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# LOKTAK BASIN: A STUDY ON HYDROGEOMORPHOLOGICAL ANALYSIS AND LANDSCAPE DEVELOPMENT

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**Abstract**

Loktak basin is one of the important sub-basins of the Manipur River basin. It is a part of the Manipur central valley. The basin comprises major part of the Manipur River system, located in the central part of the Manipur state in north-east India. The study area has been investigated for the analysis of the geomorphological settings on the significance of active tectonic origin by using Geographic Information System, most commonly used indices of geomorphological and hydrological characters, structure and topography, soil and drainage, and hydrological parameters on climate, as the basin is a tectonic origin under Indo-Myanmar Himalayan tectogenesis, represented by a humid landform of sub-aerial denudation with varying slopes. The hydrological regime of the basin is monsoonal; slightly stratification under sedimentation with centripetal drainage characterized by non–perennial and problematic exhibits the existence of the basement sedimentation of the Loktak Lake impounding various issues on water.

**Key Words**

Amphibolites mélange, synform, Barail, Centripetal, cretaceous sediments, Denudo structural, Disang, Evapo-transpiration, Hanging Wall block, Hydrological regimes, Intermountain basin, Miocene, Oblique subduction, Pelagic Sediments, Antiforms.

## Introduction

The Loktak basin is originated in the southern central part of the Manipur central valley interwoven with a complex topography and climatic conditions with a depressed oval-shape basin. The variations of the relief are a constantly and dialectic self- development. This study describes systematically the origin and development of the basin and to analyze significant geomorphological characteristics with hydrological parameters of the basin. The streams sweep the upland portion of the basin in a zigzag fashion merging each other representing dendritic to sub-dendritic pattern. The study of the basin is mainly composed of four different properties – (1) Areal, (2) Relief, (3) Linear, and (4) Hydrological properties. In qualitative attributes, it composed of (i) Size and Shape, (ii) relief, (iii) drainage network, (iv) hydrology – climatic variable, precipitation, evaporation, evapotranspiration, run-off and discharge. In order to understand geomorphic and hydrological characteristics of the Loktak basin, this study follow up on these non-linear parameters computing the laws of Strahler (1972), R.L. Singh (1974) and Betal (2011).

## Study Area

The Loktak basin is one of the major drainage basins in the southern part of the Manipur central valley. The basin covers about 500 $km^2$. The shape of the basin is an oval shape located in between$24^0 15'$ N to $24^0 30'$N Latitudes and $93^0 45'$E to $94^0 0'$E Longitudes. Loktak is a lake of fresh water associated with a number of smaller lakes in the state.The basin is constituted about 2.34 percent of the total geographical area of the state (22,327 $km^2$). It is an intermountain basin over the underlying sedimentary rocks at an elevation of 760 meters from the mean sea level.

## Methodology

The methodology employed includes, quantitative determination of slope, carefully observed the evolutionary details and identified the soil textures, drainage pattern of the main and feeder streams of the basin, analysis of the geomorphologic processes involved in sculpturing the land surface together with the study of hydrological parameters of the basin and the Loktak Lake. Available methods of basin analysis and literatures have been used. This study is based on primary and secondary data and related information supported by intensive field verifications.

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**Objectives**

The main objective of this study is (i) to assess the geomorphological characteristics of the Loktak Lake basin area by using satellite data and identify the geological and hydrological parameters of the area, and (ii) to study the problems of the Loktak hydrological regimes and to suggest an action plan for water management and ecological balances of the basin.

**Geomorphology of the Loktak Basin**

Loktak basin is a lacustrine plain of 100-200 meters depth alluvium, which formed after the Tertiary period, as a site of an ancient lake. The background of the geological formation of the basin, as a depression, belongs to the alpine system of the young fold mountains, which came into existence as a result of the Tertiary folding of the sedimentary strata by tectonic movements. This has been expected to be formed in the shallow Tethy's sea, some 40-90 million years ago[1]. It includes in a part and partial of Assam–Myanmar geological unit. The entire region was formed as a part of the Himalayan Orogeny during the early Tertiary period. The succession of the rocks and their formation occurring in the state reveals the geological history of the region to some extent as follows (Table-1).

The Ukhrul Limestone region, which have been found in a narrow belt in the north-eastern part of the state were formed during the Cretaceous age of about 60-135 million years ago. The Disang series, which belong to the Eocene period spread over the eastern half of the state were deposited about 40-50 million years ago. The Barail rock groups of the major portion of the western part of Manipur were formed some 25-40 million years ago. The Tipam and Surma groups of Miocene periods, in the western flank of the state were deposited about 13-25 million years back[2].

Table 1-Ages of the Rocks in Manipur

| Era | Period | Absolute age in tears | Rock Formation |
|---|---|---|---|
| | 1. Recent (Holocene) | 10,000 | Imphal Alluvium |
| | 2. Pleistocene | 1,000,000 | ___ |
| | 3. Pliocene | 13,000,000 | ___ |
| | (b) TERTIARY | | |
| | 4. Miocene | 25,000,000 | Tipam and Surma Groups |
| | 5. Oligocene | 36,000,000 | Barail Group |
| | 6. Eocene | 60,000,000 | Disang Group |
| MESOZOIC | 7.Cretaceous | 135,000,000 | Ukhrul Limestone Group |

Source : Geology and Mineral Resource of the states of India, Part IV, New Delhi 1974.

The Alluvium groups of the Manipur centralvalley, on which the Loktak basin existed were the recent origin, which has been deposited within the last 10,000 years, according to the Geologists of the Myanmar Oil Company, the Tertiary rocks in Manipur were belonging to two series namely Disang and Barail. They preferred the term Axial in the restricted sense, for those rocks older than Disang, probably of cretaceous[3]. 'The peridolites, altered into serpentine, were stated to be part of the pre-tertiary, probably cretaceous and part of post middle Miocene'[4]. The Manipur central alluvium, on which the Loktak basin lies, may be deposited during the post Tipam periods, where there were principally composed of dark grey to black grey, silt and sand specially in the central part of it, above the underlying Disangshale. These have been thought to be partly older alluvium and partly new alluvium, although assign to be recent might have been extended up to Pleistocene and probably older, since no lithounits represents the post Tipam periods in the state'[5].

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**Structure**

Structurally, Manipur belongs to the Himalayan young fold mountain system, which came into existence after Tertiary folding of the sedimentary strata some 40-90 million years ago. The region was formed as a part of the Himalayan orogeny during the early tertiary period. It includes in a part of Assam-Myanmar geological unit, which was formed as a part of the Himalayan mountain system during the early Tertiary period. The structural and topographic feature of the basin includes into the close proximity, in which regional plate margins and the cycle of deformations of the rocks had been undergone during the geological past. The hills of the state, surrounding the Loktak basin were belonging to the Alpine system of new fold mountains. The Loktak basin shows a lacustrine plain formed by alluvial deposition under water and silted up to its present form with the Loktak Lake.

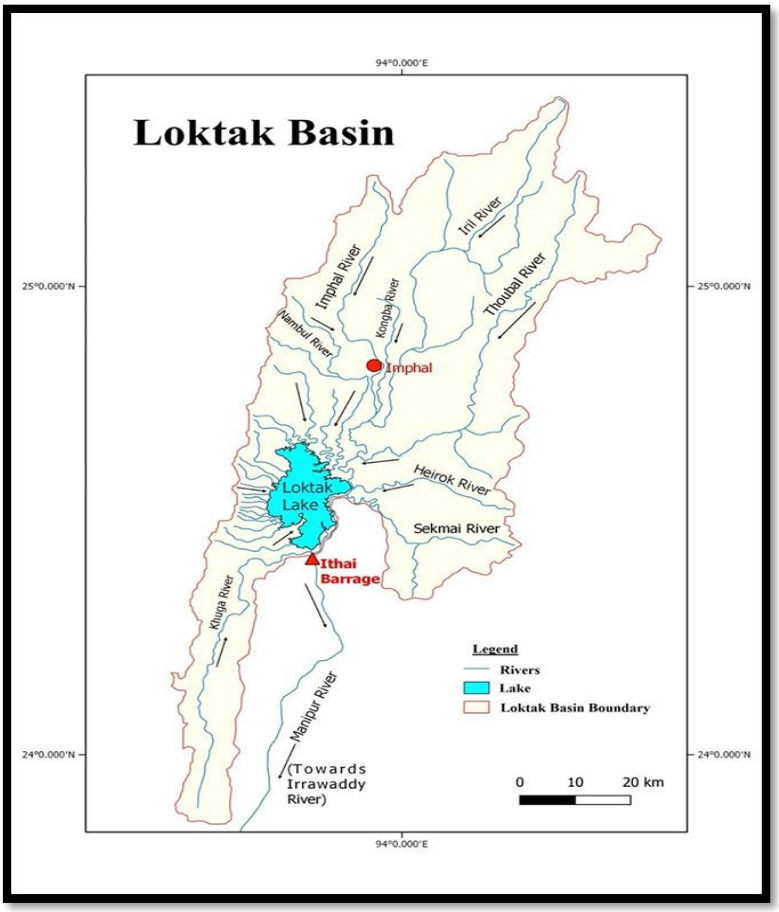


Fig.1

The tectonic settings of the basin had an excellent distinct entity with other parts of the N. E. India, because of its unique geographical position with the Indo-Myanmar Range geological units, as the region is an integral part of it. The succession and formations of the rocks can be visualized from the Ukhrul limestone in Cretaceous to the alluvium of the Manipur central valley in recent Holocene in order to ages.

The alluviums of the basin where the Loktak Lake is sited were recent origin of 100-200 meters depth, deposited during the past 10,000 years ago, above the underlying Disang rocks. They are mainly composed of dark grey to black clay, silt and sands above the underlying Disang shale represented by clay to boulder size rock materials along

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the foothills and old river valleys, thought, to be older alluviums by Oldham (1883)[6]. The age of these alluviums had assigned to be recent and might be extended up to the Pleistocene and probably more-older, since no litho units are represented during the post Tipam period in the state. The Tertiary rocks had belonged to two series namely Disang and Barail, most preferred probably of cretaceous. The peridolites altered into serpentine were stated to be part of the pre-Tertiary rocks, probably cretaceous and in part post middle Miocene.

The rocks of this basin are predominantly tertiary and cretaceous sediments with minor igneous and metamorphic rocks materials occurring in the eastern part. They are formed by the flysch sediments of tertiary age, constituting about 65 percent of the geographical area. The eastern side of the basin is mainly occupied by amphibolite mélange with deep sea pelagic sediments and some metamorphic rocks along with sedimentary limestone. It is observed that the basin is a part and parcel of the eastern Himalaya. The structure of the region is a continuation of the Himalayan Mountain System starting from the north-east. It is a part of Indo-Myanmar Mobile Belt; one of the geological provinces of North-East India and adjoining regions[7].

**Topography**

Loktak is a sub-basin of the Manipur river basin. The basin is most striking feature of an intermountain basin with a gradient toward south from north, well drained by Manipur River system. The basin is an alluvium with 760 mts from the mean sea level. It had become a lacustrine plain under sub-aerial conditions, as a site of an ancient neotectonics lake. There are certain hillocks standing above the alluvium; these hillocks are parts of the eroded residual synclinal structure scattered within the basin. The western part of the alluvial plain is represented by piedmont zone and alluvial fans along the foothills. The upper part of the basin is represented by denudo structural hills of about 1000-1500 mts from the mean sea level. Loktak basin is a depression of an oval shape in the humid landform. The depth of the lake varies from 0.50 to 4.58 meters with an average depth of 2.7 meters.

The surface of the Loktak Lake basin has an oval shape of a depression. There are 34 streams from the western hills, which fed the Loktak Lake directly; and other indirect fed of the Loktak Lake basin is Manipur River. The drainage of the Loktak catchment's area has centripetal Pattern to the Loktak Lake. The rivers and streams originated from different parts of the hills and mountains surrounded the lake basin had formed part of the Manipur river system.The slope of the Loktak basin and its adjoining region is nearly level ($1^0$- $2^0$); the western and eastern part of it is very gentle along the foot hills of the piedmont zone ($2^0$ -$3^0$). Above the piedmont zone, the slope is partly gentle ($3^0$-$5^0$); and partly moderate ($5^0$-$10^0$) to strong ($5^0$-$10^0$) in the western and north western part; and strong to steep ($10^0$-$25^0$) slope below the upper part of the denudo structural hills and mountains in the western part, and the upper part of the basin is very steep ($25^0$-$60^0$). The outer part of the basin is escarp steep (above $60^0$). The shape of the basin is a saucer or an oval shape.

The Loktak basin has a catchment's area of 980 $km^2$; of which 430 $km^2$ is under habitation, and 400 $km^2$is under forests. The remaining are the arable lands. The average elevation of the basin area is 768 meters from the mean sea level. The area adjoining the Loktak basin has become a cradle of human civilization amidst the barbarians.

**The Loktak Islands**

Islands are body of land surrounded by water. There are 14 islands of varying sizes and elevations, appearing as hills and hillocks, in the southern part of the lake basin. The most prominent of them are Sendra, Thanga and Karang Islands. The Loktak islands are tectonic origin of varying in size. Most islands are quite small covering less than half hectare. They are little more than barren rock with few plants and animal on them.These tiny islands are called islets. Sendra, Thanga and karang are bigger islands of the Loktak Lake basin inhabited by human population.

There are other islands on Loktak basin formed by thick matted weed as floating islands, for centuries, these islands have been utilizing as stopping places of boats, and shelters for fisherman; and because of their isolation some of them have also been home to some of world's most unusual and fascinating wildlife, such as keibulLamjao floating island for brow antler deer Sangai. Many creatures ride to islands on natural floating matted masses of plants, branches and soil, sometimes with trees standing on them. These land rafts are called *floating islands.* The Keibul Lamjao floating island is a very symbolic island of the Loktak Lake formed by floating weed of 2-3 meters thick with an area of about 40 $km^2$ in the southern most part of the basin. It is a habited island of the world rare species of

brow antler deer, locally kniown as Sangai deer. This island is surrounded by Keibul in the south, deep blue lake water in the north, Thanga island in the west and Manipur River and Ithai in the east.

**Loktak Hydrology**

The Manipur River system is only the source of water to Loktak basin. The Khordak channel plays a very important role in the water regimes of the Loktak Lake; it is an instrumental to Loktak Lake basin, as it is a controlling factor to maintaining the water level of the lake in alternate seasons. It deepened to facilitate inflow of Manipur River water to the Loktak Lake during the lean seasons and outflow of lake water during the rains to minimize the over topping water of the lake. Rain and seepages is only the source of water in the basin.

The hydrological parameters are the key elements for the sustainable development of water resource of the basin. The amount of water received from the precipitation is estimated about 90 percent from the sea origin, and about 10 percent from the land origin through the process of evaporation and evapotranspiration. The amount of rainfall received in the basin accounts for 64.04 percent during June to September; 14.53 percent in October and November; 4.03 percent in December to February; and 17.39 percent in March to May.

Table 2 Annual Rainfalls in cm.

| 1 | 2 |
|---|---|
| Year | Rainfalls in cm |
| 1990 | 177.20 |
| 1991 | 223.86 |
| 1992 | 144.43 |
| 1993 | 158.24 |
| 1994 | 118.05 |
| 1995 | 127.65 |
| 1996 | 111.57 |
| 1997 | 154.23 |
| 1998 | 175.62 |
| 1998 | 196.82 |
| 1999 | 184.85 |
| 2000 | 173.33 |
| 2001 | 170.98 |
| 2002 | 160.55 |
| 2003 | 184.14 |
| 2005 | 173.02 |
| 2006 | 154.09 |
| 2007 | 152.20 |
| 2008 | 120.09 |

| | |
|---|---|
| 2009 | 117.37 |
| 2010 | 172.57 |
| 2011 | 153.91 |
| 2012 | 132.54 |
| 2013 | 163.91 |
| 2014 | 125.36 |
| 2015 | 165.72 |
| 2016 | 174.79 |
| 2017 | 243.94 |
| 2018 | 132.57 |
| 2019 | 113.71 |
| 2020 | |
| Annual Average | 158.71 |

Source; Meteorological Data of Manipur. 1990-2020

The rainfall is highly irregular in the basin often resulting excess or scanty of water in different periods. The water resource of the basin is measured in term of the surface water only, because, it may include both surface and ground water in some part on the theory that, except for some static ground water which could be trapped as fossil water, the ground water aquifers flow in the basin sooner or later join the surface water flow; and the ground water that finds its way direct towards the sea is not significant magnitude [8].

Rainfall distribution of the basin clearly reflects the water surplus or deficit in the Loktak hydrology. The potential evapotranspiration, which follows a set pattern of close parallelism between rainfall and temperature are the result of different causes directly related to temperature

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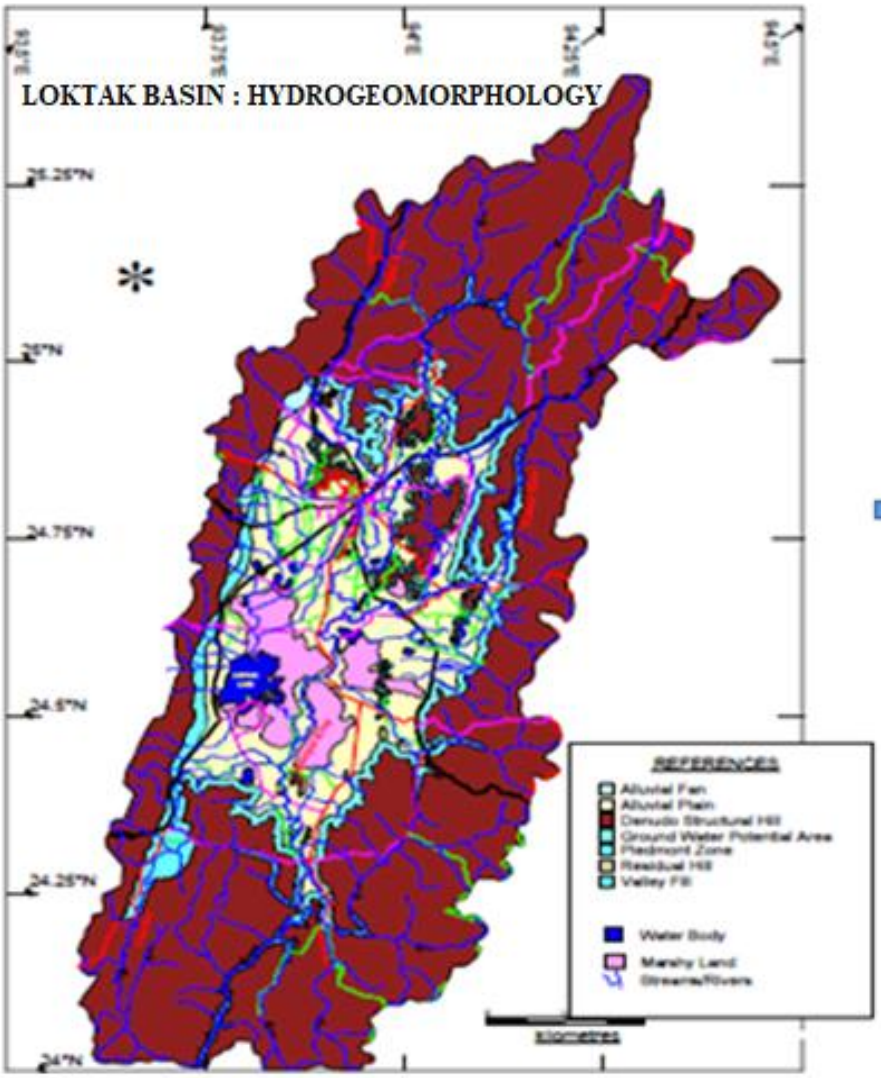


Fig. 2

and inversely to relative humidity. The Loktak basin has increasing evaporation and evapotranspiration rate steadily from December-January to May with the increasing temperature and aridity, followed by a rapid decreasing from June onwards with the arrival of monsoon rains. The annual potential evapotranspiration rate of the basin is ranges from 1100 mm to 1240 mm and higher the potential evapotranspiration has maximum in May and minima in January. The actual evapotranspiration of the basin varies from 910 mm to 1102 mm annually. The actual evapotranspiration will either be less than or equal to the potential evapotranspiration and whether water deficiency exist or does not exist depends upon it [8]. It is realized that the existence of annual water deficiency is very significant in the basin, because of the irregularities of monsoon rains and poor seepages of the underlying rocks, even the Manipur River system has an estimated annual average potential yield of 0.5129 million hectometers of water. The actual water balance of the basin cannot be clearly traced out due to the lack of reliable hydro-geological data. However, Loktak is confronting various issues and problems of its hydrological regimes, whether scarcity or excess. Changes of hydrological regimes in the basin affected various changes in the ecosystem and functions of the Loktak and its associated wetlands; high siltation and sedimentation into the lake from the denuded higher slope are important issues of the Loktak hydrology. It has been estimated about 2.3 million cubic meter of silts had been deposited into the Lake during the past 30 years resulting ever changing hydrological regimes of the lake; the water holding capacity

of the Loktak was about 600 million cubic meters during 1980's with 5.74 meters depth, but during 2010's it reduced to 300 million cubic meters with 2.09 mts depth. It realized that Loktak is reduced nearly half to depth during the past 30 years. Deforestation along the catchment's area, high siltation with free flow of water among the river regimes of the basin, construction of Ithai barrage blocking the free flow of loaded flood water are determining factors for enhancing problems of hydrological regimes of the lake resulting excessive expansion and revolting large area of arable lands into swamps and marshes due to no able to absorbed flood water. Loktak has at risk from rapid proliferation of weed of Sylvania species and paragrass, pollution, loss of biodiversity, reducing economic value and environmental decayed at various stages. The main cause of it is due to lack of management planning in the hydrological regimes of the basin and the lake. The Hydrology of the Loktak is a complex and it has several issues need to investigate thoroughly with formulating sound strategies for water resource management.

**Problems of Loktak Hydrological Regimes:**

1. Fluctuating Water Levels

   i. Artificial Regulation: The construction of the Ithai Barrage in 1983 for the Loktak Hydro Power Project led to artificial regulation of the lake's water levels. This has disrupted the natural hydrological cycle, causing excessive flooding during the rainy season and reduced water levels during the dry season.

   ii. Impact on Phumdis: The artificial regulation has severely impacted the floating biomass called "phumdis," which are unique to Loktak Lake. These floating islands are crucial for the lake's biodiversity and the local community. Prolonged submergence of phumdis has affected their health, leading to the degradation of the lake's ecosystem.

2. Siltation

   Erosion and Sedimentation: The catchment area around Loktak Lake is prone to erosion due to deforestation, shifting cultivation, and other unsustainable land-use practices. This results in heavy sedimentation in the lake, reducing its depth and water-holding capacity. Siltation also leads to the shrinking of the lake's area, affecting its hydrological balance.

3. Pollution

   i. Domestic and Agricultural Runoff: The lake receives pollutants from surrounding human settlements and agricultural fields. Pesticides, fertilizers, and untreated sewage contribute to the degradation of water quality, leading to eutrophication, which causes algal blooms and depletes oxygen levels, harming aquatic life.

   ii. Industrial Waste: Although industrialization around Loktak is limited, any industrial waste entering the lake exacerbates pollution, further disrupting the hydrological and ecological balance.

4. Encroachment and Habitat Loss

   i. Human Encroachment: The increasing human population around the lake has led to the encroachment of the lake's shorelines for agriculture, settlements, and fishing activities. This reduces the effective water area and disrupts natural hydrological processes.

   ii. Loss of Wetlands: Encroachment has also led to the loss of peripheral wetlands, which act as natural buffers and help maintain the hydrological regime of the lake.

5. Climate Change

   i. Altered Rainfall Patterns: Climate change is leading to altered rainfall patterns in the region, with more intense and unpredictable monsoons and prolonged dry spells. This further destabilizes the already fragile hydrological regime of Loktak Lake, exacerbating issues like flooding, drought, and water level fluctuations.

ii. Temperature Changes: Rising temperatures due to climate change affect evaporation rates and the overall hydrological cycle, which can lead to more rapid drying of the lake during dry seasons.

6. Loss of Biodiversity

Impact on Flora and Fauna: The changing hydrological conditions and pollution have led to a decline in the biodiversity of Loktak Lake. Species that depend on stable water levels and clean water are particularly at risk, which in turn affects the livelihoods of people who rely on fishing and other resources from the lake.

7. Conflicting Interests

i. Hydropower vs. Ecosystem Conservation: The lake is at the center of conflicting interests between hydropower generation and ecosystem conservation. The operation of the Ithai Barrage for power generation conflicts with the need to maintain natural water levels for the health of the lake's ecosystem.

ii. Community Livelihoods: Local communities, who depend on the lake for fishing, agriculture, and other activities, are often in conflict with policies that prioritize hydropower or tourism over sustainable management of the lake's resources.

8. Inadequate Management and Policy Implementation

i. Lack of Integrated Management: There is a lack of a comprehensive and integrated management plan for Loktak Lake that balances ecological conservation with economic development. The existing policies and regulations are often inadequately enforced, leading to the continuation of harmful practices.

ii. Community Involvement: Insufficient involvement of local communities in decision-making processes related to the lake's management often leads to policies that are not aligned with the ground realities and needs of the people who depend on the lake.

**Action Plan for Water Management & Ecological balances of the Loktak Basin:**

1. Restoration of Natural Hydrological Regimes

i. Re-evaluate the Operation of Ithai Barrage: Conduct a detailed assessment of the Ithai Barrage's impact on the lake's water levels and explore alternative operational strategies that minimize ecological disruption while meeting hydropower needs.

ii. Seasonal Water Level Management: Implement a seasonal water level management plan that mimics the natural hydrological cycle of the lake, allowing for the periodic exposure and submergence of phumdis to maintain their health.

iii. Desiltation Programs: Initiate desiltation projects to remove excess sediment from the lake bed, restoring its original depth and water-holding capacity. This should be done carefully to avoid disturbing the lake's ecology.

2. Pollution Control and Water Quality Improvement

i. Wastewater Treatment Facilities: Establish and upgrade wastewater treatment facilities in towns and villages around the lake to prevent untreated sewage from entering the lake.

ii. Agricultural Runoff Management: Promote the use of organic farming practices and integrated pest management (IPM) in the catchment area to reduce the runoff of pesticides and fertilizers into the lake.

iii. Industrial Waste Regulation: Enforce strict regulations on industries to prevent the discharge of harmful effluents into the lake and its tributaries. Regular monitoring and penalties for non-compliance should be implemented.

3. Catchment Area Management

i. Afforestation and Reforestation: Implement large-scale afforestation and reforestation projects in the catchment area to reduce soil erosion, improve water retention, and enhance the hydrological balance of the basin.

ii. Sustainable Land Use Practices: Encourage sustainable agricultural practices, such as contour farming, agroforestry, and the use of cover crops, to reduce erosion and sedimentation.

iii. Community-Based Conservation: Involve local communities in the management of the catchment area through initiatives like community forestry, watershed management, and participatory monitoring programs.

4. Biodiversity Conservation

i. Phumdis Restoration: Implement programs to restore and maintain the phumdis, including controlled water level management, removal of invasive species, and replanting native vegetation.

ii. Wetland Conservation: Protect and restore peripheral wetlands that act as natural buffers, support biodiversity, and maintain the lake's hydrological regime.

iii. Species Protection Programs: Develop and implement conservation programs for endangered species dependent on Loktak Lake, such as the Sangai deer, by protecting their habitat and reducing human-wildlife conflict.

5. Climate Change Adaptation

i. Resilience Building: Develop climate resilience strategies, such as enhancing water storage capacity, improving early warning systems for floods and droughts, and promoting climate-resilient agricultural practices.

ii. Research and Monitoring: Establish a climate and hydrological monitoring station to track changes in rainfall, temperature, and lake water levels, providing data for informed decision-making.

6. Community Engagement and Livelihood Support

i. Alternative Livelihoods: Provide training and support for alternative livelihoods, such as eco-tourism, handicrafts, and sustainable fishing practices, to reduce dependency on the lake's resources and pressure on its ecosystem.

ii. Education and Awareness: Conduct awareness campaigns to educate local communities about the importance of ecological balance and sustainable water management. Promote community-led initiatives for lake conservation.

iii. Participatory Decision-Making: Involve local communities in the decision-making process for lake management through the formation of Loktak Basin Management Committees (LBMCs) that include representatives from local communities, government agencies, and NGOs.

7. Integrated Water Resource Management (IWRM)

i. Formation of Loktak Basin Authority: Establish a Loktak Basin Authority to coordinate water management efforts across different sectors and stakeholders. This authority should be responsible for implementing the action plan, monitoring progress, and ensuring compliance with regulations.

ii. Data Sharing and Collaboration: Promote data sharing and collaboration among government agencies, research institutions, and local communities to ensure a holistic approach to water management in the basin.

iii. Policy Integration: Integrate water management policies with other regional development plans, such as agriculture, forestry, and urban planning, to ensure a balanced approach to basin management.

8. Sustainable Tourism Development

i. Eco-Tourism Initiatives: Develop eco-tourism projects that showcase the natural beauty and cultural heritage of the Loktak Basin while ensuring minimal ecological impact. Revenue generated from tourism can be reinvested in conservation efforts.

ii. Tourism Management Plans: Create and enforce tourism management plans that limit the number of visitors, regulate boating activities, and promote environmentally friendly practices among tourists and operators.

9. Policy and Legal Framework Strengthening

i. Review and Strengthen Existing Laws: Review existing policies and laws related to water management, conservation, and land use in the Loktak Basin, and strengthen them where necessary to ensure they effectively address current challenges.

ii. Strict Enforcement: Ensure strict enforcement of environmental regulations, with regular inspections and penalties for non-compliance. Establish an independent monitoring body to oversee compliance with environmental laws.

10. Monitoring, Evaluation, and Reporting

i. Regular Monitoring: Establish a robust monitoring system to regularly assess the health of the lake, water quality, biodiversity, and the effectiveness of management interventions. Use remote sensing and GIS tools for continuous monitoring.

ii. Evaluation and Adaptive Management: Conduct periodic evaluations of the action plan's implementation, allowing for adaptive management practices that can respond to changing conditions and new challenges.

iii. Transparent Reporting: Ensure transparent reporting of the lake's status and management outcomes to all stakeholders, including the public, to build trust and encourage broader participation in conservation efforts.

**Conclusion**

Loktak Basin is a sub-basin of the Manipur River basin. It is a lacustrine basin above the underlying Disang rock series. The basin is formed by the deposition of sediments in an oval shape in the southern part of the Manipur Central Valley. The geomorphological process has brought changes of landscape development in the basin area with the changes of the climatic condition in the region. The Loktak ecosystem has been degraded at different levels due to hydrological changes of the basin. It is observed that the Loktak basin has been degraded at different stages due to the changes of geomorphic process and hydrological regimes by the deforestation and technological development on its environment with long-term sustainable development planning.

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