper water tariffs. Individual water users do not pay for their household water use and thus there is no behavioural change among water users.

Although specific mention of these interventions is in the water regulations, there is a gap between the existing policies and intervention. Bhutan cannot rely solely on supply-side solution; it must manage demand, enforce

regulations and foster a culture of conservation. We should start serious discourse on introducing Public-Private Partnerships (PPP).

The above-mentioned strategies are an outcome of the systems analysis of the water sector, challenges, policies, programmes, and practices in Bhutan. In conclusion, Bhutan can ensure long-term water security through further in-depth systems analysis of transitioning to a regenerative water sector and carving out a detailed strategic roadmap.

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