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IMPACT OF URBANIZATION AND AGRICULTURAL EXPANSION ON WATER QUALITY IN DAL LAKE, NW HIMALAYA, INDIA

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ABSTRACT:

Most biosphere changes today are caused by humans. Understanding these behaviour and their social causes is essential to modeling, predicting, managing, and responding to local, regional, and global environmental change. A powerful cycle like land utilization that is impractical damages the land framework. Water bodies overall are compromised by impractical human action. Water bodies' quality and ecosystem influence human wellbeing in the event that not preserved. Understanding the causes and impacts of rotting water body frameworks is critical. Himalayan water body ecosystems are particularly compromised by uncontrolled urbanization. This study analyzes land use/land cover (LULC) elements and their impacts on Dal Lake water quality in Kashmir Himalaya, India. We investigated moving LULC against Dal Lake's diminishing trophic state utilizing time-series satellite symbolism of the lake's catchment and water quality information. Results showed that expanded compost and residue loads from the catchment because of critical anthropogenic activities have fundamentally debased Dal Lake's water quality. Throughout the course of recent many years (1980-2018), the timberland class has declined due to extraordinary LULC changes in the catchment, affirming the lake's physicochemical decay. The analysis showed that NO3–N, TP, and COD increased from 1990 to 2018. Forest, farm, and foating garden decreases were negatively correlated with decadal average COD, NO3–N, and TP increases.

INTRODUCTION:

Land change is one of the main areas of human-instigated environmental change, and it has a long and celebrated history that traces all the way back to old times [1]. The start of the Modern Upheaval, the globalization of the worldwide economy, the development of populace, and the increment of innovative limit all were factors that added to the speed increase and expansion of land change. Disregarding the way that they are restricted, land changes add to foundational processes that are more far and wide and territorial. Not long from now, it is normal that the interest for the items that are created by the land will keep on expanding. It will keep on being absolutely critical to guarantee that the land keeps on having the ability to fulfill that need effectively. It is possible that a significant amount of land alteration could be considered land degradation in some sense, and the level of worry that is evoked by current trends reflects this possibility [2]. Through the burden of designs, structures, cleared surfaces, and compacted exposed soils on the ground surface, settlement is the land cover that represents the main modification of the common habitat that has been caused by individuals. Likewise, settlements produce requests that outcome in other land-cover changes. These changes remember the expulsion of vegetation and soil for request to remove sand, rock, block muds, and rock; the supplanting of vegetation with established cover in nurseries, stops, and sports grounds; the distance of ground for landfill and waste treatment; the transformation of wetlands and open space for settlements; and the use of land for transportation courses.

The reason for change is to invigorate improvement and to balance impacts that empower degeneration [3]. Adjustment is almost indivisible from human work and use. Estimating (future asset requests and open doors as impacted by specialized and financial turn of events) and assessment (conveyance and the privileges of people in the future) are two testing worries that should be addressed to decide the impact that a specific land change and its ramifications will have. Then again, we currently have a more exhaustive logical comprehension of the actual greatness, nature, and results of land modification, which fills in as the reason for any evaluation of this sort.

The regular habitat is harmed because of the concurrent quick expansion in both the populace and the financial creation per capita, as well as the changes in land use design that have come about because of these advancements [4-6]. Using multiplier impacts, segment expansion can empower underlying change, and conduct changes can draw in migration. Metropolitan regions have turned into the point of convergence of movements of every sort because they are filling in size, land use is going through fast changes, metropolitan lands are being heightened consistently, and enormous scope land change is occurring because of significant expansions in the worth of metropolitan land. Subsequently, metropolitan regions have taken the spotlight. Urban communities are actual designs that are made by people and are arranged in regular habitats. The stylish concordance between the urban communities and the common habitat can be kept up with in the event that the urban communities are strategically situated, very much planned, and all around assembled. In any case, urban areas that are encountering quick development (essentially in non-industrial countries) develop without arranging, and the transaction between metropolitan structure (the fabricated climate) and nature gives an unending stockpile of strains and discussions. Urban communities require extra assets, and thus, they keep on creating; this expansion reaches out from the focal business area to suburbia and the edges, further and farther removing individuals from the regular landscape.

The motivation behind this study is to investigate the general example of metropolitan expansion and land change in Himalaya city. Also, it plans to explore the particular impact that these land changes have on the water groups of the city, which are viewed as the city's help. Streams and lakes are critical for their size and volume, yet in addition for the way that they give homes to sea-going widely varied vegetation, especially for various species that are just tracked down in that specific locale. Tragically these waterways have been altogether impacted by changes in land use that have been caused by people. Broad agricultural recovery is generally liable for the corruption of these bodies, which has prompted unfriendly ecological repercussions like the event of successive flooding, a decline in biodiversity, and the elimination of various species that are particular to the area [7].

Likewise, the water quality in most of wetland regions has been seriously weakened, principally because of wastewater releases, which are the essential supporters of the broad eutrophication that has happened [8-10].

The urban lake known as Dal Lake can be found in the urban centre of the Himalayan city that is located in the union territory of Jammu and Kashmir. The city of Himalaya is home to a significant number of tourists who come to visit this destination since it is both beautiful and fascinating. There are a number of names that have been given to the lake because of its stunning appearance, including "Lake of Flowers," "Himalaya's jewel," and "Jewel in the crown of Kashmir." The splendour of this lake is further increased by the presence of a spectacular Mughal Garden on the other side of the lake, which encourages people from all over the world to visit this aesthetically pleasing location. In addition to being a popular destination for recreation, Dal Lake is one of the most well-known bodies of water in the Kashmir valley. It provides a source of portable water, fish, vegetable foods, and fodder. The lake has a catchment area of 316 km2 and is located at an elevation of 1584 metres above sea level [11]. There are two freshwater lakes in the state of Jammu and Kashmir, but this urban lake is the second largest of the bunch. The lake is located at around 34 degrees 07 minutes north latitude and 74 degrees 52 minutes east longitude. It has an average elevation of 1584 metres above sea level, a catchment area of 316 km squared, and a maximum depth of 5.4 metres. Bod-Dal, LokutDal, Nigeen, and Gagribal are the four basins that make up the lake, which has a total area of

11.4 square kilometres or 11.4 square km [11].

There are human settlements that are located at higher heights than the Dal body that surround Dal Lake. These human settlements are highly populated. In addition, there are a significant number of houseboats floating around in Dal, which are home to a great number of residents as well as tourists. The Dal is utilised for a variety of economic activities, including tourism, sightseeing, recreation, fishing, harvesting of food and fodder plants, and irrigation of vegetable fields, all of which have increased in quantity and extent over the course of the past few years. Because of the floating gardens that are built on rafts, the lake is one of the most significant vegetable producing sites in the valley [12]. As a result of these activities, as well as the day-to-day acts of people, such as washing clothes, using fertilisers in floating gardens, and directly discharging garbage from residences into the lake, it has been determined that the multiplication of bacteria in excessive numbers is the cause. In addition, the situation of Dal Lake's water has only gotten worse over the years as a result of the ever-increasing cultural eutrophication that has occurred there. An increase in the number of hazardous bacteria, in conjunction with an excessive enrichment of lake water, has the potential to induce diseases in aquatic organisms as well as infections in humans who are either directly or indirectly related with the lake.

As a result of the ecological stress caused by human activities, the lake system is not only decreasing in surface area, but its water quality has also worsened. This is because the lake receives a considerable number of untreated sewage and waste from human settlements as well as business settlements [13]. In order to acquire a better understanding of the current state of the contamination in Dal Lake, a study was carried out with bacterial populations serving as the markers of organic load. There have been numerous instances in which scientists [12-13] have deemed bacteria to be trustworthy markers of pollution. due to the fact that they are able to react rapidly to any change in the conditions of the environment. Comparing the levels of bacterial populations at various locations within Dal Lake over the course of seven years was the primary purpose of the study. This was done with the intention of gaining a knowledge of contamination, particularly as it pertains to organic pollution.

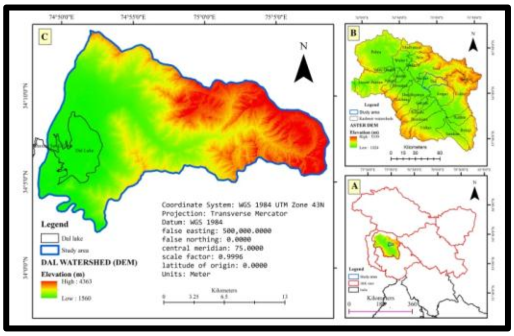

Figure 1: The research area's location in relation to India and the J&K UT [14].

The inverse is valid; land cover (LC) alludes to the regular cover that is available on the land and is safeguarded by normal cycles. It incorporates the dissemination of greenery, water, desert, and ice, as well as the close subsurface, which incorporates biota, soil, geography, surface water, and groundwater [15]. The change in LULC is a powerful cycle that is driven by normal peculiarities and activities that are anthropogenic. These activities, thusly, request varieties that affect normal ecosystems [16]. The event of such a change can be credited to an assortment of physical, natural, or substance factors, for example, the improvement of seepage frameworks, the establishment and use of water system frameworks, the development of homestead dams, pollution and land debasement, the evacuation of vegetation, the change of the ripeness system, the engendering of weeds and fascinating species, and the progress to non-agricultural uses [17].

Changes in LULC significantly affect earth framework cycles like hydrology, environment, and biogeochemical cycles, which can prompt negative environmental issues assuming they are permitted to spread uncontrolled [18, 19, 20]. LULC change is viewed as the absolute generally essential variable of worldwide change and is pretty much as extensive as that related with the environmental change, altogether affecting the climate [21]. , because of which stock, evaluation, and checking of LULC change gives an indispensable contribution to environmental decision-production [22] and are essential for additional comprehension and demonstrating of change system at various scales [23,24].

Satellite symbolism has been used in a large number of metropolitan land use studies, which have brought about the age of exact metropolitan land use maps and the ID of movements in metropolitan land use and land cover [25-31]. With regards to the management of normal assets, it is vital for assemble joins between strategy independent direction, administrative activities, and future land use arranging endeavors [32-34]. This can be achieved through the observing of LULC change throughout both short and long time periods.The catchment has a critical influence in laying out the structure of the lake water quality, and changes in the LULC of the catchment affect the environmental cycles that happen further downstream, especially the water quality.

DAL LAKE CATCHMENT LULC CHANGE ANALYSIS:

An assessment of the land use and land cover (LULC) of the exploration locale for the year 1980 found that, out of eleven LULC classes, the woods class was the most predominant class in the review region, covering 135.72 km2 and representing very nearly a little less than half of the all out watershed region. Scour involved 58.12 km2 (17.43%) of the general review region, while farming covered 34.43 km2 (10.33%) of the complete region (Fig. 2). The region covered by uncovered rock was 20.86 km2 (6.25%), trailed by developed land (20.15 km2, 6.04%), manor land (18.81 km2, 5.6%), field land (16.30 km2, 4.9%), water (14.36 km2, 4.31%), foating garden land (8.74 km2, 2.62%), exposed land (3.80 km2, 1.13%), and sea-going vegetation (2.03 km2, 0.60%).

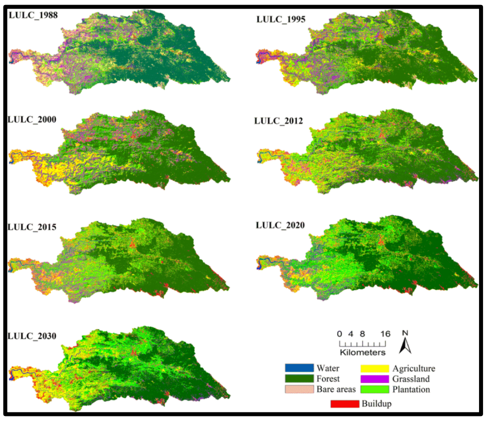

Figure 2: LULC maps for the PRB for the years 1988, 1995, 2000, 2012, 2015, 2020, and 2030 [35].

DECADE-LONG LULC CHANGE ANALYSIS OF DAL LAKE CATCHMENT:

The in-depth investigation of Land Use and Land Cover (LULC) changes that have occurred within the Dal Lake catchment area in the Northwest Himalaya, India, over the course of the last ten years marks a crucial effort to untangle the intricate interplay of forces that are creating the environment of the region [36]. This all-encompassing investigational endeavour serves as a foundational component for comprehending the complex dynamics that have been the driving force behind transformative activities in this ecologically vulnerable region [37]. The primary objective of this investigation is to identify the complex effects that human actions have on the environment, taking into account the relevance of these alterations for the preservation of the natural environment as well as for the well-being of individuals [38].

A strategic strategy is taken at the beginning of the analytical journey. This technique involves the acquisition of satellite images that captures the transformation of the terrain throughout several temporal periods [39-40]. This imagery is supplemented by the compilation of a wide range of auxiliary data, which includes climate parameters and socio-economic variables, which together serve to provide a comprehensive background for the subsequent analysis [41]. In order to guarantee the highest possible level of accuracy in the research, a series of thorough preprocessing activities are carried out. These steps include making modifications to the geometry and rectifying the atmosphere [42]. This series of measures is absolutely necessary in order to ensure the precision and dependability of the ensuing study, which will ultimately result in a comprehensive comprehension of the alterations that are taking place within the catchment area of Dal Lake [43-36].

The implementation of sophisticated remote sensing methods and classification algorithms is of the utmost importance to this analytical endeavour [44-45]. In order to identify and quantify changes in land use patterns throughout the defined timeframe, change detection approaches are utilised. Some examples of these methodologies are image differencing and post-classification comparison.

This validation method not only improves the reliability of the categorization results, but it also guarantees that the insights that are gained appropriately reflect the reality that exists on the ground [41-46-47]. Specifically, the research is intended to be all-encompassing, taking into account the intricate interaction between anthropogenic forces, such as urbanisation, and natural effects, such as climate change, which jointly create the changing environment of the Dal Lake catchment area [48-49].

The analysis that has been conducted over the course of ten years is more than just a scientific investigation; rather, it is a sophisticated investigation of the complex link that exists between human activities and changes in the environment. The purpose of this study is to provide valuable insights and recommendations for sustainable land use practices and conservation strategies in the Dal Lake catchment area. Its purpose is to serve as a guide for informed decision-making and responsible stewardship of this ecologically significant region. The study is a culmination of these efforts.

The implementation of sophisticated remote sensing techniques and classification algorithms is the central focus of the investigation. These approaches are used to classify the obtained imagery into discrete land cover classes [50-53]. The following implementation of change detection approaches, such as image differencing and post-classification comparison, will reveal and quantify the changes that have occurred in the patterns of land use. Not only does the rigorous accuracy assessment that is accomplished through ground truthing authenticate the results of the classification process, but it also strengthens the reliability of the whole study.

In the analytical lens, the identification of the drivers of change is a primary focus. These drivers of change encompass a wide range of issues, ranging from anthropogenic influences such as urbanisation to natural forces associated with climate change. This sophisticated investigation dives into the factors that are responsible for the changes that have occurred in the landscape, thereby providing a comprehensive grasp of the forces that are functioning. An interpretation of trends is the result of this analysis. This interpretation enables the formation of well-informed suggestions that are directed at the conservation and sustainable management of the catchment region of Dal Lake [54].

A complete report is produced as a result of the synthesis of findings. This report is a document that comprehensively captures the intricacies of the evolution of the landscape and the ramifications of this evolution. A collaborative approach to decision-making is fostered through the use of this report, which acts as a cornerstone for various stakeholder engagement activities. Therefore, it is of the utmost importance to involve local officials, researchers, and members of the community in order to guarantee that the insights gained from this comprehensive investigation will make a significant contribution to the conservation and management of the ecosystem that is found in the Dal Lake basin. In order to achieve the ultimate goal of creating a solid framework for informed decision-making, the emphasis will be placed on the necessity of striking a balance between the requirements of development and the preservation of the environment.

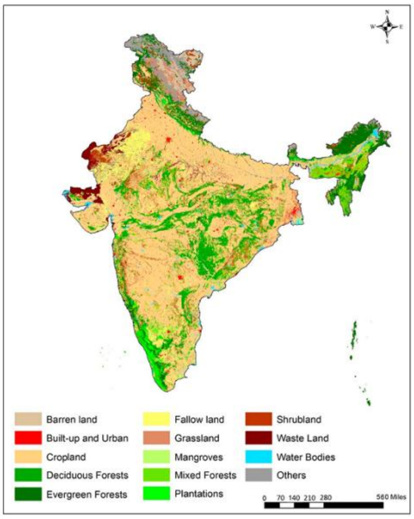

Figure 3: Land use and land cover map of India for 2005 [35].

HIMALAYA CITY'S WATER BODIES AND URBAN LAND TRANSFORMATION:

Despite the fact that they are not only tourist attractions, the water bodies of Himalaya city are also integral to the city's economic, social, and cultural survival. As a result, these water bodies are considered to be key landscapes of the city. These bodies of water are absolutely necessary for maintaining the ecological equilibrium of the city. According to the findings of the current study, the growth of Himalaya city and the change of terrain inside it have had a significant impact on the aerial extent of water bodies as well as the quality of water. Listed below are the observable impacts and the consequences that result from them:

Communities encircling bodies of water: Because of the expansion of settlements nearby the water bodies in Himalaya city, new networks are being laid out. The most unmistakable survivor of this pattern is Dal lake, which is at present being occupied by individuals for private purposes and has altogether filled in size and populace thickness throughout the years [50]. Right now, Dal lake fills in as a shelter for around fifty villas, every one of which is home to in excess of 50,000 individuals. These villages have property freedoms to multiple hundred hectares (6,000 kanals) of agricultural land and 600 700 hectares (13,400 kanals) of water region. Furthermore, an immense number of business and private structures, including inns, visitor homes, and eateries, have arisen around and around the Dal lake. These structures have been built lately.

Houseboats in bodies of water: The Dal Lake is home to in excess of 1,200 house boats, making it one of the most well known vacationer locations in Himalaya City. House boats are quite possibly of the most well known fascination in the city. Moreover, these houseboats release their squanders straight into the lake, which prompts the amassing of dregs and the expansion of an extreme measure of weeds [58-59]. In the current day, there are around 1,200 houseboats situated inside Dal Lake, and an expected 9,00 metric lots of waste are discarded straight into Dal Lake on a yearly premise.

Rise in the influx of nutrients: Moreover, the water bodies are defenseless to pollution because of the presentation of synthetic compounds into them. As indicated by research, there are fifteen significant channels that release their items into the lake waters. These channels are stacked with nutrients and contain around 18.17 lots of phosphorous and 25 tons of inorganic nitrogen, every one of which adds to the improvement of the lake waters and the residue [55]. Indeed, even the water quality of the Jhelum Stream has weakened because of the immediate release of metropolitan trash, which incorporates both human and household excreta. Pretty much every waterway has now turned into a "Supply of Sewage" because of the squanders and effluents that are released from it [56]. What's more, the investigations directed on the water have uncovered that the waters of Dal Lake incorporate critical degrees of all out alkalinity, absolute phosphorus, complete nitrogen, and pH esteem [57].

CONCLUSION:

According to the findings of the study, the concentration of bacteria in the water has increased, which is a clear indication that the water quality in the various locations of Dal Lake has deteriorated. In light of the fact that this Lake is of significant importance to both the economy and the ecological of this Valley, the authorities are obligated to take the appropriate actions to improve its circumstance.

The research presented above makes it abundantly evident that urbanisation has resulted in the consumption of a sizeable amount of the water bodies. In addition to this, the quality of the water is decreasing at a rate that is extremely concerning. It is of the utmost importance to safeguard and maintain what was formerly referred to as the "Paradise on Earth" for the sake of future generations [60]. The value of these bodies of water lies not only in the fact that they serve as tourist attractions, but also in the fact that they serve as a vital resource for the city, since they give a means of subsistence to a significant number of people, either directly or indirectly [61]. The appropriate administration of Himalaya city is therefore an absolute necessity if the city is to continue to exist in a sustainable manner while also preserving its ecological balance. According to the findings of the study, there are three significant steps that a sustainable management of water bodies in Himalaya city should take:

1) Limiting any further expansion of settlements in and around these water bodies and muddy areas is the main mediation that can be taken to resolve the issue. Because the state high court in 2003 has recently disallowed a wide range of constructional tasks inside 200 meters of the outskirts of Dal Lake [62], the proactive position taken by the public authority is vital when seen according to this point of view.
2) Also, the populace that has previously settled in and around the lake locale ought to be emptied and restored beyond the Dal Lake fringe [63]. Presently, around 1221 households residing in 441 residences have been resettled, however the total restoration of these families is as yet pausing. Yet again it is important for the public authority to step up to the plate and clear and restore the leftover 5,029 households that are as yet living there.
3) Eliminating algae, water ferns, and duckweed is another essential procedure that must be carried out in order to preserve the bodies of water. For the purpose of preserving the cleanliness of the water in the impacted bodies of water, there must be genuine efforts made to carry out deweeding and dredging activities on a regular basis [64-65]. It is also necessary for Himalaya city to have sewage treatment plants that are working in order to prevent any untreated sewage from being discharged into any of the bodies of water. Additionally, research has proposed the utilisation of weed as a raw material for the production of organic manure. This would serve a dual goal, namely the purification of water and the utilisation of trash.

REFERENCES:

1. *Knitter, D., Brozio, J. P., Dörfler, W., Duttmann, R., Feeser, I., Hamer, W., ... & Nakoinz, O. (2019). Transforming landscapes: Modeling land-use patterns of environmental borderlands. The Holocene, 29(10), 1572-1586.*
2. *Schoolman, E. M. (2022). Reconceptualizing the Environmental History of Sixth-Century Italy and the Human-Driven Transformations of Its Landscapes. Studies in Late Antiquity, 6(4), 707-733.*
3. *S. Fazal, "Urban Expansion and Loss of Agricultural Land," A GIS Based Study of Saharanpur City, India.*

Environment and Urbanization, Vol. 12. No. 2, 2000, pp 133-149.

4. *J. E. Cohen, "How Many People Can the Earth Support?" W.W. Norton & Co., New York, 2004.*
5. *O. O. Ifatimehin and M. E. Ufuah, "An Analysis of Urban Expansion and Lost of Vegetation Cover in Lokoja Using GIS Techniques," Journal of Environmental Studies and Human Development, Vol. 17, No. 1, 2006b, pp. 28-36.*
6. *O. O. Ifatimehin and S. D. Musa, "Application of Geoinformatic Technology in Evaluating Urban Agriculture and Urban Poverty in Lokoja," Nigerian Journal of Geography and the Environment, 2008.*
7. *S. Q. Zhao, J. Y. Fang, S. L. Miao, B. Gu, S. Tao, C. H. Peng and Z. Y. Tang, "The 7-Decade Degradation of a Large Freshwater Lake in Central Yangtze River," Environmental Science & Technology, Vol. 39, No. 2, 2005, pp. 431-436.*
8. *S. K. Karn and H. Harada, "Surface Water Pollution in Three Urban Territories of Nepal," India, and Bangladesh. Environ Manage, Vol. 28, No. 4, 2001, pp. 483-496.*
9. *B. A. M. Bouman, A. R. Castaneda and S. I. Bhuiyan, "Nitrate and Pesticide Contamination of Groundwater under Rice-Based Cropping Systems: Past and Current Evidence from the Philippines," Agriculture, Ecosystems & Environment, Vol. 92, No. 2, 2002, pp. 185-199.*
10. *J. G. Liu and J. Diamond, "China's Environment in a Globalizing World," Nature, Vol. 435, No. 7046, 2005, pp. 1179-1186.*
11. *Qadri, H. and Yousuf, A. R. 2008. Dal Lake ecosystem: conservation strategies and problems. p. 1453-1457. In: Proceedings of Taal 2007 (Sengupta, M. and Daiwani, R., eds.): The 12th World Lake Conference.*
12. *Malik, M., Balkhi, M.H. and Abubakr, A. 2017. Comparative study on the contamination level of Dal Lake, Kashmir based on Total Viable Bacterial Counts over a period of time. Eco. Env. & Cons. 23 (4) : 2145-2147.*
13. *Saleem, S., Kamili A.N, Kakru, D.K., Bandh, S.A. and Ganai, B.A. 2011. Isolation, identification and seasonal distribution of bacteria in Dal Lake, Kashmir. International Journal of Environmental Sciences. 2(1) : 185-193.*
14. *Shah AH, Teli PA, Bhat (2014) Dynamics of land use/land cover change in Dal Lake watershed of Kashmir valley—a remote sensing and GIS approach. Int J Adv Inf Sci Technol (IJAIST)*
15. *Meraj G, Romshoo SA, Yousuf AR (2012) Geoinformatics approach to qualitative forest density loss estimation and protection cum conservation strategy- a case study of Pir Panjal range, J&K, India. Int J Curr Res Rev 04(16):47–61.*
16. *Skilodimou H, Livaditis G, Bathrellos G, Verikiou Papaspiridakou E (2003) Investigating the fooding events of the urban regions of Glyfada and Voula, Attica, Greece: a contribution to Urban Geomorphology. Journal Geografska Annaler 85A(2):197–204*
17. *Addiscott TM, Thomas D (2000) Tillage, mineralization and leaching: phosphate. Soil Till Res 53:255–273*
18. *Bhat SA, Meraj G, Yaseen S, Bhat AR, Pandit AK (2013) Assessing the impact of anthropogenic activities on spatiotemporal variation of water quality in Anchar Lake, Kashmir Himalayas. Int J Environ Sci 3(5):1625–1640*
19. *Bhat SA, Meraj G, Yaseen S, Pandit AK (2014) Statistical assessment of water quality parameters for pollution source identifcation in Sukhnag stream: an infow stream of Lake Wular (Ramsar site), Kashmir*

Himalaya. J Ecosyst 2014, Article ID 898054

20. *Bhat SA, Meraj G, Pandit AK (2016) Assessing the infuence of stream fow and precipitation regimes on water quality of the major infow stream of Wular Lake in Kashmir Himalaya. Arab J Geosci 9:50.*

21. *Gujree I, Wani I, Muslim M, Farooq M, Meraj G (2017) Evaluating the variability and trends in extreme climate events in the Kashmir Valley using PRECIS RCM simulations. Model Earth Syst Environ 3(4):1647–1662*

22. *Meraj G, Yousuf AR, Romshoo SA (2013) Impacts of the Geo-environmental setting on the food vulnerability at watershed scale in the Jhelum basin. M. Phil. dissertation, University of Kashmir, India.*

23. *Van De Wiel MJ, Coulthard TJ, Macklin MG, Lewin J (2011) Modelling the response of river systems to environmental change: progress, problems and prospects for palaeo-environmental reconstructions. Earth Sci Rev 104(1–3):167–185*

24. *Altaf S, Meraj G, Romshoo SA (2014) Morphometry and landcover based multi-criteria analysis for assessing the soil erosion susceptibility of the western Himalayan watershed. Environ Monit Assess 186:8391–8412.*

25. *Javed A, Khanday MY, Ahmed R (2009) Prioritization of subwatersheds based on morphometric and land-use analysis using remote sensing and GIS techniques. J Indian Soc Remote Sens 37:261–274*

26. *Chen L, Qian X, Shi Y (2011) Critical area identifcation of potential soil loss in a typical watershed of the three Gorges reservoir region. Water Resour Manage 25(13):3445–3463*

27. *Saghafan B, Golian S, Elmi M, Akhtari R (2013) Monte Carlo analysis of the efect of spatial distribution of storms onprioritization of food source areas. Nat Hazards 66:1059–1071*

28. *Badar B, Romshoo SA, Khan MA (2013a) Integrating biophysical and socioeconomic information for prioritizing watersheds in a Kashmir Himalayan Lake: a remote sensing and GIS approach. Environ Monit Assess 185:6419–6445*

29. *Badar B, Romshoo SA, Khan MA (2013b) Modeling the catchment hydrological response in a Himalayan Lake as a function of changing land system. Earth Syst Sci 112(2):434–450*

30. *Valipour M (2015) Land use policy and agricultural water management of the previous half of century in Africa. Appl Water Sci 5(4):367–395*

31. *Taloor AK, Kumar V, Singh VK, Singh AK, Kale RV, Sharma R, Khajuria V, Raina G, Kouser B, Chowdhary NH (2020) Land use land cover dynamics using remote sensing and GIS Techniques in Western Doon Valley, Uttarakhand, India. In: Geoecology of landscape dynamics (pp 37–51). Springer, Singapore*

32. *Mosbahi M, Benabdallah S, Boussema MR (2012) Assessment of soil erosion risk using SWAT model. Arab J Geosci.*

33. *Trabucchi M, Comín FA, O'Farrell PJ (2013) Hierarchical priority setting for restoration in a watershed in NE Spain, based on assessments of soil erosion and ecosystem services. Reg Environ Change.*

34. *Jang T, Vellidis G, Hyman JB, Brooks E, Kurkalova LA, Boll J, Cho J (2013) Model for prioritizing best management practice imple*

35. *Roy, Parth S.; Roy, Arijit; Joshi, Pawan K.; Kale, Manish P.; Srivastava, Vijay K.; Srivastava, Sushil K.; Dwevidi, Ravi S.; Joshi, Chitiz; Behera, Mukunda D.; Meiyappan, Prasanth; Sharma, Yeshu; Jain, Atul K.; Singh, Jamuna S.; Palchowdhuri, Yajnaseni; Ramachandran, Reshma M.; Pinjarla, Bhavani; Chakravarthi, V.; Babu,* *Nani; Gowsalya, Mahalakshmi S.; Thiruvengadam, Praveen. Development of Decadal (2005) Land Use and Land Cover Database for India. Remote Sens. 2015, 7, 2401-2430; doi:10.3390/rs70302401*

36. *Rather, I. A., & Dar, A. Q. (2020). Assessing the impact of land use and land cover dynamics on water quality of Dal Lake, NW Himalaya, India. Applied Water Science, 10(10), 1-18.*

37. *Bibri, S. E., Krogstie, J., Kaboli, A., & Alahi, A. (2024). Smarter eco-cities and their leading-edge artificial intelligence of things solutions for environmental sustainability: A comprehensive systematic review. Environmental Science and Ecotechnology, 19, 100330.*

38. *Agarwala, M., Atkinson, G., Fry, B. P., Homewood, K., Mourato, S., Rowcliffe, J. M., ... & Milner-Gulland, E. J. (2014). Assessing the relationship between human well-being and ecosystem services: a review of frameworks. Conservation and Society, 12(4), 437-449.*

39. *Yu, B., Shu, S., Liu, H., Song, W., Wu, J., Wang, L., & Chen, Z. (2014). Object-based spatial cluster analysis of urban landscape pattern using nighttime light satellite images: A case study of China. International Journal of Geographical Information Science, 28(11), 2328-2355.*

40. *McMullen, J. S., & Dimov, D. (2013). Time and the entrepreneurial journey: The problems and promise of studying entrepreneurship as a process. Journal of management studies, 50(8), 1481-1512.*

41. *Xie, H., Zhang, Y., Wu, Z., & Lv, T. (2020). A bibliometric analysis on land degradation: Current status, development, and future directions. Land, 9(1), 28.*

42. *Sartika, S., Bayanuddin, A. A., Putri, F. A., Ulfa, K., Hadiyanto, A. L., Candra, D. S., & Chulafak, G. A. (2023, October). Determining the Precision of Spectral Patterns Arising from Atmospheric Correction Utilizing MODTRAN-FLAASH and 6S Approaches on High-Resolution SPOT-6 Imagery. In 2023 IEEE International Conference on Aerospace Electronics and Remote Sensing Technology (ICARES) (pp. 1-7). IEEE.'*

43. *Zargar, U. R., Khanday, S. A., Rather, M. I., Dar, S. A., Zargar, N. H., & Mir, A. H. (2023). Accelerated eutrophication alters fish and aquatic health: a quantitative assessment by using integrative multimarker, hydrochemical, and GIS modelling method in an urban lake. Environmental Monitoring and Assessment, 196(1), 40.*

44. *Mashala, M. J., Dube, T., Mudereri, B. T., Ayisi, K. K., & Ramudzuli, M. R. (2023). A Systematic Review on Advancements in Remote Sensing for Assessing and Monitoring Land Use and Land Cover Changes Impacts on Surface Water Resources in Semi-Arid Tropical Environments. Remote Sensing, 15(16), 3926.*

45. *Lulla, K. P., & Dessinov, L. V. (Eds.). (2000). Dynamic Earth Environments: remote sensing observations from shuttle-Mir missions. John Wiley & Sons.*

46. *Fascista, A. (2022). Toward integrated large-scale environmental monitoring using WSN/UAV/Crowdsensing: A review of applications, signal processing, and future perspectives. Sensors, 22(5), 1824.*

47. *Huang, H., Lei, X., Liao, W., Zuo, X., & Wang, H. (2023). A novel multi-strategy hydrological feature extraction (MHFE) method to improve urban waterlogging risk prediction, a case study of Fuzhou City in China. Science of The Total Environment, 904, 165834.*

48. *Ingle, V. K., Jadhav, S. B., Awari, H. W., Khodke, U. M., & Pawar, S. N. (2017). DETERMINATION OF SURFACE DRAINAGE COEFFICIENT THROUGH RAINFALL ANALYSIS: A CASE STUDY DEONI TALUK OF DISTRICT LATUR, MAHARASHTRA. With the blessings of, 29, 124.*

49. *Ingle, V. K., Jadhav, S. B., Awari, H. W., Khodke, U. M., & Pawar, S. N. (2017). DETERMINATION OF SURFACE DRAINAGE COEFFICIENT THROUGH RAINFALL ANALYSIS: A CASE STUDY DEONI TALUK OF DISTRICT LATUR, MAHARASHTRA. With the blessings of, 29, 124.*

50. *Rashid, I., Romshoo, S. A., Amin, M., Khanday, S. A., & Chauhan, P. (2017). Linking human-biophysical interactions with the trophic status of Dal Lake, Kashmir Himalaya, India. Limnologica, 62, 84-96.*

51. *Dar, S. A., Rashid, I., & Bhat, S. U. (2021). Land system transformations govern the trophic status of an urban wetland ecosystem: Perspectives from remote sensing and water quality analysis. Land Degradation & Development, 32(14), 4087-4104.*

52. *Islam, S. T., Bhat, S. U., Hamid, A., Pandit, A. K., & Sabha, I. (2023). Impact of land-use patterns on water quality characteristics of Rambiarrah stream in Kashmir Himalaya. International Journal of River Basin Management, 1-18.*

53. *Nengroo, Z. A., Shah, A. H., & Bhat, M. S. (2017). Dynamics of land use change in rural-urban fringe: a case study of Srinagar City. Environmental Science: An Indian Journal, 13(4), 142.*

54. *Matos, P. F. D. (2020). Groundwater: geological, legal, social and ethical challenges of a unique natural resource: in memoriam Professor Luís Ribeiro (IST-U. Lisbon). In Book of Abstracts of the Geoethics & Groundwater Management Congress (pp. 107-109). Grupo Português da Associação Internacional de Hidrogeólogos (GP| AIH).*

55. *G. M. Rather, M. S. Bhat and T. A. Kanth, "Impact of Urban Waste of Srinagar City on the Quality of Water of River Jehlum," International Journal of Lakes and Rivers, Vol. 3, No. 1, 2010, pp. 17-24.*

56. *R. Gangwar, "Education and Participation Help Conserve the Dal Lake," Article in Ideas and Experiences for Education for Sustainable Development, Environmental Information System, India, 2008.*

57. *H. Rashid and G. Naseem, "Quantification of Loss in Spatial Extent and Wetlands in the Suburbs of Srinagar City during Last Century Using Geospatial Approach," In: M. Sengupta and R. Dalwani, Eds., Proceedings of Taal2007: The 12th World Lake Conference, 2008, pp, 653- 658.*