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Assessing the Impact of Climate Variability on Water Resources in Kashmirs Himalayan Landscape

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Abstract: ***Water resources are important to both society and ecosystems. We depend on a clean supply of drinking water to sustain our health. We also need water for agriculture, energy production, recreation, and manufacturing and host of almost all life activities on this planet. However Climate Change is likely to impact freshwater resource availability and thereby disturbing hydrological cycle, which may affect the spatial and temporal distribution of runoff, soil moisture, and ground water reserve and may increase droughts and floods. In J&K, increased water demand due to urbanization, agriculture expansion, increasing population, rapid industrialization and economic development has already put pressure on water and climate change is likely to exacerbate it. This paper's primary goal is to investigate how climate change affects water availability and resources for a variety of sectors, including ecosystems, agriculture, and human health.***
Keywords: Water resources, Climate change, Agriculture

I. INTRODUCTION

Ever since the human evolutionary process got rolling, the climate has exerted influence on the evolutionary pattern and human lives and has also been affected by it in return. Alteration in climatic patterns corresponds to the negative effects on the entire ecosystem. Climate change is unambiguously a reality. It poses an unequivocal threat to the livelihood of people, biodiversity, water resources, agriculture, national growth, and political economies of nations on a global scale. It is characterized by the rise in global temperatures and the occurrence of extreme weather events such as heat waves, droughts, and floods. Kashmir Himalayas, nestled in a huge Himalayan belt, is considered to be a hotspot for climate change risk owing to its complicated topography, massive glacial and water resources, quick-responding watersheds with severe seasonality, and climate variability on a smaller scale. The water cycle is a delicate balance of precipitation & evaporation. These days amount of rain falling during storms and high winds which are so prevalent now in Kashmir, provide evidence that the water cycle is already changing. As temperatures rise, people and animals need more water to maintain their health and thrive. Many important economic activities, like producing electricity at power plants, raising livestock, and growing food crops also require water. The amount of water available for these activities may be reduced as Earth warms and if competition for water resources increases.

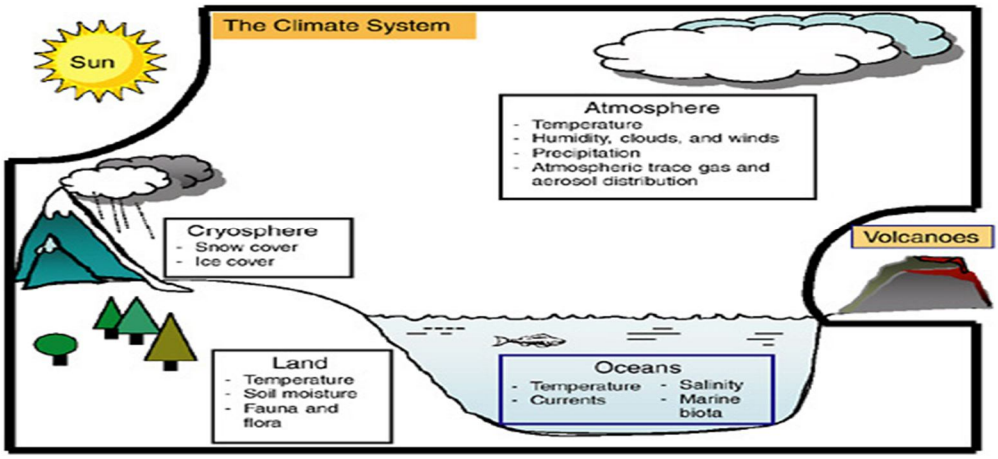

Figure 1: Pictorial representation of climate change

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The relationship between water, energy, agriculture and climate is as important as it is complex. Over time, the effects of global warming due to the human-generated build-up of greenhouse gases (GHGs) in the atmosphere have become more evident. In 2017, major GHGs, like carbon dioxide, methane and nitrous oxide hit record levels. Lockdown during Covid pandemic has not impacted the GHGs to a large extent due to the transport of health related equipment, oxygen supply and PPEs. In fact the Plastic waste which include PPEs, used Syringes, injection vials, E waste has increased manifold in the environment during current pandemic and it has found its way into water bodies directly along with other materials which has severely impacted the water quality. This will have long term ill effects on our health.

J&K is bestowed with umpteen water bodies and water resources and most of the water-bodies receive supply from mountain range, therefore, loss of glacial mass due to global warming will have a serious effect on our climate and might reduce the water availability impacting hydro power potential and lower availability of water for irrigation impacting the agrarian economy. This will affect our economy and agriculture produce, domestic water supply and health.

II. IMPACT OF CLIMATE CHANGE ON WATER RESOURCES

The three distinct river basins namely Chenab, Jhelum and Indus River are donning J&K apart from water bodies, wetlands, tributaries, lakes and rivers. The water flowing in the Himalayan rivers receives water from rain, snow and glaciers, make these rivers perennial where heavy monsoon rainfall contribute to the bulk of water in these basins which are used for irrigation and Hydro-power generation. The Indus River originates at the confluence of the Sind river and the Gar river which is Mansarovar lake in Tibet at an elevation of 518 meters, and enters India through South-eastern corner of J&K .

River Jhelum originates from Verinag spring in Anantnag and after passing through Srinagar it drains into Wular lake and then passing through Baramula and Uri it flows towards Pakistan. The total geographical area of Jhelum basin up to Indo-Pakistan border is about 34,755 sq. km. The total catchment area up to the ceasefire line is about 17,622 sq. km, spreads in seven districts namely Anantnag, Pulwama, Srinagar, Budgam, Baramulla, Kupwara, and Poonch. The Lidder River is the biggest tributary of Jhelum and is fed by a large number of glaciers. Jhelum is joined by many small streams like Vishow, Rambiara, Sandran, Aripat, Romeshi, etc .

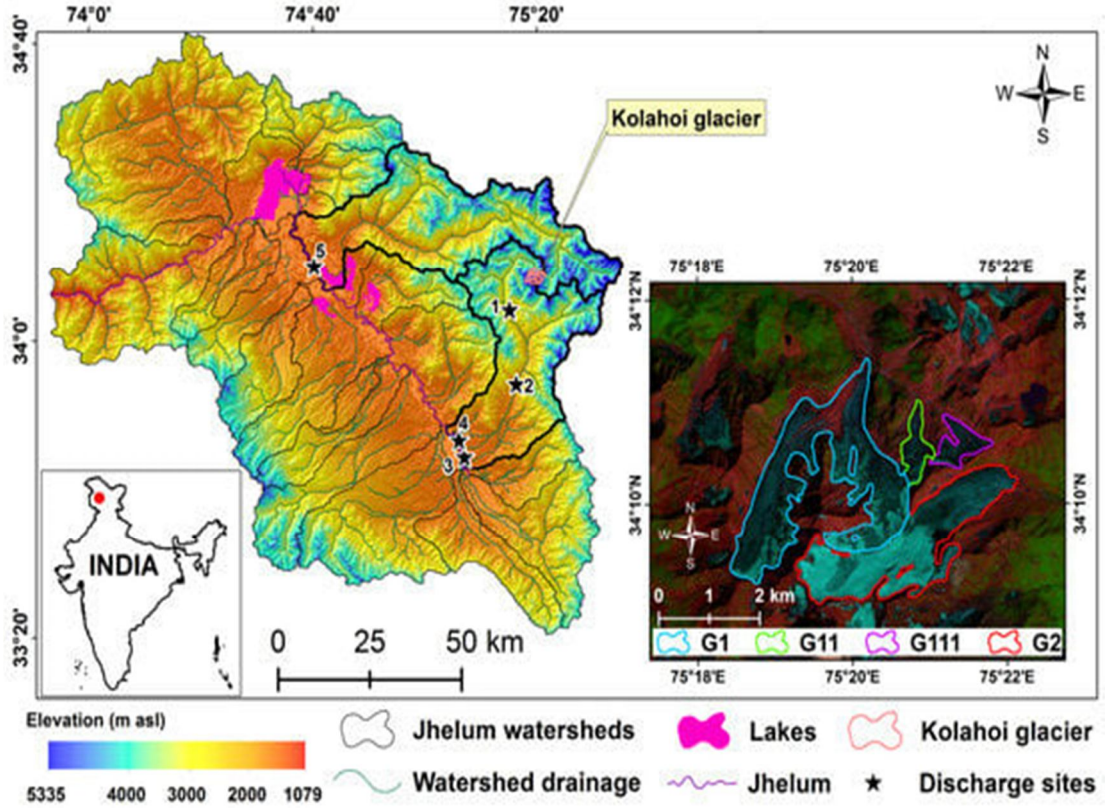

Figure 2. Location of the study area: Red dot in the India map indicates Kashmir valley. The boundaries of Lidder and Sind watersheds are outlined black

Chenab River is the merging of the two Himalayan Rivers,viz: Chandra River and Bhaga River at Tandi located in upper Himalayas. It enters the plains of Jammu and then enters into Pakistan. The Salal, Dulhasiti , Sawalkot and Baglihar ,Rattle Hydel projects have been constructed over it. River Kishan Ganga is in Drass (Kargil) in the inner Himalayas. After passing through the mountain tracks of Gurez, Keran and Karnah it joins Jhelum at Doemel.

Tawi River Originating from Kailashkund spring at Soej hills in Bhaderwath, Tawi passes through Jammu and joins Chenab in Ranbir Singh Pura and then enter Pakistan.

River Ravi is a trans-boundary river flowing through North-western India and North Eastern Pakistan. The river drains a total catchment area of 14,442 sq. km in India after flowing for a length of 720 km..

The Indus system comprises three eastern rivers namely the Sutlej, the Beas, the Ravi and three western rivers namely the Indus, the Jhelum and the Chenab. Under the Indus Water Treaty (IWT) of 1960, the waters of eastern rivers are allocated to India and those of western rivers to Pakistan except specified uses by India mostly in J&K.

We need to carve out a strategy to address our water issues so that scientific water management is observed in all our plans.

We need to plan comprehensively and create a portal for data generation so that all future plans are based on concrete scientific evidence and data.

Assessment of the water resources is the first step in understanding the water resources. This is essential to assess all water resource related activities such as efficient management of the resources, planning of the water resource for future use, readjustment of water use plans considering the changed supplies and demands etc. Baseline assessment should revolve round, hydrological study to enhance natural water availability in the basin/region/ area; • Monitoring of Ground water level and quality • Estimation of surface runoff and Evapotranspiration • Spatial Distribution and Seasonal Variability of precipitation and number of dry days • Monitoring of stream level and flow •

Undertaking study on Glaciology, Snow Hydrology, River hydrology and sedimentation .Promoting and implementing water use efficiency measures.

Mandating water audit across industrial and commercial sector to benchmark unit wise water usage and enforcing adoption of water conservation measures. • Introduction of water metering system across domestic, industrial and commercial sector to ensure judicious usage of water. • Creating awareness among the farmer groups towards judicious use of water and promoting sprinkler/ drip irrigation systems and lowering evapotranspiration. Farmers should also be trained for computing water requirements of crops and build capacity towards applying just as much needed and not irrigate randomly. Promoting System of crop intensification and achieving water use efficiency across agriculture sector. • Water recycling and reuse • Canals should be ensured free from seepages.

The total water balance, its basins, sub-basins, areas, etc. depicting the quantified hydraulic cycle is the main tool for understanding the water situation.

Water budgeting should be based on this hydraulic cycle and interaction between rain water, surface water, ground water, evaporation etc. It is therefore essential that water budgeting be carried out to chalk out efficient planning.

Formulate comprehensive rejuvenation plan for Dal Lake, Mansar/Surinsar Lake, Manasbal Lake and all other major lakes will help in better water management. Separate implementing agency with scientific capacity building is required for lake management. . These water bodies are essential sources of surface water which suffice for the domestic and drinking water requirement. Moreover these lakes are also main areas of tourist attraction. Shrinkage and deterioration of the lakes and water qualities along with encroachment and choking of drainage system might render us with water scarcity.

The artificial recharge is another scientific tool where such action for ground water aims at augmentation of ground water reservoir by modifying the natural movement of surface water utilizing suitable civil construction techniques. Artificial recharging helps to enhance the sustainable yield in areas where over-development has depleted the Aquifer, Conservation and storage of excess surface water for future requirements improve the quality of existing ground water.

Need of the hour is to Building climate change resilience through water management and ecosystems to arrest changes in the water cycle.Climate change impacts have direct consequences for water security and conflict. In order to achieve the Sustainable Development Goals, climate change adaptation will have to build climate resilience. Climate resilience is strengthened through healthy ecosystem services that rely on well-functioning river basins. Effective country-driven climate change adaptation should reflect the importance of water management in reducing vulnerability and building climate resilience.

In J&K rain water harvesting needs to be an inbuilt part of building plans issued by the municipal authorities as is the concept of green building. Water audit is also very important due to the potential of J&K in renewable green hydro power energy.

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III. CLIMATE CHANGE IN KASHMIR'S HIMALAYAN LANDSCAPE

Climate change has accelerated the already rising temperature and unstable precipitation patterns and worsened the vulnerabilities to drought, thereby bringing the Himalayan ecosystem to naught. As per the findings of the article, "Recent Glacier changes in Kashmir Alpine Himalayas, India" glaciers have shrunk by 17%. Another study 'Linking the recent glacier retreat and depleting stream flow patterns with land system changes in Kashmir Himalaya (India)' examined changes in the Kolahoi Glacier between 1962 and 2018, and reveals that the glacier is receding at an alarming rate. It has lost almost 23% of its land, splitting into smaller pieces since 1962. As per IPCC, the glacial meltdown is projected to swell flooding; avalanches from snow slopes will become rampant and erode water supplies down the river stream. Another study reveals that the annual precipitation is likely to plummet by a maximum of 2.09–6.61% in the 2080s. Along with, during the 2080s, the seasonal distribution of precipitation is predicted to change dramatically, with reductions of 9%, 5.7 %, and 1.7%, respectively, in the winter, spring, and summer seasons.

In light of the above-stated climatic transformations that have and will continue to cause life-altering events, it is important to understand, assess and evaluate the impact accounted by climate change in the Kashmir Himalayas. A study that maps climate hotspots over the forest cover in India using computer-model-based temperature and rainfall has been conducted for the three future time periods i.e. years 2030, 2050, and 2085. It has been observed that the biggest temperature rises are expected in Ladakh, Jammu-Kashmir, Himachal Pradesh, and Uttarakhand. Ladakh, Jammu & Kashmir, and Himachal Pradesh are expected to witness the smallest increases in rainfall if any at all.

The temperature variation at Srinagar is shown in the table below:

Sl. No.	Month	1985	1990	1995	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1.	January	-1.3	-1.1	-4.7	-2.7	-3.2	-0.8	-2.0	-3.6	-2.8	-2.9	0.3	-0.3	-01.3	-02.5	-02.5	0.4	-01.5
2.	February	-1.3	1.5	-0.7	0.7	-0.8	2.2	-0.3	-0.3	-0.5	0.4	1.1	0.7	03.3	02.9	01.4	1.5	00.4
3.	March	4.7	2.5	3.4	4.9	4	4.6	2.9	3.2	4.5	3.7	5.6	5.3	04.7	03.0	05.3	5.0	06.5
4.	April	8.6	6.9	7.4	7.5	7.4	8.3	7.9	8.5	8.6	8.6	8.5	7.1	07.2	08.9	07.7	8.0	09.0
5.	May	10.9	11.9	10.5	10.0	9.6	11.4	13.2	14.5	11.3	9.1	10.7	9.9	13.3	11.9	11.5	10.8	11.1
6.	June	14.1	16.3	14.1	15.4	14.7	14.4	16.3	17.4	15.2	14.9	15.0	14.4	14.7	16.0	18.3	13.0	13.5
7.	July	19.1	18.5	18.7	17.8	20	18.4	18.7	19.5	17.1	18.9	16.9	18.0	19.3	17.8	19.1	16.9	17.7
8.	August	17.9	18.3	18.5	17.5	17.1	17.3	17.7	17.6	18.2	17.1	17.1	16.9	18.3	17.8	17.8	17.9	18.8
9.	September	12.5	14.1	11.4	13.8	13.8	14.5	11.3	11.2	11.6	13.6	12.6	13.7	12.3	13.3	11.3	11.9	13.3
10.	October	6.5	4.7	6.5	5.9	7.6	5.1	5.6	6.1	6.6	5.1	6.2	5.8	08.0	03.9	06.9	5.1	07.3
11.	November	0.3	0.3	-0.6	1.1	2.3	2.5	2.5	0.9	0.7	0.7	1.1	-0.02	03.5	-01.1	01.0	0.5	02.2
12.	December	-0.8	-1.7	-0.3	-3.1	0.5	-3.9	-0.7	-0.9	-0.8	0.0	-0.7	-0.03	00.0	-02.0	00.7	-0.8	-3.7

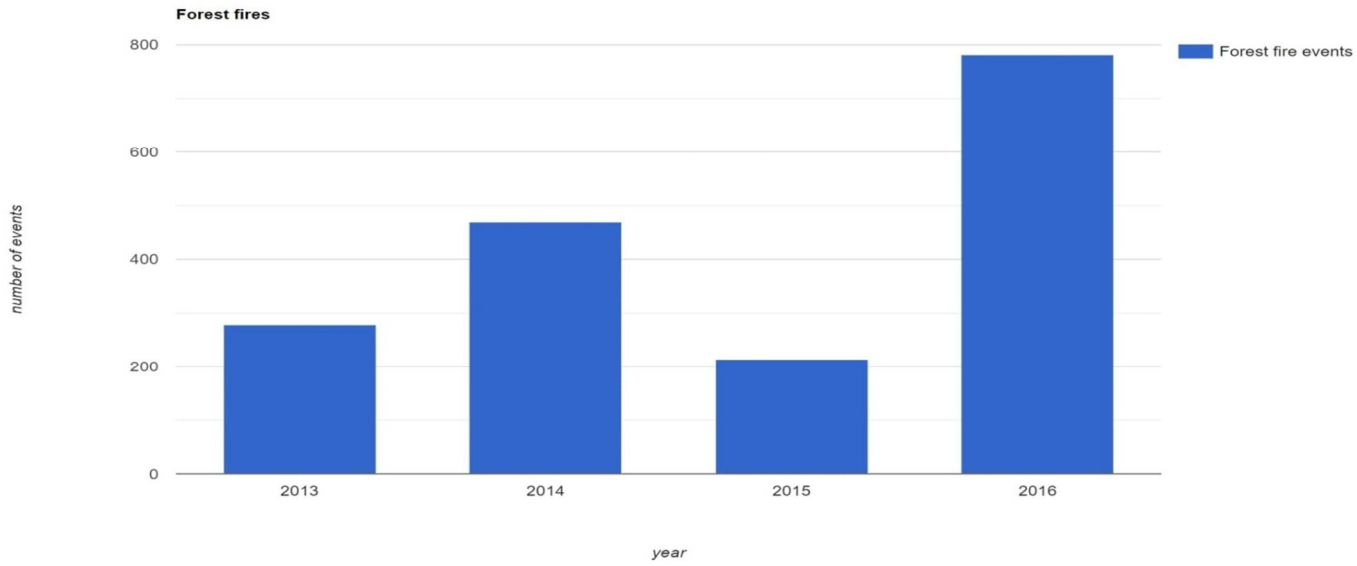
Source: State Action Plan on Climate Change (Jammu and Kashmir)

Additionally, according to the ENVIS newsletter (October-December, 2015) titled, "Climate Change and concerns of J&K": Temperate deciduous, cool mixed, and conifer forests have grown significantly (11%) at the expense of alpine meadows, which are expected to shrink. Socio-economically, the repercussions are nothing less than a catastrophe as the Kashmir valley and Jammu wrestle to preserve its pristine flora comprising of Deodar, Fir, and spruce. Surprisingly, the Blue pine and Chir pine are left unscathed from the blight of climate change.

Not only the flora but fauna of Jammu & Kashmir seem to be in deep waters.

In recent times, the phenomenon of bird migration has witnessed peculiar trends, especially in the wetlands of Jammu, Kashmir, and Ladakh throughout the winter. The latest Asian Waterbird Census Report highlighted the richness and abundance of water birds, as well as the trend in the water bird population during five years of extensive surveys from 2015-to 2021, revealed that Kashmir has recorded a total of 6.4 lakh birds. Nonetheless, the number has decreased by 1.5 lakh since 2020. The region's two Ramsar sites Hokersar wetland and Wular lake have seen a significant drop in the number of incoming birds. The census states that "birds in Hokersar wetland decreased from 4.8 lakh in 2020 to 65,000 in 2021, while birds in Wular decreased from 1.2 lakh to 707 birds in 2021".

The scourge of climate change is evident with the intensification of forest fires. It is not surprising to know that forest fires due to rising heat waves are on surge in Kashmir Himalayas. Forest fires are frequent in the subtropical woods of the Jammu region, although their intensity and frequency have been low in the Kashmir region. However, as a result of global climate change, winter precipitation has been below average for the last few years, resulting in a dry fall, which produces an atmosphere conducive to forest fires. The region has thus witnessed an increased incidence of forest fires. According to the Forest Department's official report, the year 2016 had unprecedented forest fire incidences. "In the state, there were about 781 forest fire occurrences registered." The research noted that "these infernos affected an astounding 2556.3 hectares, which is more than 200 percent greater than the equivalent year 2015." "Of the 781 events documented, 289 were fire incidents in Kashmir and 492 in the Jammu region," according to the report. "In 2015, there were 214 fire events across the state, affecting 341.4 hectares of land. The state had 470 and 278 forest fire incidents in 2014 and 2013, respectively," according to the report. The report notes that the number of forest fires in 2016 was higher than in prior years.



We have understood how detrimental climate change can be for humans, culture, and ecology. However, to understand the consequences of climate change in Jammu and Kashmir, digging out the causes is a prerequisite. In J&K, unplanned urban growth, conflicts, changing socioeconomic profiles, excessive and unplanned exploitation of natural resources (like Dal Lake or deforestation), unplanned construction, climate variability and change, and many other factors all contribute to increased vulnerability to the Himalayan ecology. Key human interventions such as encroachment, pollution, siltation, and increasing resource exploitation, together with insufficient and improper planting, have a significant negative influence on the Himalayan environment. This regressive trend may be stopped with sustainable development practices that strive for balanced growth. Bearing in mind the harmful effects of climate change, the Government of Jammu and Kashmir introduced the Sustainable Himalaya Mission. The Sustainable Himalaya Mission aims to:

1) A comprehensive investigation of the effects of climate change on species of plants, animals, and glacial ecology;
2) Research on the sensitivity of mountain ecosystems;
3) Participation of the community in the preservation and protection of the mountain, terrestrial, and aquatic ecologies;
4) Building capacities and increasing awareness among all stakeholders;
5) Institutional growth for biodiversity protection and conservation;
6) Climate grids' identification and impact on forests and biological resources;
7) Ecological research on land and water;
8) Investigation of human involvement in ecological hotspots;
9) Study of how the climate affects the timing of migratory bird movements;
10) Identification of the Himalayan ecosystem's present state and a study of climate trends for the Himalayan environment.

IV. DELETERIOUS RAMIFICATIONS

Predictive risks experienced due to climate change will have major consequences for industries such as agriculture, water resources, and human health. Although the decrease in the number of frost days and an extension of the growing season may be beneficial to agriculture, however soaring temperatures and decreasing precipitation will result in increased water demands for irrigation. Teetering temperature and precipitation scenarios will exert a direct impact on water supplies and water-dependent systems. Dry spells are a new tendency in Kashmir's environment, with exceptionally protracted dry periods occurring in recent years, causing severe water shortages. None of the 23 wells in Kashmir assessed for the May 2016 report had a water level moreover 20.0 meters below ground level, according to the Ground Water Year Book 2016-17. (m bgl). Water levels less than 2.0 m bgl have been recorded in 14 wells, according to the report, while the depth to the water level in seven wells ranges from 2 to 5 m bgl. One well showed water levels in the 5-10 m bgl range, and another well showed water levels in the 10-20 m bgl range." During the summer and autumn seasons, prolonged dry periods, as indicated by consecutive dry days, have an impact on surface water availability.

V. CONCLUSION

Climate change isn't Hailey's comet that will wake people from their carefree slumber after 75 years; rather it is akin to bacteria that grow speedily in space. Climate change is here to stay; therefore, it becomes imperative to prioritize and preserve biodiversity and address the climate change-based issues in Kashmir Himalayas. Climate change over mountainous basins demands a broader understanding of present and future temperature and precipitation regimes for better water resource management, hydropower generation, cryospheric resources, natural hazard risk assessment, and ecosystem response. The article calls for policy intervention in the future climate scenario of the Kashmir Himalayas. The changes in climatic conditions of the region will have serious ramifications in terms of water availability and the glacial environment of the Kashmir Himalayas.

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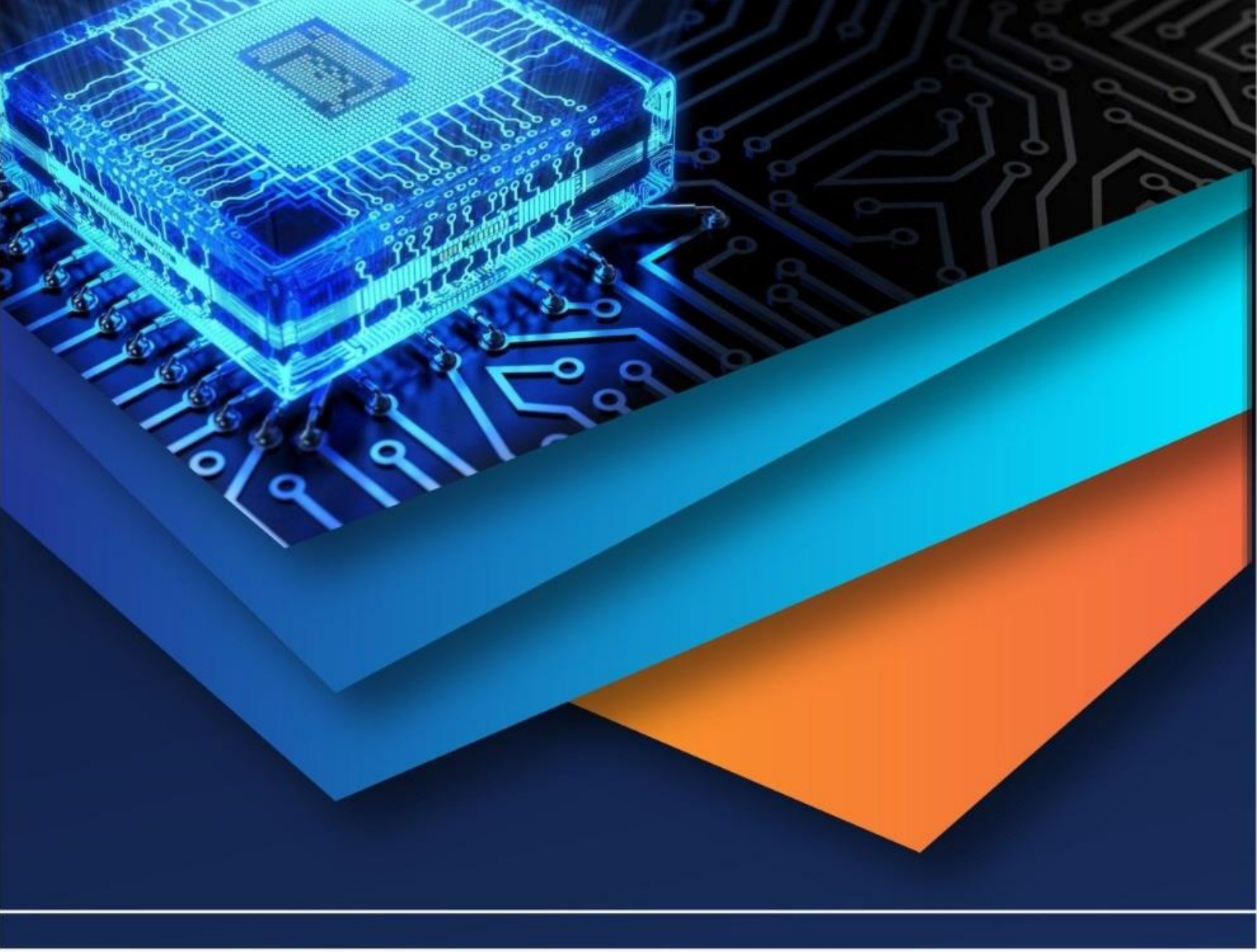

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