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IMPERVIOUS SURFACES AND LAND USE IN URBAN CONTEXTS – A FRAMEWORK FOR RESPONSIVE SUB-BASIN PLANNING

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Abstract: Urbanization has significantly influenced the land use and impervious surface growth, thereby altering the hydrology of urban sub-basins or watersheds within urban area. Sub-basins, are highly sensitive to localized land use changes due to their scale and proximity to surface water systems and its influence to change of infiltration and ground water recharge. Land use transformations, particularly those involving conversion of vegetative or permeable land to built-up areas, directly impact infiltration rates, surface runoff, and pollutant transport within these sub-basin. This review paper aims to provide few concepts and approaches for looking to the framework for responsive sub-basin planning by combining insights from 160 scholarly papers across a wide range of geographies, techniques, and temporal scales. The study categorizes present research into policy frameworks, vulnerability assessment, LID (Low Impact Development), hydrological modeling, land use changes, and impervious surface impacts. Apart from identifying methodological gaps and emerging area of discussions in change of urban land use and its effect on urban river, this paper identifying few major parameters which are required to be analyzed for understanding the relationship of urban river and changes of urban land use in a sub basin.
Keywords: hydrological modeling, urban watersheds, low impact development, policy framework, sub-basin planning, impervious surface

1. Introduction

Urbanization is a major cause of environmental and hydrological change today. As cities grow and infrastructure expands, the increase in impervious surfaces such as highways, buildings, and parking lots drastically modifies natural hydrological processes in urban areas (Chen et al., 2024) . These surfaces prevent water from infiltrating the ground, thereby increasing surface runoff, reducing groundwater recharge, and contributing to habitat loss, water pollution, and urban flooding (La Vigna, 2022). A critical aspect of understanding these impacts lies in examining the interaction between land use and sub-basin hydrology. A sub-basin is a smaller, more specialized part of a river basin that is easy to analyse for land use and hydrology. The manner in which inhabitants utilise and the extent of land within a sub-basin significantly influence water flow in that region. For example, residential and commercial land uses with high population density create extensive areas that do not absorb water. This elevates pollutant levels and speeds up peak flow, and lowers latency compared to using land with low density or naturally. The utilisation of land in the sub-basin is crucial for sustaining ecological equilibrium, enhancing water purification, and reducing runoff.

This article talks about a flexible technique to design sub-basins that takes into account how land use and urban impervious surfaces affect each other in a complicated way. Sub-basin planning is a flexible way to deal with the effects of urbanization on water and ecosystems (Tickner et al., 2020). It does this by showing how water flows in a small watershed. The suggested responsive basin planning method helps Planners and decision-makers address critical issues such as water management and the development of sustainable urban environments. It combines models of water flow, patterns of land use, and assessments of the environment. The system shows how changes in land use affect the water system by combining municipal planning with safeguarding the environment. This planning makes sure that building new roads and bridges meets people's needs and protects the environment, even as climate change and urban growth make things harder. By utilizing integrated land use strategies to slow down urbanization, responsive sub-basin planning can make watersheds healthier, increase the volume and quality of water, and enhance general health. Cities all across the world are changing quickly because more people are moving there, businesses are opening, and new infrastructure is being built. These changes make it harder for water to flow, which puts extra stress on the water system. Sub-basins are smaller and have clear hydrological boundaries, thus they react more quickly to changes in land use than larger watershed units. This makes them perfect for focused action. When managing urban water in a way that is good for the environment, you need to plan for changes at the sub-basin level.

This literature review combines the findings of 160 scholarly publications to create a strong theoretical and practical framework for planning in sub-basins. It underlines the need of understanding how land use changes over time and in different regions, how these changes affect hydrological parameters like runoff coefficient and infiltration rate, and how they affect river systems downstream. City planners, engineers, and lawmakers can use the results to safeguard the environment and make cities stronger by using smart sub-basin governance.

1.1 Background

One of the biggest threats to natural habitats is urbanisation, especially in areas that are growing swiftly. Cities put asphalt roads, concrete pavements, and rooftops over dirt and plants so that they can hold more people and businesses. These false surfaces have a major effect on how water moves about in cities. They keep rain and snow from settling, speed up surface runoff, and add more pollutants to rivers and streams. Flooding, heat islands, groundwater recharge, and difficulties with water quality in cities are all caused by this break in the hydrological cycle. You should pay attention to how the water flow varies in the sub-basin, which is a smaller part of a river basin or watershed. Hydrological sub-basins show how the weather and water move in a specific area. They are ideal for controlling water and making tiny cities. Because of its architecture, researchers and planners can see how land use and infrastructure development affect the flow, storage, and quality of water in sub-basins. Studies reveal that urbanization makes more land that can't be reached. This is because there are higher peak flows and shorter lag times for stream flow response (Booth & Jackson, 1997; Paul & Meyer, 2001). There are a lot of variations in how water flows in some sub-basins. Using land use management, urban form analysis, and hydrological models to plan at the sub-basin level is very significant. Consequently, there is growing interest in frameworks that link urban land use changes with the hydrological behavior of sub-basins to foster sustainable and resilient urban development.

1.2 Problem Statement

Urbanization induced changes in land use significantly alter the hydrological functioning of urban watersheds, particularly at the sub-basin level. While large-scale planning efforts often focus on entire river basins or regional water systems, these approaches tend to overlook the localized hydrological responses caused by specific land use transitions—such as the replacement of open green space with residential buildings or commercial infrastructure. The resulting increase in impervious surface cover impedes the natural infiltration of rainwater, leading to intensified surface runoff, erosion, sedimentation, and the degradation of aquatic ecosystems. One of the primary issues is the lack of integration between urban planning and hydrological science at actionable spatial scales. Most planning models and regulatory frameworks treat land use zoning and hydrological modeling as separate disciplines, which lead to fragmented policies and insufficient responses to urban flooding, water scarcity, and pollutant loading. Furthermore, planning tools often fail to account for the dynamic and spatially heterogeneous nature of land use change, which varies not only between cities but also within different neighborhoods or zones in the same city. Studies have also shown that sub-basins react differently depending on the composition and configuration of land use. For example, compact high-density development may produce different runoff characteristics compared to low-density urban sprawl, even if total impervious surface area remains similar (Shuster et al., 2005). Addressing these concerns requires a responsive planning framework that can incorporate spatial land use patterns, impervious surface growth, and hydrological processes at the sub-basin level. The absence of such integrative planning hinders the development of adaptive urban infrastructure capable of withstanding the environmental impacts of continued urbanization.

1.3 Significance of Sub-Basin Planning

More and more people are using sub-basin planning to manage urban water in a way that is good for the environment. Sub-basin-level evaluations are better than macro-scale planning for managing storm water in cities, lowering the risk of flooding, and keeping water quality high. Macro-scale planning could hide problems in certain places. This is because they enable you do things that are more specific to your place. From a scientific point of view, sub-basins are the best units for hydrological modeling because they show how water moves across a watershed. This means that it will be easier to predict and model how water would function if the kind of soil, land cover, slope, drainage patterns, and urban infrastructure vary. So, using sub-basins to plan helps make rules for how to use land that are different for each area. It also helps build green infrastructure like bio swales and rain gardens, as well as Low Impact Development (LID) techniques that help cities consume less water. Recent studies have shown that when cities plan their cities, they should think about the characteristics of sub-basins in order to better use Nature-Based Solutions (NBS) and Sustainable Urban Drainage Systems (SuDS) to reduce the negative effects of hard surfaces (Gironás et al., 2009; Fletcher et al., 2015). With extreme weather events becoming more frequent due to climate change, responsive sub-basin planning enables cities to prepare for hydrological stress by enhancing ecosystem services, regulating runoff volumes, and ensuring that water-sensitive urban design principles are upheld. This research thus reinforces the need to institutionalize sub-basin frameworks within local, regional, and national urban governance systems.

1.4 Scope of research

This study conducts an extensive and structured literature review encompassing 160 peer-reviewed scholarly articles published over the past two decades. The research spans diverse urban geographies—from high-density megacities in Asia to low-density suburban landscapes in North America—and synthesizes findings across a wide range of temporal and spatial scales. The selected studies include works employing GIS-based spatial analysis, remote sensing, hydrological modeling tools (e.g., SWMM, HEC-HMS, SCS-CN), and interdisciplinary frameworks that bridge urban planning, environmental science, and civil engineering. The research focuses specifically on identifying, classifying, and analyzing the interaction between urban land use change and impervious surface development at the sub-basin level. It categorizes the literature into six key thematic areas: (1) Policy frameworks for urban water governance, (2) Vulnerability assessments of urban watersheds, (3) Hydrological modeling techniques, (4) Low Impact Development (LID) practices, (5) Land use change dynamics, and (6) Environmental impacts of impervious surfaces. The study's goals are to both find out what's wrong and give suggestions. It looks at both current methodological and empirical trends and finds gaps in knowledge, discrepancies, and opportunity to utilize scientific ideas in urban policy and planning. The purpose of the research is to provide a complete framework for responsive sub-basin planning that can be applied in cities of various sizes. This means setting guidelines for figuring out how weak sub-basins are, putting limits on surfaces that don't let water through, and zoning land use that takes into consideration how water flows. In the end, the research makes it possible to combine separate scholarly findings into useful planning tools and principles that could help cities grow in a way that works well in many different socioeconomic and environmental conditions.

1.6 Contribution to Knowledge

By bringing together the fields of urban land use planning, impervious surface monitoring, and sub-basin hydrology in a systematic way, this work makes a big difference in both research and practice. It adds to the existing body of work by presenting a new way to think about developing cities based on sub-basins that makes it clear how these areas are linked. This study combines 160 papers from different fields to show how the growth of hard surfaces affects the flow of water in sub-basins with different types of land use. This study is about responsive sub-basin planning, which is a method that is both proactive and adaptable enough to work with changes in cities and the environment. The study talks about a planning tool that helps people figure out the most important impervious thresholds. This model connects biological function to patterns of land use in space, which makes it easier to choose water-sensitive urban design (WSUD). The paper also talks about new trends and methods in sub-basin hydrology, like using remote sensing to find surfaces that don't let water through, AI-driven modeling to anticipate how much water will flow off, and participatory GIS to develop communities. It also talks about problems that are still going on, like not having adequate data, using different geographical units, and needing to work together across fields. The report presents planners a list of policy suggestions based on evidence that will help them build cities with water flow in mind. It gives researchers new topics to study in fields like adapting to climate change, models that work at different scales and urban water systems that work together. By moving us from reactive management to design that is anticipatory and clever about space, this method changes how we think about urban hydrology.

2. Systematic literature review

Urban hydrology, ecological stability, and sustainable development are significantly impacted by the shift from permeable natural landscapes to impervious constructed environments as cities continue to expand. Developing effective planning and management strategies at local levels relies on knowledge of these processes. This study aims to integrate findings from a diverse spectrum of scholarly literature including remote sensing, environmental science, urban planning, and hydrology. Through thorough evaluation of peer-reviewed papers, the review identifies common techniques, main findings, knowledge gaps, and new trends related to impervious surface analysis and responsive sub-basin planning. This collection is not only to offer a comprehensive overview of present research but also to establish a strong theoretical and empirical foundation for future practical interventions and studies. Maintaining the integrity of local water systems, this article is intended to help academics, urban planners, environmental managers, policy makers, and others committed to advancing sustainable urban development. The systematic approach adopted in this study ensures a comprehensive and transparent literature selection, data extraction, and synthesis process. This study is intended to greatly contribute to the growing body of research trying to harmonize urban development with ecological and hydrological resilience.

2.1 Geographic Distribution of Case Studies in Urban Hydrology and Sub-Basin Planning

Understanding the global landscape of research on urban hydrology, impervious surfaces, and sub-basin planning is essential for identifying knowledge hubs, methodological diversity, and regional disparities in scholarly focus. Given the growing significance of urbanization and its impacts on hydrological systems, this study draws insights from 160 peer-reviewed scholarly articles covering diverse geographical regions, urban contexts, and methodological frameworks. To provide clarity on where this research has been most concentrated, the following table presents a classification of the selected case studies based on their geographical origin—highlighting the countries and cities most frequently examined. This geographic mapping not only underscores the prevalence of certain urban areas in hydrological studies (such as New York, Beijing, and London), but also reveals the underrepresentation of rapidly urbanising regions in parts of Africa, South America, and Southeast Asia. By evaluating the spatial distribution of these studies, the table helps to contextualize the global trends in urban watershed management, the adoption of hydrological models like SWMM, and the integration of Low Impact Development (LID) practices across different planning and environmental settings. It also offers insight into how regional priorities, environmental regulations, and urban development trajectories influence research intensity. This synthesis aims to encourage a more balanced and globally inclusive approach to responsive sub-basin planning, especially in developing countries where urban expansion is accelerating and hydrological challenges are intensifying.

Table 1: Geographic Distribution of Case Studies in Urban Hydrology and Sub-Basin Planning Research

Continent	Country	City/Region Examples	No. of Case Studies	Remarks
Asia	**China**	Yangtze River Basin, Yellow River Basin, Wuhan, Harbin, Hefei	26	Highest number; focus on river basins, urban expansion, resilience, UHI
	India	Ganga Basin, Chennai, Hyderabad, Dehradun, Indore, Prayagraj	18	Strong focus on LULC, erosion, hydrology, SWAT modeling
	Iran	Kal-e Shur, Dez Basin, Tehran	5	Urban flood risk, LULC effects on water quality
	Nepal	Kathmandu Valley, Koshi Basin	3	Land use, river encroachment, erosion dynamics
	Bangladesh	Urban rivers, Asian clams, pollution studies	3	Urban river pollution, ecological impact
	Pakistan	Gilgit Baltistan, Ravi River	2	LULC impacts on river systems
	Indonesia	Jakarta, Pantura Jabar	2	Urban sprawl and flooding
	Sri Lanka	Tropical catchments	1	Rainfall and erosion modeling
Africa	**Ethiopia**	Akaki River, Didessa Basin, Beles Basin	7	River catchment studies, hydrological modeling, erosion
	Nigeria	Peri-urban watershed (Lagos)	1	Riparian vegetation and streambank stability
	Tanzania	Wami Catchment	1	Climate and land cover impacts

	Algeria	Seybouse Basin	1	Soil loss distribution and LULC
Europe	**France**	Bordeaux	1	Urban ecology and hydrological impacts
	Germany	—	1	Reservoir sedimentation and urbanization
	Greece	12 Cities (UHI analysis)	1	Urban heat island and LULC
North America	**USA**	Virginia, Maine, Atlanta, Florida	5	UHI, land use planning, water quality, stream flow
	Canada	—	1	Plant biodiversity in multi-use landscapes
South America	**Brazil**	Tocantins-Araguaia Basin, São Paulo	5	Sub-basin modeling, nutrient runoff, sedimentation
Oceania	**Australia**	Sydney, stream ecosystems	1	Urban stream responses to land use
Multiple / Global	Mixed Regions	Meta-analyses, comparative studies	~10	Not focused on specific country; used models or global indices

2.2 Systematic Literature Review

To find research publications, we did an exhaustive search on SpringerLink, IEEE Xplore, and ScienceDirect. This study only included articles published in journals that accurately tracked scientific events. A systematic review using the PRISMA framework identified five recent studies (1996–2024) focusing on the impact of urban land use on river sub-basin hydrology. These studies were selected from peer-reviewed journals based on relevance to impervious surfaces, runoff, and water quality. Inclusion criteria emphasized empirical or modeling-based research at the sub-basin level. The selected cases span diverse urban contexts in Iran, Ethiopia, and the Philippines.

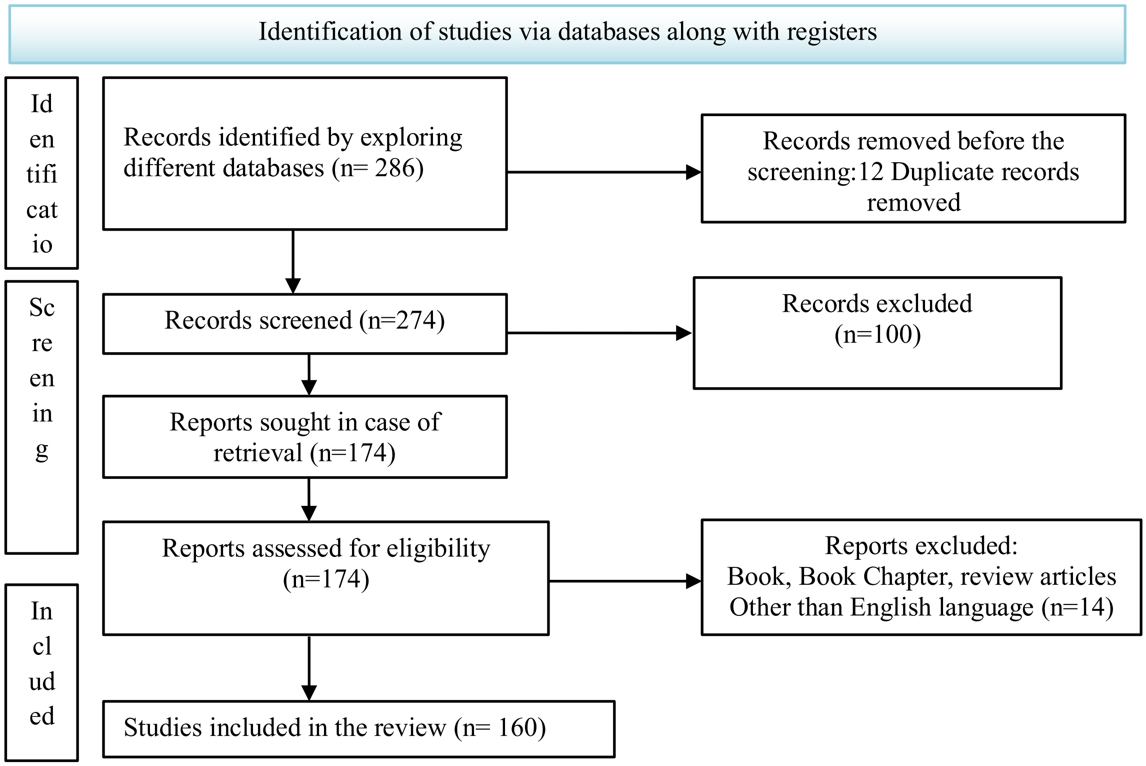

Figure 1: Prisma Flow Chart for Systematic review

2.3 Year wise frequency of research article

The following table shows year-wise frequency of research articles based on the 160 references. The table lists yearly article counts:

Table 2: Year wise frequency of research article

Year	Number of Articles
2001	1
2002	1
2003	1
2004	1
2005	1
2006	1
2007	2
2008	1
2009	2
2010	3
2011	2
2012	3
2013	2
2014	4
2015	6

2016	5
2017	7
2018	9
2019	11
2020	13
2021	16
2022	22
2023	27
2024	26

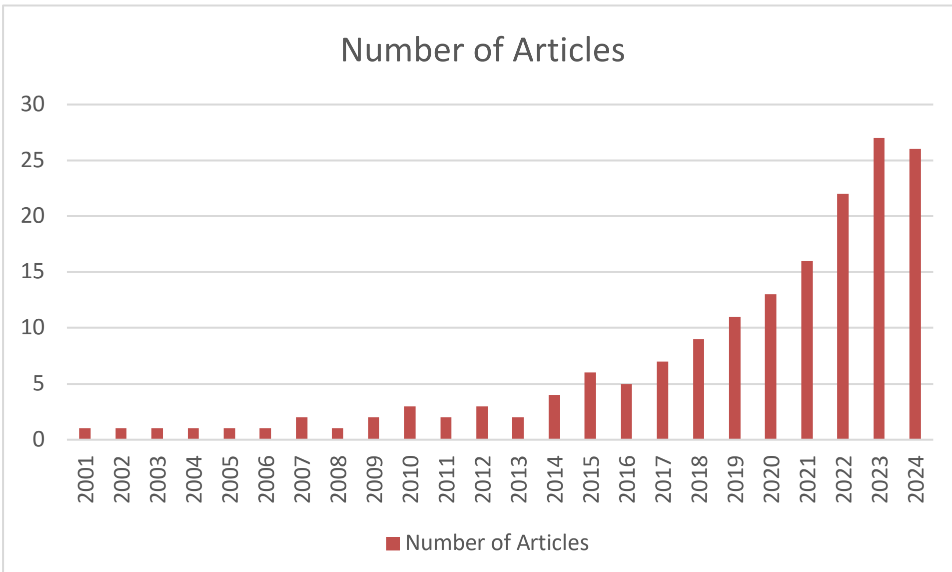

Figure 2: Year wise frequency of research article

2.4 Methodology-wise

The table below lists the research articles from the 160 references organized by common research techniques employed in urban impervious surface and land use studies, indicating the methodology-wise frequency.

Table 3: Methodology-wise

Methodology	Frequency
Remote Sensing and GIS Analysis	42
Hydrological Modeling (e.g., SWAT, HSPF)	25
Statistical/Regression Analysis	18
Machine Learning/AI-Based Approaches	9
Field Survey and Ground-Truthing	14
Scenario-Based Planning/Simulation	12
LULC Change Detection	15
Multi-Criteria Decision Analysis (MCDA)	6

Urban Planning Frameworks	7
Spatial Metrics and Landscape Analysis	6
Literature Review/Meta-Analysis	3
Policy/Institutional Analysis	3

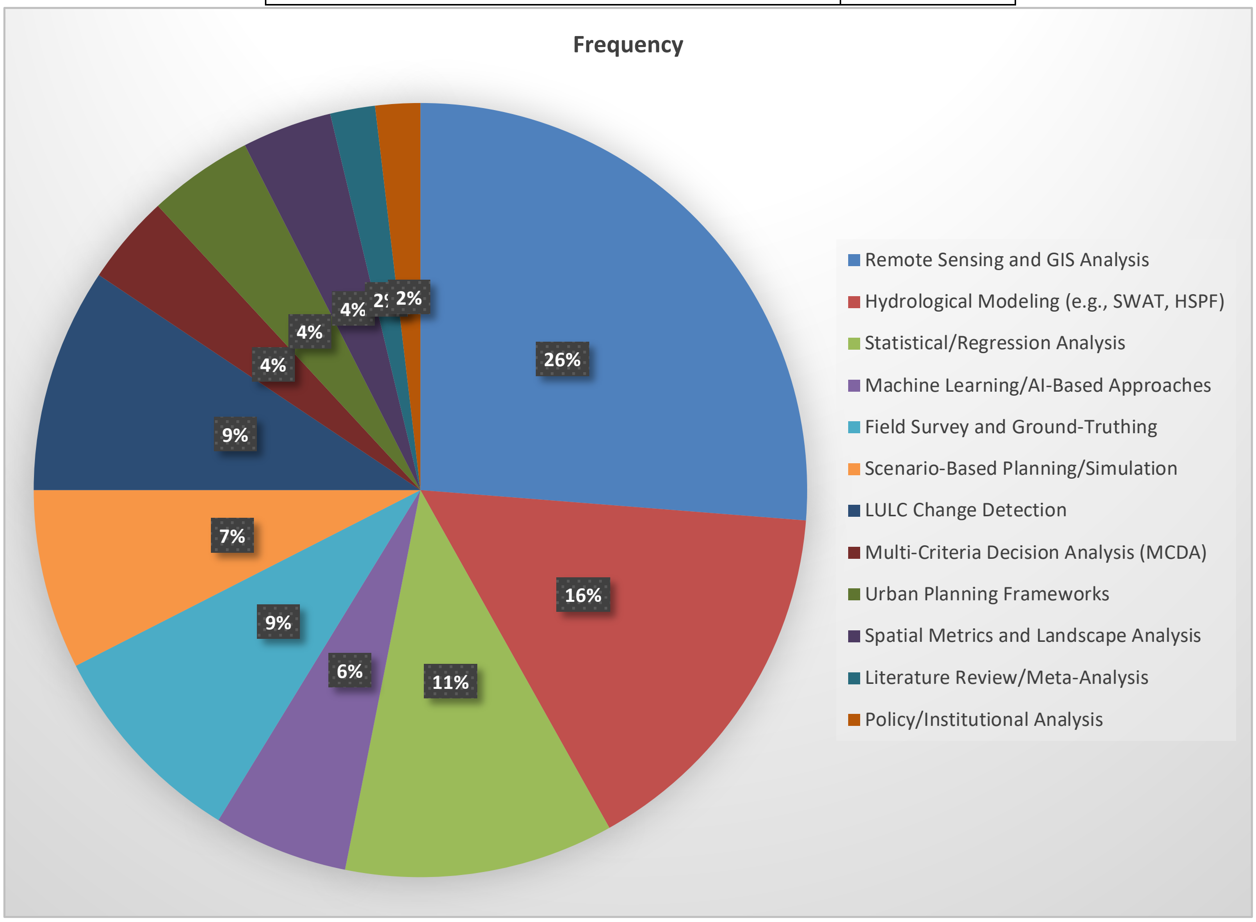

Figure 3: Methodology-wise

2.5 Related work

Urban ecosystems are increasingly complex systems shaped by various environmental and human factors. Aibcrtt (n.d.) presented a conceptual framework for understanding the urban ecosystem stressing the interaction of land use, climate, and hydrology in forming urban environments. Using this framework to investigate the dynamics discussed in contemporary studies is vitally vital. The influence of urbanisation on climate, particularly the Urban Heat Island (UHI) effect, has been well investigated. Synthesising three decades of UHI mitigation research, Akbari and Kolokotsa (2016) found a wide range of technical options aimed to minimise urban thermal stress. Focussing on Muscat, Oman, Charabi and Bakhit (2011) revealed how coastal desert cities particularly exhibit UHI due to their meteorological traits. Rising surface temperatures in western Ethiopia were linked significantly by Dibaba (2023) to LULC changes, hence stressing the need of regional adaptation strategies. Land use change is the focus of environmental vulnerability and hydrological reactions. While Danegulu et al. (2024) linked urban flooding in Kathmandu Valley to river encroachment and unplanned urban growth, Asadi et al. (2024) looked at how land use changes influenced flood discharge in the Kal-e Shur Sabzevar River sub-basins. Reaching similar conclusions, Boongaling et al. (2024) assessed the effectiveness of Low Impact Development (LID) plans in urban catchments in the Philippines, suggesting that policy-based interventions might lower hydrological risk. Many studies looked at how land use changes affect environmental services and ecosystems. Chen, Wang, and Zeng (2023) revealed that urban expansion in China diminished ecosystem services across several metropolitan agglomerations. Documenting a decline in ecosystem service value connected to LULC dynamics, Assaye et al. (2024) mirrored comparable findings in Ethiopia's Beles River Basin. Du et al. (2024), on the other hand, took the issue forward by creating ecological security patterns for arid urban environments employing landscape ecological risk assessments. Hydrological modelling and assessment became a main subject, particularly in regard to watershed and catchment responses to LULC changes. Looking at the Lake Chamo sub-basin, Bucha et al. (2024) discovered land cover changes generating water balance anomalies. Emphasising that uncontrolled land expansion significantly raises environmental risk, Campos et al. (2023) conducted a vulnerability analysis of Brazil's Doce River Basin. Cifuentes et al. (2024) similarly linked altered hydrological patterns to urban dammed basins, stressing the cumulative effects of infrastructure and urban growth. Common themes were sedimentation and soil erosion. Bouzeria et al. (2023) mapped LULC impacts on soil loss in Algeria's Seybouse Basin; de Silva et al. (2023) focused on Sri Lanka, mapping future rainfall forecasts to assess erosion intensities in tropical catchments. Similarly, dos Santos et al. (2024) applied CA-Markov modelling in Brazilian sub-basins to predict land cover changes and their implications for soil and water conservation projects. The geographical and socio-economic dimensions of urban growth were also looked at. By tracking land use changes over time, Bikis (2023) created a method for effect assessment of urban growth. By discussing spatial inequalities in urban land use using a core-periphery framework, Fang et al. (2023) added a socio-economic perspective. Conversely, Chen et al. (2024) examined land use conflicts in the Yangtze River basin of China and suggested natural-social dynamic response models to help manage the consequences of urban agglomeration. Greater emphasis was on water-related risks. Combining land use values with flood risk zones, Ding et al. (2024) examined urban waterlogging. Durrieu et al. (2023) looked at how extreme hydrological regimes influence trace element flows in small urban streams whereas Bah et al. (2024) provided a case study on Guinea's Konkoure River Basin linking LULC with flood inundation patterns. At last, microclimate changes and land surface temperature were noted as sensitive indicators of land use intensity. Especially surface temperatures; Ali et al. (2017) demonstrated how various urban land covers affect microclimate. A micro-level thermal study can help to enhance more broad ecological modelling and planning tools, hence enabling a thorough understanding of urban environmental dynamics.

Febrita et al. (2021) investigated how features of urban river landscape influence urban microclimates in tropical regions using a case study approach. The form of the river, how much forest there is, and how many developed areas are nearby all have a huge effect on the area's temperature and humidity. The report indicates that buildings along the riverbank need to be built with the environment in mind so that they can control the microclimate.

Freire et al. (2023) studied how adding fertilisers, building on land, and rain affected rivers in Brazil that are only a little dry. Statistical studies indicated that farming and creating cities enhanced the levels of nutrients, especially after it rained. This study highlights how important it is to plan how to use land and keep watersheds clean to reduce pollution.

Galvez et al. (2024) utilised a model to show how the type of land cover affects the temperature of the land surface in the Cagayan de Oro River basin. They studied tropical river basin urban heat islands (UHI) using remote sensing and statistics. They noticed that temperatures rose as cities grew.

Gandharum et al. (2024) studied how farming changed in Pantura Jabar, Indonesia, as cities grew by making predictions about how land use will change. They found out that cities were killing farmland. Many people were worried about how land would be used in the future and if there would be enough food.

Gao et al. (2023) studied how hedging approaches could improve the hydrology of China's Jinsha River after land use changes. They discovered that using different types of land use to balance biological and hydrological functions makes watershed systems more resilient. Gao et al. (2024) studied how effectively China's different land uses work along the Yangtze River. Their research indicated that urban land usage isn't very efficient, even when building is encouraged. Land use zoning and policy consistency are our key concerns.

Ge et al. (2024) looked into how mixing cities and farms changes how people use agriculture. They found that integration projects could lead to the loss of multifunctionality in agricultural land; threshold effects show significant transition periods in land use policies.

To assess riverbank erosion susceptibility, Ghosh and Sahu (2023) conducted a geomorphological study of the Ganga-Bhagirathi River. They claimed that material composition, flow dynamics, and human interventions acting together cause erosion; therefore, they suggested holistic management approaches for bank stabilisation.

Models linking land surface temperature and UHI effects in Indore, India with land use/cover changes were developed by Gohain et al. (2023). They confirmed that rapid urbanisation aggravates heat stress, hence reinforcing the need of green cover and zoning policies in urban growth.

Gonzalez Rodriguez and colleagues (2023) offered a global assessment of sedimentation rates in freshwater reservoirs. Increased agriculture and deforestation, which degrade water quality and reservoir lifetime, were found by Gonzalez Rodriguez et al. (2023) to be major causes of silt accumulation.

Goodarzi et al. (2023) looked at how land use changes affect river water quality in the Dez Basin of

Iran using land change models. Land modelling was a key planning tool; their results showed a clear relationship between agricultural expansion and water pollution.

Goodspeed et al. (2023) integrated land use scenario simulations with water quality data using random forest models. They demonstrated how predictive modelling could enhance urban planning by indicating how different development policies affect water quality indicators.

Gu (2024) examined land prices in Seongnam, South Korea and how urban revitalisation projects affect them. The research indicated that redevelopment could lead to social disparities as well as increased land value, thereby calling for equitable policy actions in revitalisation projects.
Guan et al. (2023) studied Jiaxing, China's urban growth under water conservation policies. Emphasising the need of regional cooperation in planning, they found that strict zoning not only transferred growth pressures to other areas but also practically restricted urban sprawl around water bodies.

Gücker et al. (2024) investigated how tropical stream aquatic macroinvertebrate production was influenced by urbanisation and agriculture. Emphasising the need of land management in aquatic biodiversity, their findings indicate that agricultural land use has more clear negative consequences than urban land.

Haileslassie et al. (2024) investigated water value in the Akaki River system of Ethiopia under urban–rural linkages. They discovered trade-offs between groups and competing water demands, hence promoting inclusive water governance approaches.

Hailu et al. (2024) looked at how informal settlements in urban Ethiopia alter land use and damage ecosystems. Unplanned development, they found, results in the loss of natural ecosystems and green places, thereby stressing the importance of formalised urban planning.

Halder & Bose (2024) did a comparative study of remote sensing-based metrics for evaluating urban ecological health across 12 eastern Indian cities. Their research pointed forth several more sensitive and reliable indices for monitoring urban environmental changes.

Using GIS and remote sensing, Hamid et al. (2024) tracked land use/cover changes in Kashmir Valley. They noted notable urban encroachment over agricultural and forest areas, hence underlining the environmental effects of uncontrolled urbanisation.

He et al. (2024) looked at how land use/cover change affects the urban heat environment during summer using a 15-year dataset from 365 Chinese cities. Their research showed that built-up regions raise daytime heat stress as well as nighttime heat stress, hence stressing the need for climate-adaptive urban development.

Hordofa et al. (2023) forecasted changes in blue and green water availability in the Meki River Sub-Basin brought on by climate change. They found that future climatic situations could restrict the supply of agricultural water, hence stressing the importance of climate-resilient water management strategies.

Hossain et al. (2024) examined the dangerous element accumulation in the Asian clam from tainted urban streams in Bangladesh. Their risk study showed potential human health concerns, hence underlining the importance of pollution management in urban waterways.

Imam (2021) studied urbanisation trends and district-level population increase in Bihar. He observed urban growth geographic variations that can affect regional development and infrastructure planning.

Islam et al. (2023) examined a Bangladeshi urban river for pollution and toxicity sources. By means of chemical analysis and water quality data, they discovered industrial and municipal waste to be significant pollutants, hence recommending more strict environmental rule enforcement.

Jauregui & Romales (1996) studied how convective precipitation patterns vary with urbanisation in Mexico City. Their historical meteorological research showed more rain brought on by urban-induced atmospheric shifts, hence providing early evidence of urban climate change.

Jia et al. (2024) studied how land use change influenced non-point source pollution in the Duliujian River Basin using the SWAT model. Their simulation results showed that urban growth and more intensive farming dramatically increased the amount of pollutants. This shows how important it is to manage land in a way that is good for the environment.

Jiang et al. (2024) looked at how climate change and people's actions impact how land is used in China's Central Plains. These areas are become increasingly urbanised, yet they also care about the environment. The study used both remote sensing and socio-economic data to show that urban growth, which is induced by policy and economic factors, makes land degradation and ecological fragility worse as the climate changes.

Researchers Jibitha et al. (2024) looked at how land use and land cover (LULC) and land surface temperature (LST) altered in Southern India's rapidly increasing metropolitan area. For twenty years, remote sensing showed that urban development was connected to higher LST. This indicates that there are problems with urban heat islands and that green infrastructure needs to be built.

In 2023, Jin et al. studied how land use and land cover (LULC) changed runoff in China's Jing River Basin. Hydrological modelling showed that floods were more likely to happen when there was less agriculture and more surfaces that didn't soak up water. It was harder to keep groundwater because of this.

Jodhani et al. (2023) used RUSLE, Google Earth Engine, and GIS to study how soil erosion happens in the Rel River Watershed in Gujarat. Their study found that some places were eroded because of cultivation and cutting down trees. This led to steps being taken to protect the soil.

Kamal et al. (2021) looked at how the form of a city impacts the microclimate and how much energy buildings use. Their models showed that bigger cities need more heating and cooling. This means that the amount of energy used depends on how well buildings and plants work together and how well they fit into the environment.

Kannapiran and Bhaskar (2024) used artificial neural networks to anticipate changes in land use and cover in the Tamil Nadu upstream Adyar sub-basin. They used ancient satellite data to train their deep learning model, and it correctly predicted the loss of green space and the growth of cities. You can utilise this information to make sure that cities don't have problems.

Keleş Özgenç and Özgenç (2024) talked about difficulties with the environment in cities and suggested remedies that originate from nature. The study showed how important it is to include ecological points of view in city planning in order to fight pollution, heat stress, and the loss of biodiversity through green infrastructure and biophilic planning.

Khan and Rahman (2024) used the RUSLE model to see how likely it is for dirt to wash away in different regions of the Swat River Basin. Their use of GIS showed that the main causes of erosion are steep slopes and not having enough plant cover. This shows how important it is to fix land and grow new trees.

Khan et al. (2024) looked at how changes in land use and land cover (LULC) in the Shigar area of Pakistan changed LST. Satellite photographs taken at different times showed a lot of urbanisation and glaciers melting, which corresponds with the idea of localised warming and stress on the ecology? This supports land use plans that take climate change into consideration.
In 2024, Kolling Neto and Souza looked explored how changes in land use and climate changed the flow of streams in a Brazilian savannah basin. They noticed that changing the way it rains and cutting down trees changed both the baseflows and the peak discharge. It should be easier to adjust how watersheds are run.

In 2023, Krishnaraj and Honnasiddaiah looked into how LULC changes the quality of the water in the Middle Ganga Basin all year round. Their analysis shows that farming and runoff from cities are the main causes of summer water pollution. This proves that we need standards for land and water.

In 2024, Sri Krishnaraj and Palanisamy used GIS technology to look at how climate data changed land use and land cover (LULC) in the Kaveri Basin. They noticed that the amount of land used for farming and trees differed a lot depending on the weather. Different places of the world use land in different ways because of the weather.

In 2024, Kumar et al. looked explored how changes in land use and cover affect the water cycle in tropical Southwest India. Hydrological models indicated that building towns and cutting down trees made it so that less water soaked into the ground and more water ran off the ground. This shows how important it is to find long-term ways to manage land and water.

Kumar et al. (2024) built a hybrid model that can guess how much rain would fall and how much water will run off in the Upper Narmada Sub-basin. They used both physical and data-driven methods. The model they employed was more accurate than others, which makes it seem like hybridisation would be a better approach to show how land expansion changes complicated water flow patterns.

In 2024, Kutzer et al. looked at the food chain of Japanese eels that lived in streams that went through towns and farmland. Their research showed that how people used land changed what animals ate and the food web. This could mean that there aren't as many animals in the water.

Lalika et al. (2024) looked at how the Wami watershed in Tanzania changed because of land use and climate. The study discovered that the water supply was getting worse because trees were migrating and the weather was acting abnormally. This shows how important it is to modify the way we care for water.
Lee et al. (2011) used data from the Texas Air Quality Study to look at the WRF model for urban surface parameterizations. They discovered that the simulated data and the real data were not the same. Because of this, they believed that urban representation needed to be improved in order to forecast changes in pollution and heat.

Li et al. (2024) looked into how urban resilience and urbanisation could grow in China's Yellow River Basin. Their study showed how different planning for fast urban growth and resilience may be, and they offered ideas for how to combine both to help the economy and the environment at the same time.

Li and Yeh (2000) claimed that GIS and limited cellular automata might be utilised to find out how cities can grow in a way that is favourable for the environment. Their research shows that design and physical obstacles can help cities flourish in a way that is both long-lasting and compact.

Lin et al. (2008) used numbers to figure out how urbanisation changes the way it rains in Taiwan. The results indicated greater convective rain brought on by heat island effects, hence highlighting the impact of urbanisation on altering regional climate systems.

Liu et al. (2024) look at the geographical distribution of production-living-ecological functions across urban-rural gradients in Xiangyang City. Their findings indicated spatial differences with ecological functions declining near urban areas, hence requiring harmonised land use planning.

Examining how cities influence precipitation rates, Lowry (1998) found that urban-induced convection can locally raise rainfall. The study underlined the significance of adding urbanisation in weather prediction models and provided rudimentary knowledge on urban climatology.

Lu et al. (2024) looked at how land use and landscape patterns affect water quality in the Ganjiang River Watershed. Their study showed that urban and agricultural land were major contributors of nutrient pollution, hence encouraging landscape-level planning to lower non point source pollution.

Lundy & Wade (2011) stressed the significance of merging scientific disciplines to preserve urban ecological services. Their concept directed sustainable urban planning and the preservation of environmental benefits by linking ecological, hydrological, and social processes.

Ma et al. (2024) looked at how environmental regulations increased eco-efficiency of urban land use in Chinese cities. Using spatial econometric models and eco-efficiency indices, the study found regional variations and supported customised regulatory approaches, so demonstrating that environmental regulation directly controls eco-efficiency and fosters innovation.

Mahata et al. (2024) geospatially evaluated land use and land cover (LULC) changes brought on by urban growth in the Kolkata metropolitan area. Using remote sensing and GIS technology, the study found significant transformations of agricultural and open lands into built-up regions, hence stressing the need for sustainable urban growth.

Maheshwari & Vyas (2024) assessed the vulnerability of urban waterbodies in India using the WRASTIC model. Their findings imply that human activity pressures such as trash dumping, recreational abuse, and land use changes significantly increase waterbody susceptibility, hence suggesting necessity for conservation efforts.

Mahmood et al. (2014) presented a comprehensive study of biogeophysical impacts of land cover changes on regional and global climate. The study integrated multi-scale data indicating that changes in surface albedo, evapotranspiration, and roughness affect local and global climate trends, including temperature and precipitation regimes.

Marin et al. (2024) developed a spatial model to monitor wild boar activity in Bordeaux, France's urban green areas. Combining empirical tracking data with urban ecological modelling, the study offered insights on wildlife adaption in cities and suggestions for biodiversity-sensitive urban design by means of urban ecological modelling.
Under the EU Water Framework Directive, Markert et al. (2024) investigated how land use influences micropollutant concentrations. Emphasising the need of concentrated source

management strategies, their research throughout several catchments showed that both agricultural and urban areas had a major impact on micropollutant loads.

Martin et al. (2012) investigated whether urbanisation has altered ecological flow characteristics in Maine, United States. The hydrological study showed that urban land cover significantly altered flow timing and volume, with effects on water resource management and aquatic ecosystem health.

Merga et al. (2022) investigated land surface temperature (LST) change in reaction to LULC changes in Ethiopia's Didessa River Sub-basin. The study found that urban and agricultural expansion increased LST, which affects climate change adaptation and land use planning.

Miedema Brown & Anand (2024) investigated how different types of urban land cover affect plant variety in a multi-use environment. The results showed that although mixed land-use patches with vegetation encourage different plant communities, impermeable surfaces reduce plant variety.

Mishra & Arya (2024) looked at LULC changes and the urban heat island (UHI) impact in Dehradun, India using remote sensing. Emphasising the urgent need for climate-resilient urban planning, the research found a tight relationship between built-up growth and increasing land surface temperatures.

Modiri et al. (2023) suggested "urban DNA" to simulate urban growth in Tehran. Their findings suggest that administrative decisions, infrastructural development, and socio-cultural trends impact future modelling tactics for rapidly expanding cities.

Mouris et al. (2023) created an interdisciplinary model chain to evaluate how global change influences reservoir sedimentation. By means of climate, land use, and hydrology models, the study underlined water infrastructure and reservoir management issues by means of sediment yield in future scenarios.

Nigussie et al. (2023) examined how LULC changes affect ecosystem services in the Little Akaki River watershed of Ethiopia. Results pointed to increasing mismatch between service supply and demand brought on by urbanisation, which called for integrated ecosystem service planning in peri-urban areas.

Nizar et al. (2024) assessed soil erosion in India's Cauvery River Basin using a hybrid RUSLE-SDR-TLA model. Their combined modelling approach revealed notable erosion risks in areas with steep slopes and agricultural activity, hence supporting targeted conservation actions.

In an Indian urban context, Noori & Singh (2023) examined LULC in relation to rainfall patterns and urban water collecting capability. Their study indicated suitable locations for artificial groundwater recharge by linking land use control with water resource sustainability.

Odhiambo et al. (n.d.) examined historical land use and sedimentation trends in two urban Virginia, USA reservoirs. The study discovered long-term silt deposition related to urban expansion and inadequate watershed management, which would affect reservoir longevity and water quality.

Considering land use, riparian vegetation, and lithological variations, Okeke et al. (2022) provided a comprehensive assessment of streambank stability in Nigeria. Their results show how hard it is to prepare for the degradation and restoration of watersheds because of both natural events and things that people do.

Palinkas et al. (2022) looked at how different ways of managing land affect the quality of water and sedimentation in estuary areas. They said that how urban and agricultural land is handled has a big impact on nutrient and sediment levels, which backs up land management strategies for the whole watershed.

Pathirana et al. (2014) used sensitivity analysis to find out how changes in how people use land in cities affect the microclimate and the way heavy rain falls. The article said that we need to plan cities with the weather in mind and that surfaces that don't let water through make it rain heavier and change microclimates.

Paul and Bhattacharji (2023) utilised a CA-ANN model to predict how land use and land cover (LULC) will change and how these changes will affect the erosion of the banks of the Bhagirathi River. The model projected that cities would grow and subsequently fall apart. This emphasised how crucial it is to think ahead about how waterways will grow.

Pena, Vieira Leal, and their coworkers used hydrological modelling to see how changes in land use and cover (LULC) affected the flow of Brazil's Ibicuí River Basin. Urbanisation and logging made runoff and peak floods harsher. This makes hydrology more susceptible to changes in the environment.

Rahmani and Fattahi (2024) studied how drought and long-term land use and cover (LULC) affect the quality of river water. The study revealed that urban expansion, forestry, and long-term hydrological dryness all rendered the water less clean. Because of this, we required water management that could change.

Ranjan and Singh (2023) studied how LULC affects the flow of water in India's Punpun River Basin. Their research indicated that as cities grew, runoff and flooding got worse. This meant that they had to get ready for both watersheds and cities at the same time.

Reed et al. (2024) looked into how the number of people in a city affects how much turbulent heat moves in and out of the city at different times of the year. Their research showed that energy exchanges fluctuated a lot with the seasons, especially in crowded areas. This knowledge helps keep cities' microclimates in check.

Regasa and Nones (2024) built a model to find out how changes in land use and land cover (LULC) in the past and future could impact the water cycle in an Ethiopian watershed. The results showed that there will be concerns in the future with reduced baseflow and increased runoff. This led to ideas for regulations about how to take care of land and stop floods.

Rendana et al. (2023) studied how land usage changed urban heat islands (UHIs) in Hulu Langat, Malaysia. GIS and remote sensing data showed that built-up areas made UHI worse, while vegetation and water bodies made it better. Their results demonstrate that developing on land that is excellent for the environment could help cities stay cooler.

Roberts et al. (2024) used history to look at challenges in cities during the Anthropocene. The study says that we should use both archaeology and history to make cities today that are stronger and stay longer.

Royer et al. (1988) studied how the reflectance of Landsat-MSS altered in cities with temperate climates. Their research demonstrated that urbanisation changed the land surface and the amount of vegetation cover, which modified the patterns of spectral reflectance. This shows how crucial remote sensing is for long-term monitoring of cities.

Sampath & Radhakrishnan (2024) predicted sediment output and soil erosion in ungauged basins using land use/land cover (LULC) data. They demonstrated through modelling that significant land cover changes increase erosion risks, hence underlining the need of land management in watershed maintenance.

Sandeep et al. (2024) mapped the spatiotemporal expansion of Bengaluru's urban sprawl using earth observation data. The study, which provided important insights for urban planning and sustainable infrastructure development, revealed fast urban growth and fragmentation of green spaces.

Sarkar et al. (2024) examined how urbanisation has affected land use patterns and ecosystem services in industrial Indian cities. Their results show less environmental services from industrial expansion; they advocate scenario-based modelling to steer future sustainable urban development.

Under LULC and climate change both alone and in combination, Sharma et al. (2024) assessed the hydrological balance of a tropical river basin. Their model results indicated that both factors significantly influence evapotranspiration and runoff, thereby suggesting that coordinated watershed management strategies are needed.

Shem & Shepherd (2009) estimated how urbanisation might influence summer storms in Atlanta using numerical models. Near urban areas, they found more convection and localised rain, which provided early evidence of urban-induced meteorological change.

Shepherd (2006) presented observational data showing how urbanisation affects rainfall patterns in desert regions. Urban surfaces, the study claims, especially in cities with limited vegetation, create localised convection and rainfall fluctuation.

Shi et al. (2024) judged urban development suitability in Zhengzhou, China using limitation and probable growth components. By means of ecological, infrastructure, and socio-economic data integration, their strategy guides even urban growth and land resource optimisation.

Shohan et al. (2024) investigated the relationship between land surface temperature (LST) changes in Southeast Asia and urban sprawl. They indicated that significant LST increases have resulted from substantial urban growth and recommended better planning and greening projects to reduce microclimatic influences.

Using the SWAT model, Shree & Kumar (2023) investigated the hydrological impact of LULC changes in the Subarnarekha River Basin. Urban expansion and forest cover loss increased surface runoff and reduced baseflow, thereby their work influencing watershed sustainability.

Silver (2021) examined declining infrastructure in American towns from a political ecology perspective. Emphasising pipeline failures, the paper supported fair and enduring infrastructure improvements by linking infrastructure neglect to persistent urban inequality.

Singh et al. (2024) discovered a link between flood risk in the Kosi River Basin and LULC changes. By means of flood mapping and land cover research, they showed that urban expansion and deforestation increased flood risk, hence underlining the need of coordinated land-flood planning.

Skovira & Bohlen (2023) examined water quality and vegetation of stormwater ponds draining different urban land uses. Their study indicated that nutrient levels and plant structure are greatly influenced by land use, hence directing better pond design for urban water management.

Song et al. (2024a) investigated Tianshan urban agglomerations' changing land use and its effects on ecosystem services. Their findings showed that rapid urban growth resulted in service loss, particularly in the supplying and regulatory categories, thereby suggesting policy realignment for ecological sustainability.

Song et al. (2024b) built an integrated system to manage urban expansion in China balancing development with conservation. The approach proposes green borders and spatial zoning to strike a balance between economic growth and environmental conservation.

Stathopoulou & Cartalis (2007) calculated daytime UHI effects in Greek cities using Landsat ETM+ and CORINE data. Strong correlations between urban land covers and rising temperatures were found, hence promoting climate-adaptive urban development.

Su et al. (2024) investigated the multi-stage interaction between ecological quality and land use efficiency. Since high land use efficiency does not always equal to great ecological performance, the study proposed a coupling coordination model stressing the need of dual-focused urban policy.

Subbiah et al. (1990) provided a statistical analysis of urban climate change in Tamil Nadu by linking increasing urbanisation to temperature and rainfall variations. The early investigations served to define urban climate dynamics in tropical areas.

Suthar et al. (2024) conducted a land-use suitability study using MCDM in three Himalayan districts. Their spatial study identified optimal locations for urban expansion by combining geographical, environmental, and infrastructural elements for planning.

In Adama Zuria District of Ethiopia, Tafesse & Suryabhagavan (2019) simulated LULC impacts on LST. Remote sensing revealed to them that expansion of built-up areas significantly increased LST, hence highlighting the need of spatial planning in controlling thermal environment.

Taha et al. (1988) looked at how urbanisation modifies the surface albedo and how it affects how much heat buildings need to cool down and the urban heat island effect. Their model stated that cities should employ more materials that reflect light to minimise UHI and cooling.

Tao et al. (2024) used SWAT to study how climate change and land expansion impacted the flow of water in China's Shaying River Basin. Their results revealed that as cities got bigger and it rained more, runoff became more problematic. This means that watershed solutions should be flexible and alter as they need to.

Tilahun and Desta (2023) used GIS and USLE to find out how much soil erosion was happening in the Ada'a watershed in Ethiopia. Some regions were more prone to break down because of changes in land cover. They said that basin conservation would stop the silt from moving.

Tiwari et al. (2023) studied how the channels of the middle Ganga plain river change land use and cover. The research employed GIS and remote sensing to watch how the morphology of the river and the way people used and covered the land changed. It is very vital to manage rivers and land in a way that is good for the environment since the movement of rivers has an immediate effect on the loss of farmland and settlements.

Ullah et al. (2024) used GIS-based hydrological models to see how climate change and land development affect the flow of the Ravi River. Their study showed that river flow is affected by urban expansion, fewer plant cover, and changes in rainfall patterns. This backs up the premise of planning for the long-term sustainability of all water resources.

Uyan and Ertunç (2024) employed spatial autocorrelation to study how land is used and how cities change over time in Konya, Turkey. The study's findings on strong spatial clustering of urban growth underlined the need of spatial analysis in urban planning as it generated agricultural land loss and fragmented green areas.

Walsh et al. (2016) examined how stream ecosystems respond to urbanisation given physiography and urban water management. Their findings suggested that local geomorphological circumstances and management practices including stormwater infrastructure significantly influence urban effects on stream health, hence proposing context-specific mitigation approaches.

Wang, Shi, & Fan (2024) investigated how farmers in China's ore-agriculture zone perceive ecosystem services and how these perceptions relate to their well-being. Although land degradation and pollution decreased perceived benefits, cultural and provisioning services were shown to be directly linked to well-being, thereby supporting targeted ecosystem management.

Using mobile temperature monitoring, Wang et al. (2022) looked at the cooling effect of an urban river and its interaction with the surrounding constructed environment. Results revealed that especially in high-density metropolitan areas, closeness to rivers considerably lowered ambient temperatures, therefore supporting the function of blue infrastructure in heat reduction.

Wang et al. (2023) investigated scale-dependent land use impacts on river water quality in the Tuojiang River Basin. The study emphasised that various land use types—e.g., farm, urban, forest—had diverse impacts depending on the geographical scale, hence providing valuable information on optimal watershed management.

Ward, Murray, and Phinn (n.d.) proposed a stochastically constrained cellular automata model for simulating urban expansion. By including spatial constraints and randomisation, their model generated more realistic urban expansion patterns, hence supporting future land use planning.

Wu et al. (2024) conducted a fuzzy assessment of changes in urban ecological health in the Wei River Basin. Their fuzzy model identified important hindering factors such population pressure and land use change as well as thorough understanding of ecological deterioration in metropolitan settings.

Wu et al. (2023) studied how and why two Chinese cities grew. The study showed that land, rules, and money all had an effect on how fast things grew. This allowed municipal planners from all over the country to see how their work compared to others.

Chinese villages were divided into two kinds by Xiao and Jingsheng (2024): urban and rural. Their typology revealed that different places change in different ways and gave varied approaches to plan for modernisation while yet retaining the rural identity.

Yadav et al. (2024) studied how the Kumbh Mela in Prayagraj impacted the environment and how cultural events contributed to the building of communities. The study looked at how the event had a major but short-term effect on planning, infrastructure, the environment, and urbanisation.

Yan et al. (2024) studied how mixed land use affects the quality of stormwater in cities when it rains. They noted that mixed land use made contaminants less predictable, thus stormwater treatment should fluctuate based on the type of land use and how much rain falls.

Yan et al. (2023) studied how land use and slope changed the water quality in the Weihe River Basin. The results showed that land utilisation increased worse as the slope got steeper. Farming in the hills made pollution worse and needed more specialised treatments.

Yang et al. (2024) studied how ESV altered over time and in different regions of the Yangtze River Basin. Changes in how land was used had enormous effects. Urbanisation and the growth of farming led to ESV's decline. This emphasised how crucial it is to limit how land can be used to protect ecosystems.

Yang et al. (2024) used models to make guesses on how climate change and land development would affect the water flow in the Hanjiang River Basin. They found that combination scenarios made floods more likely and changed the way water flowed, which suggests that land management and infrastructure need to be able to change.

Yang et al. (2024) studied how cities grow and how much it can rain. Emphasising the need for climate-resilient urban designs, they showed using observational and modelling data that dense, impermeable metropolitan forms aggravate rainfall intensity and frequency.

Yang, Li, & Shi (2008) used cellular automata and support vector machines to simulate land use changes. Their hybrid model improved projected accuracy and incorporated complex urban dynamics, hence demonstrating the power of machine learning in land change modelling.

Yangouliba et al. (2023) projected past and future land use/cover changes in West Africa's Nakambe River Basin. By means of scenario analysis, they forecasted continuous land degradation and urban encroachment, hence stressing the importance of land governance initiatives.

Yao & Huang (2023) investigated land use changes across many urbanisation periods in the Pearl River Delta and their effect on summer rainfall. Urban expansion was shown in the study to have impacted rainfall patterns, particularly by increasing localised convective storms, which influenced urban climate resilience planning.

Yigez et al. (2023) linked soil loss and sediment export in Nepal's Koshi River Basin to LULC changes. Key reasons were found to be deforestation and agricultural expansion; the study underlined the need of reforestation as well as erosion control.

Yu, Jia, & Cui (2024) investigated land use economic efficiency in the Yellow River Basin in connection to urban ecological resilience. Their dynamic research showed a complex interplay whereby efficiency improvements sometimes undermined resilience, implying a need for balanced development approaches.

Yu et al. (2017) discussed climate adaptation planning for urban green space in subtropical cities.

They proposed architectural concepts optimising ecological advantages including cooling and flood reduction to strengthen urban climate resilience.

Zhan et al. (2024) investigated village development in the upper Tuojiang River basin using land, population, and industry data. By revealing several transformation routes formed by topographical, economic, and policy factors, the study directed rural revitalisation efforts.

Zhang et al. (2024) conducted a coupling coordination study on ecological services and urban land green use efficiency in the Yangtze River Economic Belt.

Zhang et al. (2024) investigated how the characteristics of dissolved organic matter (DOM) in Wuhan's urban streams were influenced by various land use categories. Their findings indicated that residential, commercial, and industrial land uses obviously alter DOM composition, therefore suggesting a tight link between human activities and deterioration in water quality in urban aquatic systems.

Zhang, Sun, and Hu (2024) evaluated the carbon emission efficiency of land use in urban agglomerations along the Yangtze River Economic Belt using a three-stage SBM-DEA model. They discovered differences in carbon efficiency among locations; main influences on low-carbon development potential were determined to be policy, economic growth, and land use structure.

Zhang, Chen, and Li (2020) looked examined how urban form measures—such as building density and road networks—related to plant biomass loss under urban expansion all across China. Their study found that dense and fragmented urban forms cause notable green space loss, hence underlining the importance of urban design in ecological protection.

Zhang et al. (2024) utilised the FLUS model with two assessments to show how changes in land use might affect cities in Harbin and stop them from rising too quickly. When city planners find a good balance between developing new things and cleaning up where people live and work, they do their best work.

Zhao et al. (2024) looked at how digital banking influences how well cities along the Yangtze River Economic Belt can handle environmental problems. Digital finance growth is good for the environment since it makes it simpler to keep an eye on it and gets people to put money into green technology.

Zhao et al. (2024) looked into how land use and cover changed in the Shiyang River Basin. Changes in the economy, geography, and policy had an effect on them. They found out that the main reasons for the changes in land use and cover were urbanisation and the rise of agricultural. This revealed that land management needed to be more connected.

Zhou (2023) looked at how green efficiency has changed over time and in different regions of the Yangtze River Economic Belt urban development zones. The study found that land usage is varied and has effects in other areas. A number of rules need to work together to make land usage better for the environment.

Zhou et al. (2024) looked at how changes in land use over time and space affect the ecosystem services (ESV) in the Lhasa River Basin. They looked at how the slope of the ground influences this. People moving on steep slopes and changing how they used the land had a big effect on ESV. This shows that alpine areas are quite sensitive to damage to the ecosystem.

Using the WRF-UCM model, Zhou et al. (2024) assessed how LULC changes and climate variability influence urban heat islands (UHI) in Hefei. Results showed that urban growth and loss of vegetation aggravated UHI effects, hence stressing the need of green infrastructure in urban climate mitigation.

Zhou, Wu, and Tao (2024) investigated the seasonal and regional variation of the cooling effects urban rivers provide. Their landscape-scale analysis revealed that rivers always lower urban heat; the effect varies seasonally and depending on surrounding land use, so supporting river conservation as a climate adaptation technique.

Table 4: Literature Review

Ref	Author / Year	Objectives	Methodology	Findings	Limitations	Conclusion
1	Aibcrtt, M. (n.d.)	To conceptualize urban ecosystems through a modeling framework.	Conceptual framework analysis in urban planning literature.	Proposes a holistic model for urban ecosystem representation.	Lacks empirical validation or case studies.	Provides theoretical grounding for future urban ecosystem studies.
2	Akbari & Kolokotsa (2016)	Review of three decades of urban heat island (UHI) research and mitigation.	Systematic literature review from 1980s to 2016.	Highlights evolution and effectiveness of UHI mitigation strategies.	Limited regional focus and lack of quantitative synthesis.	Supports integrated urban design and energy efficiency.
3	Ali et al. (2017)	Analyze microclimatic LST variations across different LULC types.	Remote sensing and statistical analysis.	Strong correlation between LULC and temperature variations.	Limited spatial resolution; lacks seasonal data.	Supports climate-sensitive urban planning policies.
4	Asadi et al. (2024)	Evaluate LULC change impact on discharge and flood intensity.	Hydrological modeling using GIS and SWAT.	Land use changes increase flood risks.	Model uncertainty and local calibration limitations.	Emphasizes land management for flood mitigation.
5	Assaye et al. (2024)	Assess ESV variation under LULC dynamics.	Remote sensing and ecosystem	LULC changes affect provisioning	Generalized ESV coefficients	Highlights need for sustainable

			service valuation.	and regulating services.	reduce accuracy.	land planning.
6	Bah et al. (2024)	Study LULC impact on flood inundation in Guinea.	GIS-based flood modeling with historical data.	Urban expansion increases flood risk and extent.	Limited hydrological ground truthing.	Recommends LULC-informed flood control strategies.
7	Bhakta et al. (2024)	Identify groundwater potential zones relative to land use.	Remote sensing, AHP, and GIS.	Links agriculture/settlement with groundwater availability.	Limited temporal data.	Aids in sustainable water resource planning.
8	Bikis (2023)	Quantify urban growth and its LULC impacts over time.	Temporal GIS analysis using satellite imagery.	Urban growth intensifies LULC change.	Ignores ecological/social outcomes.	Encourages spatial monitoring for urban planning.
9	Boongaling et al. (2024)	Evaluate LID strategies across land uses in urban sub-catchments.	Modeling and scenario analysis.	LID reduces runoff and improves water quality.	Applicability may vary by region.	Confirms LID effectiveness in urban water management.
10	Bouzeria et al. (2023)	Evaluate soil loss under LULC changes.	RUSLE modeling with historical LULC maps.	Deforestation and urbanization worsen erosion.	Assumes constant rainfall erosivity.	Recommends reforestation and erosion control.
11	Bucha et al. (2024)	Examine hydrological response to LULC changes in Lake Chamo sub-basin.	Hydrological modeling and water balance assessment.	LULC changes significantly altered water balance and streamflow.	Uncertainties in model inputs and calibration.	Advocates integrated watershed management.
12	Campos et al. (2023)	Assess environmental	Multi-criteria GIS-based environment	High vulnerability linked to	Static vulnerability index;	Useful for prioritizing

		vulnerability in Doce River basin, Brazil.	al vulnerability analysis.	anthropogenic pressure and land misuse.	lacks temporal dimension.	environmental risk zones.
13	Charabi & Bakhit (2011)	Assess canopy UHI in Muscat, Oman.	Thermal remote sensing and temperature index mapping.	Intense UHI effect observed in dense urban zones.	Older data may not reflect current urban patterns.	Supports climate-responsive city planning in arid zones.
14	Chen & Zhang (2024)	Analyze land use conflicts and natural-social factor dynamics.	GIS and statistical conflict detection in urban agglomeration.	Rapid urbanization leads to spatial conflicts in land use.	May oversimplify socio-political factors.	Emphasizes dynamic land use governance.
15	Chen et al. (2023)	Study urban form's spillover effects on land use efficiency.	Spatial econometric modeling using urban data from China.	Compact urban forms improve land use efficiency.	Regional differences limit generalizability.	Encourages compact development in urban planning.
16	Chen, Wang & Zeng (2023)	Assess urban expansion impacts on ecosystem services across China.	Remote sensing, ESV estimation, and urban growth analysis.	Expansion reduces regulating services but boosts provisioning ones.	Uses average ESV values; site-specific variations ignored.	Recommends ecological zoning in urban expansion.
17	Cifuentes et al. (2024)	Examine hydrological effects of land use change in dammed urban basin.	Hydrological modeling of urban basin in Argentina.	Urbanization altered flow regimes and increased runoff volume.	Limited rainfall scenarios considered.	Calls for green infrastructure in urbanized basins.
18	Danegulu et al. (2024)	Characterize urban flooding in	Remote sensing, GIS, and	Urbanization and river encroachment	Informal settlements not fully mapped.	Recommends participatory urban flood

		Kathmandu Valley.	stakeholder analysis.	intensify flood risk.		management.
19	de Silva et al. (2023)	Assess soil erosion due to LULC and projected rainfall in Sri Lanka.	Soil erosion modeling under climate and land use scenarios.	Combined rainfall and land changes heighten erosion intensity.	Projections depend on climate models' accuracy.	Urges erosion control under climate change planning.
20	Dibaba (2023)	Analyze surface temperature and heat flux change due to urbanization.	Remote sensing LULC and thermal indices in Ethiopian cities.	Urban growth significantly increased surface temperature and flux.	Focused only on two cities; lacks seasonal detail.	Highlights urban greening to mitigate heat impacts.
21	Ding et al. (2024)	Assess spatial overlay effect of waterlogging risk and land use value in urban areas.	GIS and spatial analysis of waterlogging risk and land value.	Identified areas at high risk for urban waterlogging based on land use.	Limited data on flood mitigation measures.	Critical for urban planning in flood-prone areas.
22	dos Santos et al. (2024)	Use CA-Markov model to predict land use/cover changes in the Tocantins-Araguaia River Basin.	CA-Markov prediction modeling and land use/cover assessment.	Significant future land use changes predicted, with agriculture declining and urban areas expanding.	Uncertainty in predicting long-term trends.	CA-Markov model is effective for land use prediction.
23	Du et al. (2024)	Construct ecological security patterns for arid areas based on landscape	Landscape ecological risk assessment in urban agglomeration.	Identified critical areas for ecological security in Wu-Chang-Shi urban area.	Only considers ecological factors, ignoring social dynamics.	Ecological security pattern essential for sustainable urban planning.

		ecological risk.				
24	Durrieu et al. (2023)	Study impact of extreme hydrological regimes on trace element partitioning in a small urban river.	Trace element analysis and hydrological modeling.	Extreme flows lead to increased trace element concentration and fluxes in urban rivers.	Limited to one urban river.	Urges better management of urban river systems to mitigate contaminatio n.
25	Fang et al. (2023)	Analyze changes in urban land spatial inequality in core-periphery structures.	Geospatial analysis and inequality modeling in urban agglomeratio ns.	Unequal land distribution with concentration in central urban areas and marginalization of peripheral regions.	Focuses on inequality, without addressing social impact.	Suggests policy intervention to reduce urban inequality.
26	Febrita et al. (2021)	Investigate urban river landscape impact on microclimate in tropical regions.	Microclimate modeling based on urban river landscape features.	Urban rivers significantly affect local temperature and humidity, enhancing microclimate variation.	Limited data on non-riverine landscapes.	Highlights urban rivers' role in managing tropical microclimate s.
27	Freire et al. (2023)	Explore effects of rainfall and land use on nutrient responses in rivers in Brazil.	Statistical analysis of rainfall and land use data.	Land use change and rainfall significantly affect nutrient levels in rivers.	Limited temporal data.	Recommend s land use management to prevent nutrient pollution.
28	Galvez et al. (2024)	Model influence of land cover changes on surface temperature	Land cover dynamics and thermal imaging analysis.	Land cover changes correlate with increased surface	Limited to a single region.	Suggests sustainable land management to reduce heat effects.

		variations in Cagayan de Oro.		temperature in urbanized areas.		
29	Gandharum et al. (2024)	Assess impact of urban development on agricultural land in Indonesia.	Land use change analysis and predictive modeling.	Urban development has led to a significant decline in agricultural land, especially along major highways.	Does not consider socio-economic impacts on farming.	Calls for policies to protect agricultural land from urban sprawl.
30	Gao et al. (2023)	Investigate hedging effects in river basins due to land use changes in China.	Hydrological and statistical modeling of river systems.	Hedging in land use has helped mitigate the impacts of urbanization on hydrological regimes.	Relies on historical data that may not represent future trends.	Recommends incorporating hedging strategies in land use planning.
31	Gao et al. (2024)	Examine mismatch between land use functions and efficiencies in the Yangtze River region.	Spatial analysis of land use efficiency and function mapping.	Mismatch between land use efficiency and function, highlighting inefficiencies in resource use.	Does not account for policy impacts on land use efficiency.	Suggests better alignment of land use with regional needs.
32	Ge et al. (2024)	Study impacts of urban-rural integration on arable land use functions.	Analysis of land use transition and integration effects.	Urban-rural integration has led to better optimization of land use for agriculture in some areas.	Threshold effects need more detailed exploration.	Emphasizes the need for integrated land use planning.
33	Ghosh & Sahu (2023)	Investigate susceptibility of river bank materials to erosion in the Ganga-	Geotechnical analysis of riverbank materials.	Riverbanks show significant erosion susceptibility, especially in	Localized study, may not be representative of wider regions.	Urges enhanced riverbank stabilization and

		Bhagirathi River.		areas of urbanization.		management.
34	Gohain et al. (2023)	Model relationship between LULC changes, surface temperature, and UHI in Indore city, India.	Remote sensing and spatial modeling.	Urban expansion correlates with increased surface temperature and UHI in Indore.	Limited consideration of socio-economic factors.	Recommends green spaces to mitigate UHI in urban areas.
35	Gonzalez Rodriguez et al. (2023)	Review sedimentation rates in freshwater reservoirs and causative factors.	Literature review and meta-analysis of sedimentation studies.	Sedimentation rates have increased due to land use change, especially in deforested regions.	Limited to recent studies, may miss historical data.	Recommends better management of land use near reservoirs.
36	Goodarzi et al. (2023)	Assess land use changes' effect on water quality in Dez Basin using LCM.	Land Change Modeler (LCM) and water quality monitoring.	Land use changes have degraded water quality, with urbanization as a key factor.	Limited to one basin; lacks broader regional analysis.	Calls for stricter land use regulations to protect water quality.
37	Goodspeed et al. (2023)	Incorporate water quality into land use scenario analysis using random forest models.	Random Forest model and water quality data integration.	Land use changes predictably alter water quality, with urbanization having a significant negative impact.	Lack of temporal data to model long-term impacts.	Emphasizes the importance of integrating water quality in land use planning.
38	Gu (2024)	Evaluate impacts of urban revitalization projects on	Land price analysis and spatial modeling of urban areas.	Urban revitalization projects led to an increase in land prices,	Study is city-specific and may not be generalized.	Highlights the economic benefits of urban

		land prices in Seongnam, South Korea.		particularly in redeveloped zones.		revitalization .
39	Guan et al. (2023)	Assess impact of water protection policies on urban growth in Jiaxing.	Policy analysis and urban growth modeling.	Water protection policies have slowed urban expansion, especially in protected areas.	Policy enforcement and implementation challenges.	Suggests strengthening water protection policies for sustainable urban growth.
40	Gücker et al. (2024)	Compare impacts of agriculture and urban land use on macroinvertebrate production in Neotropical streams.	Ecological assessment of macroinvertebrate production in streams.	Agriculture negatively impacts macroinvertebrate populations, while urbanization leads to mixed effects.	Limited scope of study; other ecological factors not considered.	Urges better management of both agricultural and urban land use to protect aquatic life.
41.	Haileslassie et al. (2024)	To explore the diversity and trade-offs of water values in the Akaki River system	Qualitative and quantitative data analysis from urban-rural linkages	Identified trade-offs between water quality and accessibility	Limited to one region, not applicable globally	Suggests more equitable water management for urban-rural linkages
42.	Hailu et al. (2024)	To assess the impact of urban informal settlements on land use and ecosystems	Case study approach with GIS and remote sensing	Urban informal settlements cause land use transformation and ecosystem degradation	Limited geographical scope to specific settlements	Urban planning needs to address ecosystem preservation while managing informal settlements

43.	Halder & Bose (2024)	To compare remote sensing-based indices for urban ecology	Remote sensing data analysis of 12 urban centers in eastern India	Revealed significant urban ecological differences using different indices	Spatial and temporal limitations of available satellite data	Remote sensing is a useful tool but needs further refinement in urban ecology
44.	Hamid et al. (2024)	To assess land use/land cover change in Kashmir Valley	Remote sensing, GIS techniques	Land use change significantly alters the environment, leading to environmental degradation	Limited to Kashmir Valley, not scalable	Remote sensing and GIS are effective in monitoring land use change
45.	He et al. (2024)	To study the impacts of land use/cover change on urban heat environment	Panel data study using 365 cities over 15 years	Found direct and indirect impacts on urban heat island effect	Study restricted to China, may not apply elsewhere	Need for policies to mitigate urban heat impacts from land use changes
46.	Hordofa et al. (2023)	To assess climate change impacts on blue and green water in Meki River Sub-Basin	Water resource modeling and climate data analysis	Identified significant reductions in blue and green water resources due to climate change	Limited focus on a specific sub-basin	Water management strategies should address climate change impacts
47.	Hossain et al. (2024)	To evaluate human health risks from pollutants in Bangladesh's urban rivers	Pollution monitoring of the invasive Asian clam and risk assessment	High levels of toxic pollutants identified in urban rivers	Focused on one species, not generalizable to all fauna	Risk assessments are crucial for human health protection in urban river systems

48.	Imam (2021)	To analyze population growth and urbanization at the district level in Bihar	District-level statistical analysis	Rapid population growth correlates with urbanization, straining resources	Limited to one state in India	Urban planning in Bihar needs to consider rapid urbanization pressures
49.	Islam et al. (2023)	To identify sources and toxicity of pollutants in an urban river	Chemical analysis of pollutants in water	Detected high levels of toxic pollutants impacting river ecosystem	Focused on one river, results may not be applicable to all regions	Pollution control measures are needed for urban rivers in Bangladesh
50.	Jauregui & Romales (1996)	To study urban effects on convective precipitation in Mexico City	Meteorological data analysis of precipitation patterns	Urban areas increase convective precipitation through heat island effects	Limited temporal data and geographical scope	Need for urban planning to mitigate precipitation changes
51.	Jia et al. (2024)	To simulate the effects of land use change on non-point source pollution	Simulation modeling in Duliujian River Basin	Identified significant impacts on water quality due to land use changes	Limited to one river basin, not applicable elsewhere	Land use planning is critical to mitigate non-point source pollution
52.	Jiang et al. (2024)	To analyze impacts of climate change and human activity on land use evolution	Long-term data analysis of land use in China’s Central Plains	Found a clear link between climate change and human-induced land use change	Study limited to one region in China	Urbanization and climate change require coordinated management to mitigate impacts
53.	Jibitha et al. (2024)	To assess changes in land use/land cover and its impact on	Remote sensing and land surface temperature data analysis	Land use changes significantly affect land surface	Limited to one region in southern India	Climate adaptation strategies should consider land

		land surface temperature		temperature in urban agglomerations		use impacts on temperature
54.	Jin et al. (2023)	To assess the hydrological response of runoff to land use change in the Jing River Basin	Hydrological modeling and land use data analysis	Significant increase in runoff due to land use change	Focused only on Jing River Basin	Land use change significantly affects water cycles and needs regulation
55.	Jodhani et al. (2023)	To assess soil erosion using RUSLE and geospatial techniques	Geospatial analysis using RUSLE and Google Earth Engine	Significant soil erosion in the Rel River watershed due to land use changes	Study limited to one watershed	Soil erosion management is necessary for sustainable land use
56.	Kamal et al. (2021)	To study the impact of urban morphology on microclimates and energy usage	Urban morphology analysis and energy modeling	Urban morphology affects microclimates and building energy demand	Limited to energy modeling and building performance	Urban design strategies should account for microclimate impacts on energy efficiency
57.	Kannapiran (2024)	To predict land use/land cover changes in the Adyar sub-basin using deep learning	Artificial neural networks and deep learning techniques	Deep learning models effectively predict land use changes	Model performance varies with data quality	Deep learning models are promising for land use prediction, but data quality is crucial
58.	Keleş Özgenç (2024)	To evaluate urban ecological problems and propose nature-based solutions	Ecological assessment and case studies	Nature-based solutions offer effective remedies for urban ecological problems	Limited to urban centers with specific ecological conditions	Nature-based solutions can address ecological issues if properly integrated

						into urban planning
59.	Khan & Rahman (2024)	To assess soil erosion risk in the Swat River Basin	RUSLE approach with geospatial techniques	Significant soil erosion risks identified in the Swat River Basin	Limited to one river basin	Soil erosion risk management is critical in vulnerable areas like the Swat River Basin
60.	Khan et al. (2024)	To assess the impact of land use changes on land surface temperature in Gilgit Baltistan	GIS and remote sensing data analysis	Land use changes lead to higher land surface temperatures in the region	Limited to one district	Effective land management strategies can mitigate temperature rise due to land use changes
61	Kolling Neto, A., (2024)	To assess the effects of land use and cover changes and climatic variability on streamflow in a Brazilian savannah basin.	Theoretical and applied climatology analysis, streamflow modeling.	Land use changes and climate variability significantly affect streamflow patterns in the basin.	Limited data availability for some climatic parameters.	Effective land and water management strategies are crucial for sustainable streamflow in the basin.
62	Krishnaraj, A., (2023)	To analyze the multi-spatial-scale influences of land use/land cover on water quality along the Middle Ganga Basin.	Spatial analysis using remote sensing and water quality monitoring.	Land use changes, particularly urbanization, lead to degraded water quality in the basin.	Lack of long-term monitoring data.	Urban planning should consider the impact of land use on water quality in the Ganga Basin.

63	Krishnaraj, V., & Palanisamy, J. (2024)	To examine the impact of climate data and land use/land cover changes in the Kaveri River Basin.	Geospatial analysis and climate data modeling.	Climate data and land use changes influence water quality and availability in the region.	Limited representation of future climate scenarios.	Incorporating climate and land use changes into management policies will aid water resource conservation.
64	Kumar, G. P., G. S. (2024)	To explore the influence of land use/land cover transitions on hydrology in a tropical river basin in Southwest India.	Hydrological modeling using GIS and remote sensing.	Land use transitions lead to significant hydrological changes affecting water availability.	Data gaps on vegetation and soil parameters.	Sustainable land management practices are necessary for maintaining hydrological balance.
65	Kumar, S., (2024)	To enhance rainfall-runoff prediction using hybrid physical and data-driven models for the Upper Narmada River Sub-basin.	Hybrid modeling combining physical models and machine learning techniques.	Hybrid models improve the accuracy of rainfall-runoff predictions compared to conventional models.	Limited data for model validation during extreme weather events.	Hybrid models provide a promising tool for improving water resource management in the region.
66	Kutzer, A., (2024)	To study the trophic ecology of Japanese eels in small rivers of urban and	Ecological field studies, dietary analysis of Japanese eels.	Eels show different dietary habits and trophic responses in urban vs. agricultural environments.	Variability in eel populations between different study sites.	Urban and agricultural landscapes significantly impact the trophic ecology of

		agricultural areas.				Japanese eels.
67	Lalika, C. B. C., S. (2024)	To assess the influence of climate variability and land cover change on water resources in the Wami River catchment, Tanzania.	Hydrological and climate variability analysis using GIS tools.	Land cover changes exacerbate the effects of climate variability on water resources.	Limited long-term climate data for accurate predictions.	Integrated climate and land use management is necessary for water resource sustainability.
68	Lee, S. H., (2011)	To evaluate urban surface parameterizations in the WRF model using measurements during the Texas Air Quality Study 2006.	Numerical simulations and observational data comparison using the WRF model.	Urban surface parameterizations improved predictions of air quality and meteorological conditions.	Limited geographical coverage of the study area.	Urban surface parameterizations are critical for improving urban climate models and air quality predictions.
69	Li, H., (2024)	To study the coupled and coordinated development of urban resilience and urbanization in the Yellow River Basin.	Spatial analysis using urban resilience indicators and urbanization data.	There is a strong relationship between urban resilience and urbanization, with urbanization often enhancing resilience.	Lack of temporal analysis in urban resilience development.	Integrated urban resilience strategies can promote sustainable urbanization in the Yellow River Basin.
70	Li, X., (2000)	To model sustainable urban development through the integration of	Integration of cellular automata models and GIS for urban	The model effectively simulates sustainable urban	The model's accuracy depends on the quality of input data.	GIS and cellular automata can aid in planning sustainable

		cellular automata and GIS.	growth simulation.	development patterns.		urban growth.
71	Lin, C. Y., (2008)	To study the impact of urbanization on precipitation over Taiwan.	Numerical simulation of precipitation changes due to urbanization.	Urbanization leads to increased precipitation intensity and frequency in urban areas.	Limited model coverage for other factors influencing precipitatio n.	Urbanization significantly alters local precipitation patterns and urban weather.
72	Liu, C., (2024)	To assess production–living–ecological spaces and their gradients in Xiangyang City, China.	Land use function analysis and spatial distribution modeling.	Urban and rural gradients influence land use function distribution and spatial interactions.	Lack of detailed socio-economic data for urban-rural transitions.	Understandi ng spatial gradients can enhance land use planning and urban-rural integration.
73	Lowry, W. P. (1998)	To evaluate urban effects on precipitation amount.	Comprehensi ve review and synthesis of urban precipitation studies.	Urban areas tend to increase precipitation amounts and alter local microclimates.	Variability in data sources and urban definitions across studies.	Urbanization significantly influences precipitation patterns and urban climate systems.
74	Lu, J., (2024)	To explore the response of water quality to land use and landscape pattern in the Ganjiang River Watershed.	Geospatial analysis using water quality indicators and land use data.	Land use changes and landscape patterns significantly affect water quality in the watershed.	Limited consideratio n of hydrologica l and climatic factors.	Sustainable land use and landscape planning are essential for maintaining water quality in the watershed.
75	Lundy, L., (2011)	To integrate scientific methods to sustain urban	Literature review and theoretical analysis of	Integration of various scientific disciplines is	Theoretical approach with limited	Multi-disciplinary approaches are necessary

		ecosystem services.	urban ecosystem services.	crucial to maintaining ecosystem services in urban environments.	empirical data.	for sustaining urban ecosystem services.
76	Ma, L., (2024)	To explore environmental regulations' effect on urban land use eco-efficiency in China.	Environmental regulation modeling and eco-efficiency assessment.	Environmental regulations significantly improve urban land use eco-efficiency.	Limited regional applicability of findings.	Strengthening environmental regulations can enhance urban land use sustainability in China.
77	Mahata, D., (2024)	To assess urban expansion's influence on land use and land cover changes in Kolkata metropolitan region.	Geospatial analysis using remote sensing and GIS.	Urban expansion leads to a significant increase in built-up areas, reducing agricultural land and forests.	Limited temporal analysis of urban expansion patterns.	Sustainable urban planning is required to mitigate land use changes in metropolitan areas.
78	Maheshwari, S., (2024)	To conduct a vulnerability assessment of urban waterbodies using the WRASTIC model.	Vulnerability assessment using the WRASTIC (Water Quality, Risk, and Spatial) model.	The model identifies high-risk areas in urban waterbodies susceptible to pollution.	Limited application in non-urban areas.	The WRASTIC model provides valuable insights into urban waterbody management.
79	Mahmood, R., et al. (2014)	To study land cover changes and their biogeophysic	Synthesis of land cover change studies and their impacts	Land cover changes influence local climate patterns,	Lack of consistency in global data across regions.	Biogeophysical effects of land cover changes must be

		al effects on climate.	on biogeophysical properties.	including temperature and precipitation.		considered in climate models.
80	Marin, C., (2024)	To model wild boar use of urban nature areas.	Empirical modeling and field observations of wild boar movements.	Urbanization affects wild boar distribution and behavior in urban nature reserves.	Limited data on other wildlife species.	Urbanization alters wildlife behavior, necessitating better urban ecosystem management.
81	Markert, N., (2024)	Assess micropollutant monitoring under Water Framework Directive with land use sources	Micropollutant monitoring, catchment land use analysis	Significant correlation between agricultural & urban sources and micropollutant levels	Limited temporal data	Understanding land use impact on water quality is crucial for effective monitoring and management.
82	Martin, E. H., (2012)	Assess the effect of urbanization on ecological flow characteristics	Hydrological modeling, comparative study	Urbanization has altered the ecological flow patterns in the Maine River	Does not consider future urbanization scenarios	Urbanization impacts on river ecosystems must be mitigated for sustainable water management.
83	Merga, B. B., (2022)	Investigate LST variation due to land-use and land-cover changes	Remote sensing, data analysis	Significant LST variations linked to land-use changes	Lack of high-resolution data	Land-use changes significantly affect LST and need to be addressed for climate impact assessments.

84	Miedema Brown, L., (2024)	Study urban land-cover impacts on plant biodiversity	Ecological surveys, GIS mapping	Urbanization negatively affects plant community structure and biodiversity	Limited spatial coverage	Proper urban planning can help mitigate biodiversity loss in urbanized areas.
85	Mishra, A., (2024)	Assess urban heat island effect in Dehradun due to land-use dynamics	Remote sensing, urban heat island analysis	Land-use changes significantly contribute to the urban heat island effect	Data sparsity in peri-urban areas	Urban planning should incorporate green spaces to reduce UHI impacts.
86	Modiri, M., (2023)	Model urban growth dynamics in Tehran	Cellular automata, urban DNA modeling	Urban growth patterns can be modeled with cellular automata and urban DNA	Incomplete urban expansion data	The model offers valuable insights into controlling urban sprawl and managing resources.
87	Mouris, K., (2023)	Quantify the global change footprint on reservoir sedimentatio n	Interdisciplin ary modeling, sensitivity analysis	Global change significantly affects reservoir sedimentation	Focus on specific reservoirs only	A need for broader modeling to understand global change effects on water storage.
88	Nigussie, S., (2023)	Study the impact of land use change on ecosystem services in Little Akaki River	GIS-based ecosystem service modeling	Land use change is negatively affecting ecosystem services in the region	No future land use projections included	Sustainable land management practices are critical to preserving ecosystem services.

89	Nizar, A., (2024)	Assess soil erosion through RUSLE-SDR-TLA model	Soil erosion modeling, GIS	The integrated model effectively predicts soil erosion risk in the Cauvery basin	Uncertainty in model calibration	The model can guide soil conservation practices and erosion mitigation.
90	Noori, A. R., (2023)	Assess water harvesting potential with land use/land cover approach	Water harvesting, land-use classification	Land use and cover directly impact groundwater recharge potential	Limited by available precipitatio n data	Land use management is essential for optimizing water harvesting and groundwater recharge.
91	Odhiambo, B. K., (n.d.)	Examine historic land use and sedimentatio n in two urban reservoirs	Historical data analysis, sedimentatio n modeling	Historic land use has significantly contributed to sedimentation in reservoirs	Lack of comprehens ive data from other regions	Urban land use policies need to consider sedimentatio n impacts on water quality.
92	Okeke, C. A. U., (2022)	Evaluate impact of land use and riparian vegetation on streambank stability	GIS and remote sensing analysis	Land use and riparian vegetation are key factors in streambank stability	Limited by accessibility to field data	Proper riparian management is essential to prevent streambank erosion and stabilize ecosystems.
93	Palinkas, C. M., (2022)	Evaluate land-use change impacts on water quality and	Comparative study, water quality sampling	Land-use changes are significantly affecting water quality and sedimentation in estuaries	Focus on specific estuaries limits generalizati on	Land use must be considered in estuarine management plans to improve

		sedimentation in estuaries				water quality.
94	Pathirana, A., (2014)	Study urban growth impact on microclimate and precipitation	Sensitivity study, microclimate modeling	Urban growth drives changes in microclimate and precipitation patterns	Not generalized to other regions	Urban planning should integrate climate change models to mitigate microclimate impacts.
95	Paul, A., & Bhattacharji, M. (2023)	Predict land use and riverbank erosion in Lower Ganga Plain	Cellular automata, ANN modeling	CA-ANN model can predict land use and its impact on riverbank erosion	Model accuracy depends on data quality	Integrated models can support effective riverbank management strategies.
96	Pena Vieira Leal, (2023)	Study hydrological flow changes due to land-use change	Hydrological modeling, climate data analysis	Significant flow changes due to land-use changes in the Ibicuí River Basin	Lack of detailed land-use change projections	Hydrological flow models should include land-use change scenarios for better water management.
97	Rahmani, F., (2024)	Assess the impact of land use change on hydrological drought patterns	Hydrological modeling, drought pattern analysis	Land-use change alters hydrological drought patterns	Model assumptions about future land-use may not be accurate	Understanding land-use effects on drought patterns is crucial for drought management strategies.
98	Ranjan, S., & Singh, V. (2023)	Investigate land use change effect on	Hydrological modeling, land use classification	Significant impact of land use change on	Limited by spatial resolution of	Land-use policies need to be revised to mitigate

		hydrological response of Punpun River basin		hydrological behavior	land-use data	hydrological risks in river basins.
99	Reed, D. E., (2024)	Study impact of urban density on turbulent heat fluxes	Urban density modeling, heat flux analysis	Urban density significantly influences turbulent heat fluxes across seasonal cycles	Focus on short-term impacts limits long-term predictions	Urban density management should account for seasonal heat flux variations for sustainability.
100	Regasa, M. S., & Nones, M. (2024)	Model impact of land use changes on hydrological response in Ethiopian watershed	Hydrological modeling, land-use scenarios	Land-use changes affect hydrological response, altering water availability	Data uncertainty in future land-use predictions	Hydrological modeling must consider future land-use trends to plan for water resource sustainability.
101	Rendana et al., 2023	Investigate the relationship between land use types and urban heat island (UHI) intensity in Hulu Langat, Malaysia.	GIS and remote sensing techniques to analyze UHI intensity across different land uses.	UHI intensity is significantly higher in built-up areas compared to agricultural and forested zones.	Limited to one district; spatial resolution may impact result accuracy.	Urban heat islands can be mitigated by incorporating more green spaces in urban planning.
102	Roberts et al., 2024	Explore how urban pasts can inform present urban dynamics in the	Qualitative analysis of historical urban data and its relation to	Historical urban planning impacts modern urban resilience and	Limited by historical data availability and its relevance to	Understanding urban pasts is crucial for addressing

		Anthropocene.	current urban patterns.	sustainability strategies.	modern contexts.	current urban challenges.
103	Royer et al., 1988	Study Landsat-MSS reflectance variation in urbanized temperate zones.	Remote sensing of Landsat-MSS data over multiple years.	Urbanization significantly alters land surface reflectance patterns.	Limited by the use of older remote sensing data with lower resolution.	Urbanization causes significant reflectance changes, impacting land surface energy balance.
104	Sampath 2024	Predict soil erosion and sediment yield in an ungauged basin based on land use changes.	Application of soil erosion prediction models (RUSLE and SWAT).	Land use changes, especially agricultural activities, lead to increased erosion.	Model assumptions may not fully capture complex watershed dynamics.	Land use management is crucial for controlling soil erosion in ungauged basins.
105	Sandeep et al., 2024	Estimate spatiotemporal dynamics of urban sprawl in Bengaluru using Earth observation data.	Remote sensing and spatiotemporal analysis of urban expansion.	Urban sprawl has led to significant land cover changes in Bengaluru, contributing to environmental stress.	Data resolution limits detailed analysis at finer scales.	Spatiotemporal monitoring is vital for understanding urban sprawl and its impacts.
106	Sarkar et al., 2024	Examine the impacts of urbanization on ecosystem services in industrial cities of India.	Urban ecosystem service evaluation and land use change analysis.	Industrialization has degraded several ecosystem services, including water quality and air regulation.	Limited data on ecosystem service quantification.	Urban planning must integrate ecosystem service preservation to maintain urban sustainability.
107	Sharma et al., 2024	Assess individual	Hydrological modeling	Both land use and climate	Model limitations	Adaptation strategies are

		and combined impacts of land use and climate change on water balance components.	using SWAT to assess land use and climate interactions.	change significantly alter water balance components.	in capturing all hydrological processes.	needed to mitigate combined land use and climate change impacts on water resources.
108	Shem 2009	Assess the impact of urbanization on summertime thunderstorms in Atlanta.	Numerical modeling of urban effects on weather patterns.	Urbanization intensifies thunderstorms by altering local atmospheric conditions.	Limited by model assumptions and sensitivity to input variables.	Urbanization significantly alters local weather, especially storm dynamics.
109	Shepherd, 2006	Investigate urban-induced precipitation variability in arid climate regimes.	Analysis of precipitation patterns in urban versus non-urban areas.	Urban areas show increased precipitation variability, altering local hydrology.	Lack of long-term observational data limits the robustness of findings.	Urbanization influences precipitation in arid climates, affecting water availability.
110	Shi et al., 2024	Evaluate urban development suitability based on various constraints and development factors in Zhengzhou, China.	Multi-criteria decision analysis (MCDA) and spatial modeling.	Development suitability in Zhengzhou is influenced by ecological, economic, and social factors.	Simplified model assumptions may not reflect all urban complexities.	A comprehensive approach is necessary for sustainable urban development in China.
111	Shohan et al., 2024	Assess the relationship between urban sprawl and land	Remote sensing and spatiotemporal analysis of LST data.	Urban sprawl significantly increases LST, affecting microclimates	Spatial resolution limitations in remote	Urban planning must consider sprawl's

		surface temperature (LST).		and local temperatures.	sensing data.	effect on microclimates to mitigate urban heat island effects.
112	Shree & Kumar, 2023	Assess land use change impacts on hydrological components in the Subarnarekha River Basin, India.	SWAT model for hydrological simulation based on land use data.	Land use changes lead to alterations in water flow and sedimentation patterns in the basin.	Model assumptions may not fully capture all watershed dynamics.	Land use changes play a significant role in altering hydrological cycles and water management strategies.
113	Silver, 2021	Examine the urban political ecology of decaying infrastructures in the U.S. pipeline crisis.	Qualitative analysis of urban infrastructure degradation and socio-political factors.	Decaying infrastructure exacerbates urban vulnerability, especially in low-income areas.	The focus is more on political and social factors than on direct environmental consequences.	Addressing urban infrastructure decay is critical for enhancing urban resilience in post-industrial cities.
114	Singh et al., 2024	Investigate the relationship between flood mapping and land use patterns in the Kosi River Basin, India.	Remote sensing and flood mapping using GIS tools.	Flood susceptibility is influenced by land use changes, especially deforestation and urbanization.	Flood prediction models may not fully account for non-linear land use changes.	Effective flood management requires integrating land use and hydrological data.
115	Skovira & Bohlen, 2023	Study water quality and vegetation in	Comparative analysis of stormwater	Stormwater ponds in residential areas	Limited to stormwater ponds, not	Vegetation and land use significantly

		stormwater ponds across different urban land uses in central Florida.	ponds in various land use types.	have better water quality and biodiversity than those in commercial zones.	representative of all water bodies in urban areas.	affect the water quality in urban stormwater ponds.
116	Song et al., 2024	Investigate the effects of land use transformation on ecosystem services in urban areas in Tianshan Mountains, China.	Spatial modeling and ecosystem service valuation.	Urban land use transformations have altered key ecosystem services like water regulation and biodiversity.	Limited focus on certain ecosystem services, excluding others like carbon storage.	Urbanization in mountainous regions threatens ecosystem services, necessitating careful planning.
117	Song et al., 2024	Examine development vs. conservation in managing urban sprawl in China.	Integrated framework combining spatial and socio-economic factors.	Conservation measures can mitigate the adverse effects of urban sprawl on the environment.	Challenges in balancing development and conservation goals at the local level.	A balanced framework is essential for managing urban sprawl in China’s rapidly growing cities.
118	Stathopoulou 2007	Analyze daytime urban heat islands using Landsat ETM+ and land cover data in Greece.	Remote sensing analysis using Landsat ETM+ data for urban heat island assessment.	Urban heat islands are more pronounced in densely built cities compared to less urbanized areas.	Limited by the resolution of satellite data and urban area classification.	Urban heat islands are a critical issue that requires mitigation strategies, including increased green cover.
119	Su et al., 2024	Study the coupling and interaction between land use	Systematic coupling analysis using multistage	Urban land use efficiency is closely tied to ecological	The model's complexity might hinder practical	Improving land use efficiency is crucial for maintaining

		efficiency and ecological quality.	interactive models.	environment quality.	implementation.	ecological balance in urban areas.
120	Subbiah et al., 1990	Analyze urban climate patterns in Tamil Nadu, India, focusing on temperature and rainfall trends.	Statistical analysis of historical climate data in urban versus rural areas.	Urban areas show rising temperatures and changing rainfall patterns due to rapid urbanization.	Limited data scope and time frame.	Urbanization in Tamil Nadu has altered local climate patterns, leading to increased temperatures and erratic rainfall.
121	Suthar et al. (2024)	To assess land-use suitability for urban development in Himalayan districts of Shimla, Nainital, and Darjeeling using Multi-Criteria Decision-Making (MCDM).	Multi-Criteria Decision-Making (MCDM) analysis with GIS data.	Identified areas best suited for urban development in these districts, considering multiple land-use factors.	Limited to three districts, may not be applicable to other Himalayan areas.	MCDM is an effective tool for urban planning and land-use suitability assessment in diverse regions.
122	Tafesse & Suryabhagavan (2019)	To model the impacts of land-use and land-cover changes on land surface temperature in Adama Zuria, Ethiopia.	Systematic modeling using remote sensing data and GIS.	Land-use changes, especially urbanization, increase land surface temperature.	Temporal data limitations and reliance on remote sensing accuracy.	Land-use changes have significant impacts on local temperature, calling for sustainable land management strategies.

123	Taha et al. (1988)	To explore the effects of urban heat island (UHI) and albedo on residential cooling loads.	Experimental study and analysis of albedo effects on UHI.	UHI significantly increases cooling loads in urban areas, with albedo playing a key role in mitigating this effect.	Focused mainly on residential cooling, not other urban energy consumption.	Albedo modification is an effective strategy to mitigate urban heat island effects and reduce energy demands.
124	Tao et al. (2024)	To evaluate the impacts of land use and climate change on runoff in the Shaying River Basin using the SWAT model.	SWAT model to simulate runoff based on various land use and climate scenarios.	Both land use and climate change contribute to increased runoff in the river basin.	Model assumptions and data limitations in simulating complex climate variables.	Integrated management of land use and climate change is critical for sustainable water resource management.
125	Tilahun & Desta (2023)	To model soil erosion and sediment transport in Ada'a watershed, Ethiopia.	USLE (Universal Soil Loss Equation) and GIS techniques for erosion modeling.	Soil erosion rates are high, and sediment yield is strongly influenced by land-use changes.	Limited to a specific watershed, generalizability to other regions is uncertain.	Land use planning is essential to minimize soil erosion and sediment transport in vulnerable areas.
126	Tiwari et al. (2023)	To assess river channel dynamics and its impact on land use/land cover in the middle Ganga plain, India.	GIS-based analysis of river channel shifts and land cover changes.	River channel dynamics have significant effects on adjacent land use/land cover, especially agriculture.	Study focused on a specific region, not applicable universally.	Monitoring river channel dynamics is crucial for effective land use and water management strategies.

127	Ullah et al. (2024)	To evaluate the impact of land use and climate change on Ravi river flows using GIS and hydrological modeling.	Hydrological modeling with GIS integration to study river flow changes.	Land use and climate change both have substantial impacts on river flow variability.	Focuses on a single river, limited by the spatial scale of study.	Comprehensive management of land and climate factors is essential for maintaining river flow stability.
128	Uyan & Ertunç (2024)	To investigate the impact of urban growth on land use using spatial autocorrelation methods in Konya, Turkey.	Spatial autocorrelation analysis of urban growth patterns using GIS.	Urban growth patterns exhibit significant spatial clustering, influencing surrounding land use.	Method dependent on the quality of available spatial data.	Spatial autocorrelation methods are useful for understanding urbanization trends and their effects on land use.
129	Walsh et al. (2016)	To explore variability in stream ecosystem responses to urbanization, focusing on physiography and urban water management.	Comparative analysis of stream ecosystems in urbanized vs. natural environments.	Urbanization alters stream ecosystems, with physiography and water management practices playing a significant role.	Limited to specific urban areas, not all urban ecosystems were considered.	Stream ecosystem management should consider both physiographic features and urban water management practices.
130	Wang et al. (2024)	To study the factors influencing ecosystem service perceptions and well-being of farmers in	Survey and statistical analysis of farmer perceptions and well-being related to ecosystem services.	Farmers' perceptions of ecosystem services are influenced by land use practices, with a strong link to	Focused only on farmers, not considering other local stakeholders.	Understanding farmer perceptions can aid in improving land use policies and ecosystem service

		China's ore-agriculture zone.		their well-being.		management.
131	Wang et al. (2022)	To assess the cooling effect of an urban river and its interaction with the built environment in mitigating heat stress.	Mobile measurements and statistical analysis.	Urban rivers have a significant cooling effect, and their interaction with the built environment can reduce heat stress in urban areas.	Limited to a single urban area, and variability in heat stress conditions across different environments.	Urban rivers can serve as an effective tool for mitigating urban heat stress, particularly when integrated with surrounding urban infrastructure.
132	Wang et al. (2023)	To study the scale effects of land use on river water quality in the Tuojiang River Basin, China.	GIS-based analysis, water quality monitoring, and statistical modeling.	Scale of land use significantly affects river water quality, with larger agricultural and urban areas showing worse water quality.	Data was limited to one river basin, which may not be representative of all river systems.	Land use patterns must be carefully managed to protect river water quality, especially in larger agricultural and urban areas.
133	Ward et al. (n.d.)	To develop a stochastically constrained cellular model of urban growth.	Stochastic modeling and cellular automata for urban growth prediction.	The model effectively simulates urban growth patterns under various constraints and environmental conditions.	Model results depend on the quality of input data, which can vary widely.	The model offers a reliable tool for simulating urban growth, providing a basis for informed urban

						planning decisions.
134	Wu et al. (2024)	To evaluate urban ecological health changes in the Wei River Basin, China, using fuzzy evaluation methods.	Fuzzy evaluation and GIS-based analysis of urban ecological health.	Urban ecological health has been negatively impacted by rapid development and land use changes in the region.	The methodology's dependence on subjective evaluation in fuzzy logic could lead to biases.	Urban ecological health must be prioritized in planning, with a focus on sustainable development to mitigate negative impacts.
135	Wu et al. (2023)	To analyze urban expansion patterns and their driving forces in Chengdu-Chongqing and Middle Reaches of Yangtze River urban agglomerations.	GIS and spatial analysis to study urban expansion and drivers.	Urban expansion is influenced by factors such as population growth, industrialization, and infrastructure development.	The analysis is focused on two specific urban agglomerations, limiting generalizability to other areas.	Understanding urban expansion drivers can help in managing urban sprawl and promoting sustainable growth strategies.
136	Xiao & Jingsheng (2024)	To define village types in China by analyzing urban and rural spaces.	Conceptual analysis and classification of rural spaces based on land use patterns.	Rural spaces in China can be categorized into various types based on land use and urban-rural interactions.	The classification is theoretical and may not fully account for regional variations.	Defining village types helps understand the dynamics of rural-urban transitions and supports better rural planning strategies.

137	Yadav et al. (2024)	To explore land use transformation in the 'Kumbh Mela' of Prayagraj, India, in relation to cultural heritage and urban morphology.	Historical analysis and spatial mapping of land use changes during the Kumbh Mela event.	Cultural heritage sites and the temporary urbanization during Kumbh Mela have led to significant land use transformation in Prayagraj.	The study is context-specific to Kumbh Mela and may not apply to other cultural events.	Cultural heritage plays a critical role in shaping urban morphology, and land use changes during such events require careful planning.
138	Yan et al. (2024)	To investigate the effects of mixed land use on urban stormwater quality under different rainfall events.	Field measurements and modeling of stormwater quality in areas with mixed land use.	Mixed land use can significantly influence stormwater quality, with urbanized areas showing higher pollutant concentrations.	Study focused on specific rainfall types, which may not represent all storm events.	Mixed land use areas require targeted stormwater management strategies to mitigate pollution.
139	Yan et al. (2023)	To assess the effects of land use and slope on water quality in the Weihe River Basin.	GIS-based analysis and water quality monitoring across different land-use and slope conditions.	Water quality is significantly affected by land use and slope, with agricultural and urban land leading to poorer water quality.	Study limited to a single river basin, which may not be applicable to other watersheds.	Land use and topography must be considered in water quality management strategies, especially in sloped regions.
140	Yang et al. (2024)	To study spatiotemporal variations in ecosystem service values and their	Spatiotemporal analysis using GIS and ecosystem service	Ecosystem service values have decreased due to land use changes, particularly in areas	The study only covers a portion of the Yangtze River Basin, limiting its broader	Effective land use management is essential to maintaining and enhancing

		response to land use change in the Yangtze River Basin, China.	valuation methods.	experiencing rapid urbanization.	applicability.	ecosystem services in rapidly developing areas.
141	Yang et al. (2024)	To evaluate hydrological responses to future climate and land use changes in the Hanjiang River Basin.	Hydrological modeling and climate simulations.	Future climate and land use changes will significantly impact the hydrology of the Hanjiang River Basin, with potential increases in flood risks.	The study relies on assumptions about future land use and climate, which can be uncertain.	Effective land and water management strategies are needed to mitigate future hydrological impacts.
142	Yang et al. (2024)	To explore how urban development patterns influence extreme rainfall occurrences.	Statistical analysis and modeling of rainfall data and urban growth patterns.	Urban development increases the frequency of extreme rainfall events due to changes in land surface properties and atmospheric conditions.	The study does not account for variations in local climate conditions across different urban areas.	Urban planning must consider the effects of development on local climate patterns to reduce extreme rainfall occurrences.
143	Yang et al. (2008)	To simulate land use changes using cellular automata and support vector machines.	Cellular automata and support vector machines for land use simulation.	The model successfully simulates land use changes, showing the importance of integrating machine learning techniques in urban planning.	The model is computationally intensive and dependent on the quality of training data.	Cellular automata combined with machine learning can be an effective tool for predicting

						land use changes.
144	Yangouliba et al. (2023)	To model past and future land use and land cover dynamics in the Nakambe River Basin.	GIS-based modeling and land use scenario analysis.	Land use and cover have significantly changed, with future scenarios predicting further environmental degradation.	The model's predictions are based on historical data, which may not fully capture future socio-economic changes.	Land use management strategies need to address projected future changes to prevent environmental degradation.
145	Yao & Huang (2023)	To study the effects of land use changes during different urbanization periods on summer rainfall in the Pearl River Delta.	Statistical analysis and climate modeling.	Land use changes have altered local weather patterns, including significant impacts on summer rainfall in urbanized areas.	The study focuses solely on the Pearl River Delta and may not be applicable to other regions.	Urbanization-induced land use changes significantly influence local climate, especially rainfall patterns.
146	Yigez et al. (2023)	To investigate the dynamics of soil loss and sediment export in the Koshi River Basin due to land use/cover changes.	Soil erosion modeling, GIS, and field data analysis.	Land use changes, particularly deforestation and urbanization, have led to increased soil loss and sediment export.	The model's accuracy depends on the quality of input data and regional variability.	Sustainable land use practices are crucial to reduce soil erosion and sediment export in the region.
147	Yu et al. (2024)	To analyze the dynamic coupling between land	System dynamics modeling and	There is a complex interaction between	The study does not account for all potential	Balancing economic and ecological

		use economic efficiency and urban ecological resilience in the Yellow River Basin.	statistical analysis.	economic efficiency and ecological resilience, with certain land use patterns enhancing resilience.	socio-economic variables that influence urban resilience.	goals is key to achieving sustainable urban development in the Yellow River Basin.
148	Yu et al. (2017)	To explore how urban green spaces can be planned for climate adaptation in subtropical cities.	Case study analysis and literature review on urban green space planning.	Properly planned urban green spaces can significantly enhance climate resilience in subtropical cities.	Limited focus on subtropical regions may not apply to all urban contexts.	Green space planning is a crucial strategy for climate adaptation in cities, especially in subtropical areas.
149	Zhan et al. (2024)	To study the evolution of land-population-industry relations and their effects on village development in the upper Tuojiang River.	Longitudinal analysis and spatial data modeling.	Village evolution is closely linked to land use, population growth, and industrial development, with significant shifts observed in the upper Tuojiang River region.	The study only covers a specific geographic area, limiting its broader applicability.	Understanding the relationship between land, population, and industry is crucial for managing rural development.
150	Zhang et al. (2024)	To analyze the coupling and spatiotemporal heterogeneity of urban land green use efficiency and	Spatiotemporal analysis and coupling coordination model.	Urban land green use efficiency is positively correlated with ecosystem services, but with varying patterns across	The study is limited to the Yangtze River Economic Belt and may not be applicable to other regions.	Integrating green land use with urban planning is essential for maintaining ecosystem services in urban areas.

		ecosystem services in the Yangtze River Economic Belt.		different regions.		
151	Zhang et al. (2024)	To investigate the driving mechanisms of land use types on dissolved organic matter characteristics in urban streams in Wuhan.	Field sampling, chemical analysis, and statistical modeling.	Different land use types, particularly residential and industrial, significantly affect the dissolved organic matter in urban streams.	Limited to Wuhan city; findings may not apply to other urban environments.	Managing land use in urban areas is crucial for maintaining water quality, particularly in urban streams.
152	Zhang et al. (2024)	To evaluate carbon emission efficiency in urban agglomerations of the Yangtze River Economic Belt.	SBM-DEA model for efficiency analysis and carbon emission data.	Carbon emission efficiency varies significantly across urban agglomerations, with some areas showing higher efficiency than others.	The study focuses on a specific region, limiting its global applicability.	Improving carbon emission efficiency is vital for sustainable urban development in the Yangtze River Economic Belt.
153	Zhang et al. (2020)	To explore the relationships between urban form metrics and vegetation biomass loss under urban	Spatial analysis of urban form and vegetation biomass data.	Urban expansion leads to significant vegetation biomass loss, with certain urban form metrics having a stronger impact.	The study does not account for the effects of all types of urban expansion.	Urban expansion needs to be managed carefully to minimize the loss of vegetation biomass and

		expansion in China.				maintain ecological balance.
154	Zhang et al. (2024)	To integrate dual evaluation and FLUS model for land use simulation and urban growth boundary delineation in Harbin, China.	FLUS model, dual evaluation system, and spatial analysis for land use prediction.	The integrated model effectively simulates urban growth patterns and helps delineate growth boundaries.	The accuracy of the model depends on the quality of data and input assumptions.	The integrated model is a valuable tool for managing urban growth and defining boundaries in production-living-ecology spaces.
155	Zhao et al. (2024)	To assess the impact of digital finance on urban ecological resilience in the Yangtze River Economic Belt.	Statistical analysis and modeling of digital finance and ecological resilience data.	Digital finance has a positive effect on urban ecological resilience, particularly in urbanized areas of the Yangtze River Economic Belt.	The study does not explore the potential negative impacts of digital finance on ecological systems.	Digital finance can enhance ecological resilience if appropriately integrated into urban sustainability strategies.
156	Zhao et al. (2024)	To analyze land use and cover change and influencing factors in the Shiyang River Basin.	GIS-based analysis and statistical modeling of land use data.	Significant land use changes have occurred in the Shiyang River Basin, influenced by agricultural expansion and urbanization.	The study is based on historical data, and future land use changes may differ due to socio-economic shifts.	Sustainable land use planning is crucial to mitigate the negative effects of land cover changes in the Shiyang River Basin.
157	Zhou (2023)	To explore the spatiotempor	Spatiotemporal analysis using green	The green efficiency of urban	The analysis focuses only on	Green efficiency improvement

		al evolution and spillover effects of green efficiency of urban construction land in the Yangtze River Economic Belt.	efficiency indicators.	construction land has improved over time, with spatial spillover effects observed in nearby areas.	construction land and may overlook other land use types.	s are important for sustainable urban development in the Yangtze River Economic Belt.
158	Zhou et al. (2024)	To study the spatio-temporal evolution of land use and ecosystem service values in the Lhasa River Basin.	GIS-based spatiotemporal analysis of land use and ecosystem services.	Land use changes have significantly impacted ecosystem service values, particularly in the Lhasa River Basin's rural areas.	Limited to the Lhasa River Basin, and findings may not be applicable to other river systems.	Effective land use management is crucial to maintaining ecosystem services in the Lhasa River Basin.
159	Zhou et al. (2024)	To assess the impact of land use and cover changes and climate variations on urban heat islands in Hefei, China.	WRF-UCM model simulations of urban heat island effects.	Land use and climate variations have contributed to the intensification of urban heat islands in Hefei.	The study's findings may not be applicable to other cities with different topographies or climates.	Managing land use and mitigating climate change are

2.6 Spatial Mapping of Urban Land Use Impacts on River Sub-basins

Urbanization significantly alters natural hydrological systems, especially within river sub-basins where diverse land uses interact with surface and subsurface water processes. Each urban land use category—ranging from residential to industrial—introduces distinct modifications to the landscape, such as changes in impervious surface area, vegetation cover, drainage infrastructure, and pollutant sources. These modifications influence runoff patterns, groundwater recharge, flood risk, sediment transport, and water quality. To better understand these dynamics, a spatially informed mapping of urban land uses and their specific impacts on sub-basins is essential. The following table provides a synthesized overview of key urban land use types and their documented effects on river sub-basins, drawing from case studies across diverse geographic and climatic contexts.

Table 5: Mapping of Urban Land Uses and Their Specific Impacts on River Sub-basins

Urban Land Use Type	Specific Impact on River Sub-basins	Example Study/Case	Indicators Affected
Residential Areas	Increased impervious surfaces lead to higher runoff and peak flows	Asadi et al. (2024) - Kal-e Shur Sabzevar River, Iran	Surface runoff, flood intensity, sedimentation
Industrial Zones	Point source pollution, heavy metal contamination in sub-basin streams	Goodarzi et al. (2023) - Dez Basin, Iran	Water quality, aquatic ecosystem health
Commercial Areas	Altered flow regimes due to extensive pavement and drainage modification	Boongaling et al. (2024) - Urban Philippines sub-catchment	Runoff volume, flow alteration, pollution concentration
Urban Green Spaces	Reduce heat island effects and facilitate infiltration, lowering runoff	Yu et al. (2017) - Subtropical cities	LST, infiltration rate, microclimate modulation
Transport Infrastructure	Fragmentation of sub-basins, acceleration of surface runoff	Zhou et al. (2024) - Lhasa River Basin	Runoff coefficient, erosion hotspots
Mixed-use Development	Complex impacts: variable infiltration, runoff, and nutrient loads	Yan et al. (2024) - Urban stormwater study	Stormwater quality, nutrient concentration, LID efficacy
Informal Settlements	Unregulated development contributes to erosion and reduced ecological service values	Hailu et al. (2024) - Urban informal growth in Africa	Soil erosion, vegetation loss, flood vulnerability
Urban Expansion Areas	Land cover transitions cause reduced base flow and disturbed water balance	Bucha et al. (2024) - Lake Chamo sub-basin, Ethiopia	Water balance, base flow reduction, groundwater recharge

2.7 Urban Land Use Typologies and Impervious Surface Impacts on River Sub-basins

Land use changes and city growth have a big impact on how water flows naturally, especially when new highways, roofs, and paved areas are developed. These surfaces change the paths that silt and pollutants take, slow down the flow of water, and speed up the flow of water on the surface. The kind of land use in cities has a big effect on how far and what kinds of these consequences are. To build cities and manage water resources at the sub-basin level, it's important to know how different types of urban land use change the characteristics of impervious surfaces. The following table categorizes key urban land use types based on their degree of imperviousness and outlines their primary and secondary impacts on hydrological and ecological functions within river sub-basins. It draws upon case studies and empirical research to support spatial planning, stormwater management, and watershed conservation efforts.

Table 6: Influence of Urban Land Use Types on Impervious Surfaces and Sub-basin Impacts

Urban Land Use Type	Degree of Impervious Surface	Primary Hydrological/Ecological Impact on Sub-basins	Secondary Impact	Example Study/Case
Residential Areas (High-density)	High (~60–90%)	Increased surface runoff, flash flooding	Reduced groundwater recharge	Asadi et al. (2024) – Kal-e Shur Sabzevar River, Iran
Residential Areas (Low-density)	Moderate (~30–60%)	Moderate increase in runoff	Fragmentation of green space	Yan et al. (2024) – Urban stormwater studies
Industrial Zones	Very High (~70–95%)	Surface sealing, pollutant wash-off (heavy metals, oils)	Localized flooding, habitat degradation	Goodarzi et al. (2023) – Dez River Basin, Iran
Commercial Areas	High (~75–90%)	Altered drainage patterns, urban heat island amplification	Wastewater load increase	Boongaling et al. (2024) – Sub-catchment, Philippines
Urban Green Spaces	Low (~10–20%)	Enhances infiltration, buffers surface runoff	Cooling effects, habitat provision	Yu et al. (2017) – Subtropical cities
Transport Infrastructure	Very High (~90–100%)	Direct conduit for fast runoff and sediment transport	Landscape fragmentation, erosion	Zhou et al. (2024) – Lhasa River Basin
Mixed-use Development	Variable (~40–80%)	Mixed impact depending on zoning and infrastructure	Difficulties in stormwater management	Yan et al. (2024) – Stormwater quality assessment
Informal Settlements	Irregular (30–85%)	Often unregulated, causing uneven imperviousness and drainage issues	Soil erosion, pollution due to	Hailu et al. (2024) – Urban

			lack of sanitation	informal settlements in Africa
Urban Expansion Areas	Rapidly Increasing	Conversion from permeable to impermeable surfaces	Reduced base flow, disturbed water balance	Bucha et al. (2024) – Lake Chamo sub-basin, Ethiopia

Case Studies:

Case Study 1: High-Density Residential Areas – Kal-e Shur Sabzevar River Sub-basin, Iran

Context: Rapid urban development in the Kal-e Shur Sabzevar region has led to the expansion of high-density residential zones with impervious surface coverage exceeding 80%.

Observed Impacts:

- Increased peak discharge and reduced lag time during rainfall events.
- Substantial rise in flood intensity in urban catchments.
- Reduced groundwater recharge due to surface sealing.

Reference: Asadi et al. (2024). Evaluating the effect of land use change on discharge and flood intensity.

Case Study 2: Industrial Zones – Dez River Basin, Iran

Context: Industrial expansion in the Dez Basin resulted in a concentration of impervious areas and pollution sources close to river sub-catchments.

Observed Impacts:

- Degradation of water quality due to heavy metal and chemical runoff.
- Elevated surface runoff and reduction in soil infiltration.
- Ecosystem stress due to localized pollution hotspots.

Reference: Goodarzi et al. (2023). Assessing land use changes' effect on river water quality.

Case Study 3: Mixed-Use Urban Development – Urban Catchment, Philippines

Context: The urban sub-catchment exhibited mixed land use (residential, commercial, open land), with impervious surfaces varying from 40% to 85%.

Observed Impacts:

- Complex runoff behavior leading to inconsistent stormwater management outcomes.
- Increase in nutrient and pollutant loads during wet weather events.
- Overburdened drainage infrastructure in high-density nodes.

Reference: Boongaling et al. (2024). Assessment of LID strategies under different land uses.

Case Study 4: Informal Settlements – Addis Ababa's Akaki River Catchment, Ethiopia

Context: Informal settlements with unplanned infrastructure contributed to high imperviousness and poor drainage networks.

Observed Impacts:

- Soil erosion and high sediment loads in river tributaries.
- Elevated flood risks due to non-engineered runoff pathways.

- Water quality decline due to improper waste disposal.

Reference: Hailu et al. (2024). Land use transformation by urban informal settlements.

Case Study 5: Urban Expansion Zones – Lake Chamo Sub-basin, Ethiopia

Context: Urban sprawl in the Lake Chamo catchment resulted in the conversion of agricultural and forested land into built-up areas.

Observed Impacts:

- Drastic increase in impervious surface ratio.
- Disruption of natural flow paths and water balance components.
- Decline in base flow and increased surface flow variability.

Reference: Bucha et al. (2024). Hydrologic responses contemplating land use change.

3. Problem statement

Urbanisation has rapidly transformed natural scenery into impermeable surfaces such roads, rooftops, and pavements. Though land use planning processes are in existence, they often ignore the fine-scale hydrological consequences of impervious surface expansion at the sub-basin level. This absence of responsive, localised planning causes urban growth and watershed sustainability to be out of sync. Moreover, current urban planning models frequently overlook the geographical diversity of imperviousness and its intricate relationships with land use types, climatic conditions, and ecological processes. Without a planned framework that openly addresses these interrelations integrated and responsive, urban areas will continue to experience increasing environmental and infrastructure risks. There is absolutely a need for a systematic approach that combines present knowledge and guides sub-basin planning depending on the interaction between land use dynamics and impervious surfaces.

4. Research Objectives

The major objectives of this paper are:

- To understand how urban hydrology is influenced by rising impervious surface.
- To investigate patterns in land use change and their effects on sub-basin planning.
- To evaluate techniques and technologies applied to model urban land use and hydrological impacts.
- To propose a responsive system for sustainable sub-basin planning.

5. Methodology

This systematic literature review employs a methodical methodology made up of the following components.

1. **Literature Identification**: The uploaded reference file yielded articles ranging from institutional reports to conference proceedings to peer-reviewed publications.
2. **Screening and Inclusion Criteria**: Relevance to urban hydrology, impervious surfaces, land use, and sub-basin or watershed planning determined whether studies were deemed appropriate. Both qualitative and quantitative studies were considered.
3. **Thematic Categorization**: References were topically classified into planning strategies, case studies, geographical analysis, modelling methodologies, and impact studies.

4. **Analysis and Synthesis**: The studies were analyzed to identify patterns, methodologies, findings, and gaps.

6. Thematic Review of Literature

6.1 Impervious Surfaces and Hydrological Impact

Numerous studies have confirmed the hydrological consequences of increased imperviousness in urban settings. Focussing on rising surface temperatures and decreasing evapotranspiration, Akbari and Kolokotsa (2016) looked at how impermeable surfaces influence urban microclimates. Finding similar patterns in Muscat, Oman, Charabi and Bakhit (2011) linked impermeable development to urban heat islands. Bucha et al. (2024), looking at the Lake Chamo sub-basin in Ethiopia, discovered that surface runoff increased with a shift from vegetation to built-up regions. Examining the Konkoure River Basin in Guinea, Bah et al. (2024) discovered land cover changes raised flood risks. These studies underline the need of mapping and regulating impervious surfaces in urban catchments.

6.2 Land Use Change Dynamics

Asadi et al. (2024) used satellite pictures to look at how the Kal-e Shur Sabzevar sub-basin's land usage changed over time. Their research indicated that urbanisation and farms were slowly taking over natural plants, which changed how water flowed in a big way. Chen et al. (2023, 2024) looked at land use disputes and how they affect other parts of China from two different points of view. Their study looked at how towns that grow too quickly can take over farmland and natural areas.

6.3 Hydrological and Environmental Modeling

HEC-HMS and SWAT are two examples of hydrological modelling tools that have made it easier to figure out how much water is flowing. Campos et al. (2023) employed geographic information systems (GIS) and hydrological simulation to find out more about how fragile Brazilian basins are. Boongaling et al. (2024) utilised simulations based on several scenarios to see how effectively the LID rules worked. Their study demonstrated that adding LID to city planning considerably lowers peak runoff and makes infiltration better.

6.4 Spatial Tools and Remote Sensing

Using remote sensing and geographic information systems (GIS) to watch how land use changes and how impermeable barriers grow is useful. Cifuentes et al. (2024) used these methods to show how damming impacted the flow of water in the watershed of the Conción Metropolitan Area in Chile. Bikis (2023) said in his study that seeing how land is used over time might illustrate how things change as cities grow.

6.5 Responsive Planning and Policy Integration

"Responsive sub-basin planning" means employing scientific data, getting people involved in the community, and making choices all at once. Al-Mashaqbeh (2012) backed participatory planning methods by stressing how crucial it is for stakeholders to have control over sub-basin resources. Soberón et al. (2024), on the other hand, talked about how hard it is to plan from the top down in Colombia and suggested a system that is based on data and is less centralised. They also commented about how hard it is to plan things from the beginning.

6.6 Case Studies and Regional Applications

The things that were looked at come from a lot of different locations.

- Evidence from Nigeria, Guinea, and Ethiopia suggests that urbanisation is rising in Africa and the risk of floods is also growing.
- Asia: Studies on limited water resources and the fact that India, China, and Iran are all growing.
- Europe: Papers from the UK and Italy emphasise smart planning and environmental resilience for Europe.
- Latin America: Research in Chile, Colombia, and Brazil sheds insight on planning challenges in poor nations.

7. Synthesis and Proposed Framework

Based on the studies, we offer a five-component framework for responsive sub-basin planning:

1. **Assessment**:
    - Use high-resolution satellite images to locate impermeable surfaces.
    - Forecast runoff and infiltration using hydrological models.
2. **Monitoring**:
    - Track in real time via remote sensing.
    - Include socio-economic and environmental factors.
3. **Scenario Planning**:
    - Develop future land use possibilities.
    - Investigate green space design, infrastructure, and zoning implications.
4. **Community Engagement**:
    - Include locals in decision-making.
    - Promote responsibility and knowledge.
5. **Policy and Implementation**:
    - Use legislation to control unpervious development.
    - Promote LID, urban trees, and sustainable drainage solutions.

8. Research Gaps and Future Directions

Although many studies have examined how urbanisation and impervious surfaces influence hydrological and biological systems, particularly in connection to responsive sub-basin planning, some crucial issues remain unresolved. Most of the present research, therefore, emphasises macro-scale impacts while ignoring spatial variation and local repercussions at the sub-basin or watershed level. Though urban hydrological change is largely caused by impervious surface growth, little has been done to incorporate this knowledge into flexible, scale-sensitive land use planning tools. Many urban planning models, thirdly, do not properly represent the interactive influence of various land use types and various degrees of imperviousness on watershed health, hence generating fragmented or ineffective management strategies. Furthermore, the development of concentrated planning solutions is hampered by the lack of a comprehensive, multidisciplinary approach including land use, impervious surface distribution, and hydrological responsiveness. Addressing these shortcomings will help to foster sustainable urban development and sub-basin level resilience.

- **Lack of Standardization**: Many studies use different criteria for impermeable surfaces, which makes comparisons difficult.
- **Underutilization of AI and ML**: Predictive modelling hardly uses machine learning.

- **Need for Transdisciplinary Research**: Transdisciplinary research is required; hydrologists, urban planners, and data scientists have to work together.
- **Climate Change Considerations**: Few studies incorporate future climate projections into sub-basin planning.

Building on the identified gaps, future research should aim to develop integrated, scale-sensitive frameworks that holistically manage the interaction between impervious surfaces, land use dynamics, and hydrological responses in urban sub-basins. One possible way is high-resolution remote sensing and geospatial analytics to detect and simulate impervious surface expansion in real time, hence enabling more exact sub-basin level actions. Moreover, combining these techniques with hydrological models such as SWAT, HEC-HMS, or WRF-UCM can enhance prediction capacity for runoff, flood, and water quality effects. Models of land use planning also call for incorporation of socio-economic elements and urban growth patterns to ensure that the systems developed are not only ecologically sensitive but also socially just. Including adaptable urban infrastructure and climate change forecasts into these planning tools can help to increase resilience even more. Urban planners, hydrologists, ecologists, and politicians should finally cooperate across disciplines to turn research findings into useful sub-basin management strategies. These policies will help hydrologically sound urban growth plans as well as sustainable, climate-resilient ones.

7. Conclusion

Urbanization-driven land use transformation and the rapid expansion of impervious surfaces have emerged as dominant forces reshaping the hydrological, ecological, and climatic functioning of urban sub-basins. This study has systematically synthesized insights from 160 peer-reviewed studies across diverse geographical and climatic contexts to critically examine the complex interactions between urban land use change, impervious surface growth, and sub-basin hydrology. The review confirms that increasing imperviousness consistently leads to reduced infiltration, amplified surface runoff, degraded water quality, altered baseflow regimes, intensified flood risks, and widespread ecological degradation. These hydrological disruptions are further compounded by thermal stress, ecosystem service loss, and rising climatic vulnerability in urban environments.

A key contribution of this research lies in demonstrating that **sub-basins represent the most hydrologically responsive and operationally effective spatial unit for integrating land use planning with water system management**. Unlike conventional river-basin or city-scale approaches, sub-basin-based planning enables precise identification of localized hydrological thresholds, land use sensitivities, and vulnerability hotspots. The evidence reviewed strongly supports the adoption of Low Impact Development (LID), Sustainable Urban Drainage Systems (SuDS), and Nature-Based Solutions (NBS) at the sub-basin scale as effective strategies for mitigating hydrological risk while enhancing ecological resilience.

The findings further reveal persistent methodological and institutional gaps. These include weak integration between urban zoning regulations and hydrological modeling, inadequate use of impervious surface thresholds in planning controls, fragmented governance structures, and limited incorporation of climate change dynamics into land–water planning frameworks. Despite advances in remote sensing, machine learning, and hybrid hydrological modeling, the translation of scientific knowledge into enforceable urban planning policy remains inconsistent, particularly in rapidly urbanizing regions of the Global South.

By proposing a **responsive sub-basin planning framework**, this study advances a shift from reactive water management toward anticipatory, spatially intelligent, and ecologically grounded urban governance. This framework integrates land use regulation, hydrological modeling, ecosystem service protection, and climate adaptation into a unified decision-support structure. The approach not only enhances flood resilience and water security but also promotes co-benefits in the form of heat mitigation, biodiversity conservation, groundwater recharge, and improved human well-being.

In conclusion, sustainable urban futures cannot be achieved without rethinking how land use and water systems are jointly planned. Responsive sub-basin planning offers a scientifically robust and policy-relevant pathway to reconcile urban growth with hydrological stability and ecological integrity. Future research should focus on developing transferable sub-basin planning toolkits, strengthening data-driven policy integration, and embedding participatory governance mechanisms to ensure that urban water resilience becomes a core foundation of sustainable city development.

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