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CHANGING CITIES VI
Spatial, Design, Landscape, Heritage & Socio-economic Dimensions

CHANGING CITIES

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Edited by
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University of Thessaly, Volos, Greece

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Rediscovering Sustainable Urban River Flood Culture in the Era of Modern Climate Risks

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Abstract
Urban river floods pose significant challenges to modern societies, impacting health, property, infrastructure, cultural heritage, and the environment. Over centuries, the perception of flood risk has evolved from an external threat to a societally constructed risk, influenced by vulnerability and exposure. Geographic Information Systems (GIS) have emerged as an effective, interdisciplinary tool for flood risk assessment, integrating natural and socio-economic data to create comprehensive flood risk maps. This paper reviews 60 academic studies to identify the strengths and limitations of GIS in flood risk mapping and underscores the importance of incorporating social dimensions and vulnerability indices. The inclusion of local community participation and social dynamics is crucial for developing effective, context-specific flood risk management strategies.

Keywords: urban river floods, social evolution, flood, risk management, river culture, GIS

« Αρχή πάντων ύδωρ », Θαλής / "Water is the beginning of all things", Thales

River Floods: A Continuous Threat to Urban Societies

Urban environments are complex yet fragile ecosystems that are exposed to climate risks and their consequences for societies. Natural hazards, such as floods, pose a continuous threat to the development and sustainability of contemporary societies, as they can cause significant damage to health, property, infrastructure, cultural heritage and environment.

According to the Directive 2007/60/EC of the European Parliament and the Council, a flood is defined as "the temporary covering by water of a land not normally covered by water". Last decades have been characterized by a significant increase in the frequency of floods, leading to substantial socioeconomic and environmental consequences. Between 2000 and 2021, floods represented 40% of all natural disasters and affected, directly or indirectly, more than 140 million people per year worldwide. [1], [2] Arrighi's analysis in 2021 revealed, that more than one thousand cultural heritage sites all over the world, that underlined that 35% of natural and 21% of cultural and mixed UNESCO national world heritage sites, are currently in risk because of river floods, in terms of hazard and exposure.[3]

The inundation risk posed by urban rivers is influenced by several determinants, such as the natural characteristics of the river itself, including its morphology, dimensions, vegetation, water depth, and downstream hydrological conditions. Simultaneously, contemporary factors underscore the amplification of flood occurrences, due to rapid urbanization, demographic expansion, artificialization of natural areas upon riparian ecosystems, and the climatic alterations due to global warming. [4], [5]

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Historical Floods: Myths and Early Risk Management

Throughout history, urban rivers have played a pivotal role in shaping human settlements, offering plenty of advantages. They have served as a natural defence system for ancient cities, navigation roots for commerce and trade, and harnessed hydraulic potential for diverse industrial purposes, including tanning, milling, and more recently, electricity generation.

First communities were trying to explain the mysteries of natural disasters, by giving these phenomena a spiritual character, with mythological and folklore stories all over the world highlighting how the rivers were inspiring respect, awe and fear in human societies.

These narratives, from Scandinavian mythology, when Odin and his brothers killed the giant Ymir, whose blood inundated the earth, to the Biblical tale of the Great Flood in Genesis, when Noah's ark served as the vessel of salvation, illustrate how ancient civilizations searched ways to interpret and contextualize devastating inundations.[6], [7]

According to ancient Greek mythology, rivers were "born" by the Titans Oceanus and Tethys and considered to be gods. Kifissos River (Athens and Boeotia), Ilissos (Athens), Maiandros (Asia Minor), Alfeios and its tributary Kladeos (Peloponnese, Olympia), are some of these Greek mythological river Gods. People were praying to the water element for protection, blessing and assistance, while they would offer prayers and sacrifices to them, seeking protection on their journeys over their waters, blessing for good flow and behavior of the rivers, and other favorable actions. [8]

From Allies to Obstacles: Rivers in the Age of Industrialization

As societies were evolving, industrialization and rapid growth of the population, alongside with the technological evolution changed radically the behavior of the societies against the rivers. That resulted in extensive land consumption and artificialization, affecting riverbanks, floodways, and water basins. The previous respect for the water element, was switched, when the now called “modern city” started percieving rivers as obstacle rather than asset. Measures such as canalization, dam construction, and the implementation of artificial barriers, or even entirely covering of them, have been taken in previous decades to address climate hazards like floods or droughts, or in order to prevent water pollution in the cities. [9]

The process of artificialization has been identified as a significant disruptor of the natural hydrological cycle. This disruption leads in decreased vegetal interception, evapotranspiration, and infiltration, coupled with an increase in both the volume and velocity of surface runoff. These changes are primarily attributed to vegetation removal, soil imperviousness, modifications to natural drainage patterns, and the implementation of artificial drainage systems. [1]

An illustrative example of the consequences artificialization can be observed in Trikala (Thessaly, northern Greece) where Letheus river had been artificialized multiple times including the covering of sections of the river and the construction of dams. These interventions, despite several warnings issued in the late 19th century, led to the largest and most destructive flood of the Letheus River. This flood event occurred in June 1907, resulting in numerous fatalities and extensive property damage. Diakakis (2012), in his comparative evaluation of 545 flood events in Greece of the period 1880–2010, identified the Trikala flood as the most destructive in terms of human casualties, that caused at least 300 fatalities. [10], [11]

Another severe event was that of November 2017 in Mandra, (Attica, central Greece) owed to the covered torrents of St. Catherine and Soures. It was the result of a 150–160 mm rainfall event of 7 h duration that provoked a flash flood, with a death toll of 23 people and 6000 people being affected. Crucial was the role of the settlement’s location, on the two streams, with no planning standards. [11], [12], [13] These types of events underscored that the urban integration of the river primarily requires the removal of potential obstacles to smooth flow and the urgent construction of necessary flood control infrastructures.

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More recent example is that of Dubai flood on April 2024, were a huge and non-expected rainfall caused a great socio-economic-infrastructure impact on the city. The cruelty of the event itself, probably related to the climate changing conditions, alongside with the urban planning of the city that didn't take into consideration flood risk, led to a great catastrophe for the area. [14]

Modern Perspectives: Social Dimensions of Flood Risk

After the 1980s the perception of floods as an external risk for the society has been reconsidered. [15] Decision makers agreed on the fact that natural disasters, such as floods, are mostly socially constructed events related -as an internal risk- to the vulnerability of a system, and its characteristics. Anderson underlines since 1995 that "*Whereas previous assessments focussed on the "acts of nature" that come from outside human agency, later assessments have acknowledged that it is largely human actions, decisions and choices that result in people's vulnerability to natural events.*" [16]

Natural disasters are not necessarily 'disastrous' as they are inherently occurring phenomena on the planet. The actual risk arises from the adverse impacts of these phenomena on human-made environments. [17] Weichselgartner underlines that *"a natural disaster, in a pure sense does not exist; rather there is the interaction of changes in physical systems with existent social conditions. The disaster itself occurs within society and not within nature."* [18]

Social vulnerability is a term that explain this susceptibility of a population or a social system towards these climate extremes, because in a theoretical non vulnerable system, there is no need of adaptation to natural risks. [1] [19], [20] Various researchers and sociologists have pointed out that disasters have more to do with the social, political, and economic aspects of a group, since they reveal most of the times inequalities, injustices and weaknesses they affect mostly the socially vulnerable population.[21], [22], [23], [24] Poor population can be more vulnerable, since they can present a lack of access to coping resources and represent weak links in mitigation capacities. Elder people, women, people with disabilities or immigrants can be more vulnerable in a crisis situation, because of unequal access to information and education, physical and societal difficulties or due to communicational barriers.

Resilience describes the capacity of a system facing a risk to organize, predict, prepare, respond, resist disturbances, absorb impacts, recover, and reorganize, in order to maintain the same function and structure and continue to fulfill its purpose [28], [29], [30] Godschalk provides a well-framed definition of resilient cities, stating that resilience entails a city's capacity to recover from severe events without experiencing immediate chaos or lasting harm. He underscores the value of networked social communities and robust lifeline systems in building stronger cities through learning from past events. A resilient city, according to him, is a city that equally takes into consideration the natural systems (topography, soil, waterways...) and anthropogenic parameters (buildings, roads, energy facilities...) [24]

In order to deal with the floods, the European Commission enacted a Directive (ED) 2007/60/EC for the assessment and management of flood risks, requiring from each member the production of Flood Hazard (FHM) and Flood Risk Maps (FRM). These maps should focus on prevention, protection, and preparedness. In order to give rivers more space, these plans should, where possible, consider the conservation and/or restoration of floodplains, as well as measures to prevent and reduce damage caused by floods to human health and life, the environment, cultural heritage, economic activity, and

[1] *Although, history has witnessed as well and pure natural disasters and other events that occurred on the planet on a scale much larger than what the scale that humanity could affect (e.g., planetary temperature changes such as those that occurred towards the end of the 'Precambrian' geological era, which saw the coldest period in the planet's history leading to the extinction of many animal organisms, prolonged periods of drought, volcanic eruptions, etc.), which are beyond the scope of the present research.*

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infrastructure. [31] In order to achieve this goal from this ED, and plan sufficient FHM/FRM, an urgent need for a comprehensive and sustainable approach has been revealed, involving the participation of all stakeholders. Contemporary urbanization strategies have started to reconsider their perception towards urban floods and adaptation strategies, aiming to define new solutions that embrace resilient and flexible projects that are promoting the idea of socially coexisting with urban fluvial floods rather than combating them. [9], [32], [33]

Mileti, in his book "Disasters by Design: A Reassessment of Natural Hazards in the United States", emphasized as early as 1975, the importance of adopting an interdisciplinary approach against natural disasters with a long-term perspective that includes engagement with local communities. According to him, "*Local resiliency with regard to disasters means that a locale is able to withstand an extreme natural event without suffering devastating losses, damage, diminished productivity, or quality of life and without a large amount of assistance from outside the community''* [34]

The main challenge towards this reconsideration of the urban approaches though, lies in the difficulty of collecting, assessing and evaluating technical and social data from diverse perspectives and fields, and effectively communicate them to local authorities and stakeholders in a way that is easily understandable and coherent.

In this regard this paper proposes the use of Geographic Information System (GIS) software as an interesting tool that could serve as a connecting element for this reconsideration process towards an effective flood risk management culture for the contemporary societies.

GIS as an efficient Tool for Flood Risk Assessment

Geographic Information Systems (GIS) is a computer system designed to create digital representations of the Earth's surface by visualizing specific characteristics. Since its inception 60 years ago, GIS has rapidly evolved to a vital tool in various fields of application, research, and global business. Initially developed in Canada in 1963 by Roger Tomlinson for national land-use management, GIS has since grown into an integrated computer system for data visualization, storage, and manipulation. [5], [35], [36] ESRI's ArcGIS, the commercial form of the program was inicially launched in 1981, while Quantum GIS (QGIS), founded in 2002 as a free and open-source alternative. [37], [38] Today, GIS serves as an essential information database, analytical tool, and decision support system, facilitating complex spatial analysis and visualization.

Urban river floods are multi-dimensional events that combine both spatial and non-spatial data. [5], [39] Identifying risk zones within cities and understanding their interactions with the urban fabric are crucial steps in developing effective urban flood management plans. GIS can perform hydrologic and social analyses and thus it has been a valuable resource for researchers, urbanists and public authorities all over the world in order to produce natural risk maps for the cities. [2], [40], [41]

GIS is commonly used alone or alongside with other systems and programs. For example, RS or Remote Sensing, is a well knowing technique using satellite or aerial imagery to gather data about land cover, topography, and other relevant factors. Hydrological Modelling (such as HEC-RAS, wetspa, hydrotel, swat or ArcHydro - an extension of ArcGIS) involves using computational models to simulate the flow of water during flood events, using as data terrain, land use, soil type, precipitation, and drainage networks to predict flood extents and depths. MCDM, or Multi-Criteria Descision-Making techniques (AHP, FUZZY AHP, ANP, DEMATEL, PROMETHEE, WLC, MAUT, TOPSIS, VIKOR, ELECTRE etc) are used to evaluate and prioritize multiple criteria or objectives. Last years, Machine Learning, or ML, algorithms (DT, RF, SVM, ANN, LR) have been used in order to analyse large datasets to identify complex patterns and relationships between various factors and flood risk. The use of these methods separately or the collaboration is standing as an efficient way of data analysis Flood maps production.

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Criteria of evaluation

Throughout academic literature, there is a continusly increasing number of applications of GIS technology as a methodological tool in order to examine flood hazard and risk in different case studies, evolving alongside with the technological development and our knowledge on the matter.

This paper is effecting a state of the art in an amount of 60 papers, using a mixture of different criteria of evaluation in order to study and analyse the benefits and limitations of this tool in the FRM production.

The methodology for search, inclusion, and evaluation adheres to the parameters outlined in Table 1. Specifically, the chosen papers center on the examination of riverine or urban flash floods with the aim of producing flood analysis or flood risk maps. Selection criteria prioritize relevance to the research topic, publication year to trace methodological evolution, and geographic diversity of case studies to encompass varied socio-economic and geographical contexts across continents and countries.

Table 4 Statistical data about the reviewed papers

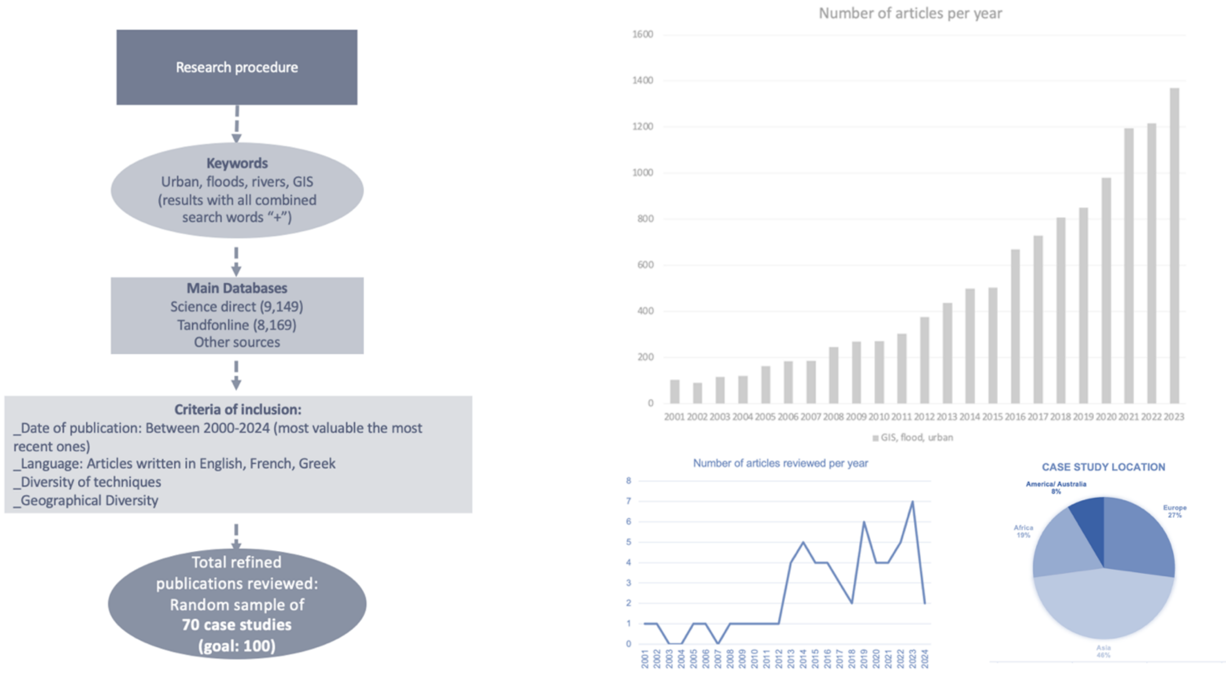

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Table 5 Results from criteria and techniques used in the reviewed papers

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Table 6 Papers reviewed analysis

						A.Hydrological	B. MCDA	C. AI / ML	D.Statistical Analysis	Verification				
Title	Case study location	Continent	Year of publication	Application area	Technique	wetspa, hydrotel, swat, HEC-RAS	MCDA, AHP, ANP	DT, RF, SVM, ANN	CF, EBF, FR, LR, SI, WOE, Wi	ROC	Historical data or other verification	Factors used	Authors	Source
Urban flood risk mapping using the GARP and QUEST models: A comparative study of machine learning techniques	Iran	Asia	2019	FRM	B and C		x	x		x		rainfall, land use/land cover (LULC), elevation, slope percent, curve number (CN), distance to river, distance to channel, and depth to groundwater, urban density, quality and age of buildings, socioeconomic conditions, population density	[redacted]	ScienceDirect
Evaluating urban flood risk using hybrid method of TOPSIS and machine learning	Iran	Asia	2021	FRM	B and C		x	x		x		HAZARD: slope aspect, elevation, slope angle, rainfall, distance to streets, distance to rivers, land use/land cover, distance to urban drainages, urban drainage density, and curve number. RISK: building density, population density, building history, and socio-economic condition	Rafiei-Sardooi et al.	ScienceDirect
Urban Flood Vulnerability and Risk Mapping Using Integrated Multi-Parametric AHP and GIS: Methodological Overview and Case Study Assessment	Kenya	Africa	2014	FRM	A and B	X	x					elevation, slope, s-soil, rainfall, drainage network, LULC	[redacted]	MDPI
Integrated machine learning methods with resampling algorithms for flood susceptibility prediction	Caspia sea	Asia	2020	FSM	C			x		x		Elevation, slope, aspect, curvature, distance to stream, rainfall, NDVI (vegetation), LULC, lithology	[redacted]	ScienceDirect
Hybrid artificial intelligence approach based on neural fuzzy inference model and metaheuristic optimization for flood susceptibilitgy modeling in a high-frequency tropical cyclone area using GIS	Vietnam	Asia	2016	FSM	C and D			x		x	x	Slope, elevation, curvature, topographic wetness index (TWI), stream power index (SPI), distance to river, stream density, Normalized Difference Vegetation Index (NDVI), lithology, rainfall	[redacted]	ScienceDirect
Exploring local perspectives on flood risk: A participatory GIS approach for bridging the gap between modelled and perceived flood	UK	Europe	2024	FRM							x	2D scaled participatory mapping of flood risk and questionnaire surveysμ consist of qualitative and quantitative responses	[redacted]	ScienceDirect
Flood hazard zonation using GIS-based multi-parametric Analytical Hierarchy Process	Dhalai river	Asia	2024	FHM	B		x			x		Flow accumulation (F), Soil (S), Rainfall (R), Elevation (E), Distance from the river (D), Slope (Sl), Land use (L), Topographic wetness index (T) and Profile curvature (P)	[redacted]	ScienceDirect
Identifying flood vulnerable and risk areas using the integration of analytical hierarchy process (AHP), GIS, and remote sensing: A case study of southern Oromia region	Ethiopia	Africa	2023	FHM	B		x					slope, drainage density, rainfall, elevation, TWI, soil, river distance, and LULC	[redacted]	ScienceDirect
GIS-based machine learning algorithm for flood susceptibility analysis in the Pagla river basin, Eastern India	India	Asia	2023	FSM	C and D			x	x	x		Elevation, Slope, Plan Curvature, Flow Accumulation, Length of Slope (LS), Topographic Wetness Index (TWI), Rainfall, Geomorphology, Topographic Roughness Index (TRI), Topographic Position Index (TPI), Stream Power Index (SPI), Drainage Density (DD), Distance from Road, Distance from River, Normalized Difference Vegetation Index (NDVI) and Land Use and Land Cover (LULC)	[redacted]	ScienceDirect
Flood hazard zone mapping incorporating geographic information system (GIS) and multi-criteria analysis (MCA) techniques	China	Asia	2022	FHM	B		x				x	Rainfall, intensity, Elevation, Slope, aspect, Curvature, Topographic wetness index (TWI), Stream power index (SPI), Land use land cover (LULC), Distance to the river (DTR), Soil texture (ST)	[redacted]	ScienceDirect
Urban flood susceptibility modelling using AHP and GIS approach: case of the Mfoundi watershed at Yaoundé in the South-Cameroon plateau	Cameroon	Africa	2022	FSM	B	X	x			x		Natural : elevation, drainage density, rainfall, slope, distance from the river, topographical humidity, hydraulic conductivity (soil permeability), groundwater level, the presence of swampy areas and geology, anthropogenic: Land Cover (LC) controlled by galloping population growth and the failure of sanitation systems	[redacted]	ScienceDirect
Planning green infrastructure to mitigate urban surface water flooding risk – A methodology to identify priority areas applied in the city of	Belgium	Europe	2020	FRM	B		x					Storm-water runoff mitigation, social flood vulnerable group protection, flood sensitive area road infrastructures protection, flood sensitive area buildings protection, environmental justice	[redacted]	ScienceDirect
Flood hazard and flood risk assessment at the local spatial scale: a case study	Slovakia	Europe	2015	FRM		X			x			Water Depth, flow Velocity, functional Land Use, vulnerability Assessment, regional Flood Discharge Formulas, hydraulic Modeling, vulnerability acceptable risk count by cadastral maps, orthophotos from the year 2011, and field research	[redacted]	TandFonline
Flood Susceptibility Mapping through the GIS-AHP Technique Using the Cloud	India	Asia	2020	FSM	B		x				x	Precipitation, river network density, and SPI, levation, slope, profile curvature, landforms, ruggedness index, distance from rivers, soil type, soil moisture, TWI, soil erodibility factor (K), rainfall erosivity, LU/LC, soil-adjusted vegetation index (SAVI), and NDVI, population density, global man-made impervious surface (GMIS), global human built-up and settlement extent (HBASE), and distance from roads	[redacted]	MDPI
Integration of remote sensing data and GIS for accurate mapping of flooded areas	Italy	Europe	2001	FDM								SAR image	[redacted]	TandFonline
Application of the GIS based multi-criteria decision analysis and analytical hierarchy process (AHP) in the flood susceptibility mapping	Tunisia	Africa	2019	FSM	B		x					River network, Watershed limit, Elevation, Slope, Soil, Drainage density, Rainfall, Groundwater level, LULC and Liyhology	Hammami et al.	ResearchGate
Application of GIS-Interval Rough AHP Methodology for Flood Hazard Mapping in Urban Areas	Serbia	Europe	2017	FHM	B		x					Height, slope, distance to the sewage network, the distance from the water surface, the water table and land use	[redacted]	MDPI
Flood risk assessment using hybrid artificial intelligence models integrated with multi-criteria decision analysis in Quang Nam Province,	Vietnam	Africa	2021	FRM	B and C		x	x		x		Elevation, rainfall, flow accumulation, SPI, STI, TWI, slope, river density, distance from rivers, plan curvature, profile curvature, curvature, land cover, and lithology	[redacted]	ScienceDirect
A GIS-Cellular Automata-Based Model for Coupling Urban Sprawl and Flood Susceptibility Assessment	Greece	Europe	2021	FSM	B		x				x	Flow accumulation, altitude, precipitation, LULC, distance from hydraulic network, slope, hydrolithology	[redacted]	MDPI
A GIS-supported fuzzy-set approach for flood risk assessment	Canada	America/ Australia	2014	FRM	A and D	X			x			Antecedent Precipitation Index (API), melt Index (MI), total Winter Precipitation (P), timing Factor (T)	[redacted]	TandFonline
Flood Early Warning with Integration of Hydrologic and Hydraulic Models, RS and GIS	Iran	Asia	2009	FHM	A	X						Slope, elevation, LULC, river characteristics, infiltration of soil, Rainfall	[redacted]	ResearchGate
Flood Hazard and Flood Risk Vulnerability Mapping Using Geo-Spatial and MCDA around Adigrat, Tigray Region, Northern Ethiopia	Ethiopia	Africa	2019	FRM	A and B	X	x				x	HAZARD: slope, elevation, flow accumulation, LULC, flow direction, annual precipitation, water table/ RISK: population density,LULC, built up density, road up density, flood hazard map	[redacted]	ResearchGate
Development of a new integrated flood resilience model using machine learning with GIS-based multi-criteria decision analysis	Pakistan	Asia	2023	FRM	B and C		x	x		x		Elevation, slope, aspect, plan curvature, Rainfall, topographic wetness index (TWI), sediment power index (SPI), sediment transport index (STI), distance to the stream, Land use and cover (LULC), distance to the roads, Literacy ratio, dependency ratio, population density, household head education, Source of income, number of income sources, income level, housing utilities, Dwelling types, no of health and education facilities, working-age group, equity, and inclusion, flood shelter, trained personals, Emergency response services, disaster risk insurance, social networks, training/drills, community-preparedness plan, early warning system, Past experience, determination to change, understanding of risk/hazard	[redacted]	ScienceDirect
Spatial prediction of flood susceptible areas using rule based decision tree (DT) and a novel ensemble bivariate and multivariate statistical models in GIS	Malaysia	Asia	2013	FSM	C and D			x	x	x		Digital elevation model (DEM), curvature, geology, river, stream power index (SPI), rainfall, land use/cover (LULC), soil type, topographic wetness index (TWI) and slope	Tehrany et al.	ScienceDirect
A GIS-Based Index of Physical Susceptibility to Flooding as a Tool for Flood Risk Management	Brazil	America/ Australia	2023	FSM	B		x					Elevation, slope, distance from the major drainage network and land use	[redacted]	MDPI
Flood Risk Index as an Urban Management Tool	Brazil	America/ Australia	2008	FRM								Depth, duration, vellocity, dwellings density, income per capita, traffic	Zonensein et al.	ResearchGate
Assessment of flood hazard areas at a regional scale using an index-based approach and Analytical Hierarchy Process	Greece	Europe	2015	FHM	B		x					Flow accumulation, distance from the drainage network, elevation, land use, rainfall intensity and geology	[redacted]	ScienceDirect
Artificial neural network for flood susceptibility mapping	Bangladesh	Asia	2023	FSM	C			x				Elevation, slope, aspect, curvature, TWI, SPI, roughness, and LULC	[redacted]	ScienceDirect
Assessment of flood hazard based on naturaland anthropogenic factors using analytic hierarchyprocess (AHP)	Greece	Europe	2013	FHM	B		x					Natural: land uses, geological subsoil, slope, shape of the watersheds, density of hydrographic network + subfactors / anthropogenic: encroachments, inadequate technical works, shpaed cross-section at the plain area of the steam	[redacted]	Scirp
GIS-based spatial prediction of flood prone areas using standalone frequency ratio, logistic regression, weight of evidence and their ensemble techniques	China	Asia	2013	FSM	D				x	x		Altitude, slope, aspect, geology, distance from river, distance from road, distance from fault, soil type, land use/cover, rainfall, Normalized Difference Vegetation Index, Stream Power Index, Topographic Wetness Index, Sediment Transport Index and curvature	[redacted]	MDPI
Flood hazard assessment in a mountainous river basin in Thessaly, Greece, based on 1D/2D numerical simulation	Greece	Europe	2022	FHM	A	X					x	Altitude, slope, aspect, geology, soil capacity, LULC	[redacted]	ScienceDirect
Evaluating the application of the statistical index method in flood susceptibility mapping and its comparison with frequency ratio and logistic regression methods	Brisbane	America/ Australia	2018	FSM	D				x	x		Altitude, slope, aspect, curvature, geology, soil, LULC, TWI, SPI, TRI, STI, distance from rivers, distance from roads	[redacted]	MDPI
Flood susceptibility mapping using frequency ratio and weights-of-evidence models in the Golastan Province, Iran	Iran	Asia	2014	FSM	D				x	x		Lithology, land-use, distance from river, soil texture, slope angle (in degree), slope aspect, plan curvature, topographic wetness index (TWI), drainage density, altitude	[redacted]	TandFonline
Flood susceptibility assessment using GIS-based support vector machine model with different kernel types	Malaysia	Asia	2015	FSM	C and D			x	x	x	x	Altitude, slope, curvature, stream power index (SPI), topographic wetness index (TWI), distance from the river, geology, rainfall, land use/cover (LULC), soil, surface runoff	[redacted]	ScienceDirect
Flood susceptibility mapping using a novel ensemble weights-of-evidence and support vector machine models in GIS	Malaysia	Asia	2014	FSM	C and D			x	x	x		Flood inventory, slope, stream power index (SPI), topographic wetness index (TWI), altitude, curvature, distance from the river, geology, rainfall, land use/cover (LULC), soil type	[redacted]	ScienceDirect
Artificial neural network approach to flood forecasting in the River Arno	Italy	Europe	2002	FHM	C			x				Rainfall data, waterlevel data, distance of raingauges, power production sites	[redacted]	TandFonline
Spatial prediction of flood susceptible areas using rule based decision tree (DT) and a novel ensemble bivariate and multivariate statistical models in GIS	Malaysia	Asia	2013	FSM	C and D			x	x	x		Digital elevation model (DEM), curvature, geology, river, stream power index (SPI), rainfall, land use/cover (LULC), soil type, topographic wetness index (TWI) and slope	[redacted]	ScienceDirect
Detection of Flood Hazard in Urban Areas Using GIS: Izmir Case	Turkey	Asia	2016	FHM	B		x					Elevation, rainfall intensity, flow accumulation, slope, land use	[redacted]	ScienceDirect
Flood risk mapping and urban infrastructural susceptibility assessment using a GIS and analytic hierarchical raster fusion approach in the Ona River Basin, Nigeria	Nigeria	Africa	2022	FRM	A and B	X	x				x	Elevation, drainage density, and slope indicators, land use, soil, and geologic structure, lithological structure, inundation, and runoff indexes, transport infrustructures, building foodprint	[redacted]	ScienceDirect
Mapping social vulnerability to floods. A comprehensive framework using a vulnerability index approach and PCA analysis	Romania	Europe	2023	FRM	B		x					Population density, Population growing rate, Share of the population under 5 years old, Share of population over 65 years old, Share of women, Share of employed population, Share of unemployed population, Percent of built-up area, Built-up area growing rate, access to drinking water, Drinking water network, Flooded area extent, Flooded area under 0.5m, Flooded area between 0.5 and 2	[redacted]	ScienceDirect
Flood risk assessment based on hydrodynamic model and fuzzy comprehensive evaluation with GIS technique	China	Asia	2019	FRM	B		x				x	Inundation depth(m), Inundation duration(h), Inundation area(ha),Ground elevation(m), Ground slope(%),Impermeability(%), Building density(%), POI density(1/ha)	[redacted]	ScienceDirect
Flood disaster risk mapping in the Lower Mono River Basin in Togo, West Africa	Togo	Africa	2017	FRM		X	x					Natural : River Flow, Elevation, Slope, Soil, Land use, Cover, Flow Accumulation / Social: family sizes, level of income, adult literacy, past experience of flooding, level of capacity measures, early warning systems etc	[redacted]	ScienceDirect
Analysis, prioritization and strategic planning of flood mitigation projects based on sustainability dimensions and a spatial/value AHP-	Greece	Europe	2023	FSM	B		x					Environmental, social and economic data	[redacted]	ScienceDirect
Application of satellite image processing and GIS-Spatial modeling for mapping urban areas prone to flash floods in Qena governorate, Egypt	Egypt	Africa	2019	FRM	B		x					Soil, geology, rainfall, elevation, slope, flow direction, stream order, land cover, total population, and population density	[redacted]	ScienceDirect
Flash Flood Hazard Mapping Using Satellite Images and GIS Tools: A case study of Najran City, Kingdom of Saudi Arabia (KSA)	Saudi Arabia	Asia	2015	FHM	B		x					Runoff, soil type, surface slope, surface roughness, drainage density, distance to main channel and land use	[redacted]	ScienceDirect
A flood risk decision making approach for Mediterranean tree crops using GIS; climate change effects and flood-tolerant species	Greece	Europe	2016	FRM	b		x				x	Flow accumulation (F), Rainfall intensity (R), Elevation (E), Geology (G), Land use (L), Slope (S)	[redacted]	ScienceDirect
Assessing urban flood disaster risk using Bayesiannetwork model and GIS applications	China	Asia	2019	FRM	C			x			x	Rainfall, river density, slope, proximity, elevation, impervious area, per unit energy consumed, population density, road density	[redacted]	TandFonline
Urban flooding risk assessment based on GIS- game theory combination weight: A case study of Zhengzhou City	China	Asia	2022	FRM	B		x			x		Hazard: flood depth, vulnerability: population density, lulc, road network density, night time light brightness, medical rescue points	[redacted]	ScienceDirect
Inundation extent as a key parameter for assessing the magnitude and return period of flooding events in southern Iceland	Iceland	Europe	2010	FDM									[redacted]	TandFonline
Flood management and a GIS modelling method to assess flood-hazard areas—a case study	Greece	Europe	2011	FHM	B		x					Flow accumulation, slope, land use, rainfall intensity, geology and elevation	[redacted]	TandFonline
Flood risk assessment and mapping in peri-urban Mediterranean environments using hydrogeomorphology. Application to ephemeral streams in the Valencia region (eastern Spain)	Spain	Europe	2012	FRM	A	X						Hydromorphologival factors (topographic features, paleochannels and alluvialfans, and streambed charactersitis) human exposure factors (LULC) economic value of properties, population density, critical infrastructures	Camarasa-Belmonte and Soriano-García	ScienceDirect
Regional scale flood modeling using NEXRAD rainfall, GIS, and HEC-HMS/RAS: a case study for the San Antonio River Basin Summer 2002 storm event	USA	America/ Australia	2005	FHM	A	X					x	Elevation, soil, LULC, streamflow, rainfall-precipiation, river geometry	[redacted]	ScienceDirect
Modelling of the flooding in the Okavango Delta, Botswana, using a hybrid reservoir-GIS model	Botswana	Africa	2006	FHM	A							Hydraulical data	Wolski et al.	ScienceDirect
GIS-based multi-criteria analysis for flood prone areas mapping in the trans-boundary Shatt Al-Arab basin, Iraq-Iran	Iran	Asia	2021	FHM	B		x				x	Rainfall data, elevation slope, soiltype, rockformations, soiltype, LULC	[redacted]	TandFonline
Flood susceptibility mapping using an improved analytic network process with statistical models	Iran	Asia	2020	FRM or FSM	B and D				x	x		Slope, Altitude, Aspect, Distance from River, Rainfall, Topographic Wetness Index (TWI), Slope Length (LS), Plan Curvature, Land Use/Land Cover (LU/LC), Geology/Lithology	[redacted]	TandFonline
GIS-based MCDM – AHP modeling for flood susceptibility mapping of arid areas, southeastern Tunisia	Tunisia	Africa	2018	FSM	B		x				x	Elevation, land use/land cover, lithology, rainfall intensity, drainage density, distance from the drainage network, slope, and groundwater depth	Souissi et al.	TandFonline

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Findings: Bridging Technical and Social Aspects in Flood Risk Mapping

By examining Table 3, it is evident that the largest percentage, 32%, of the papers used qualitative-based empirical modeling techniques (such as MCDM/AHP) to produce Flood Hazard Mapping (FHM) and Flood Risk Mapping (FRM). Smaller percentages of papers used GIS in collaboration with statistical methods, hydraulic models, machine learning techniques, or a mix of techniques to achieve even more accurate results. Out of the 60 papers reviewed, 36 papers, have verified the results of their maps either using technical programs like ROC (Receiver Operating Characteristic) or by utilizing historical data from previous floods.

Almost 30% of the papers focus on FHM production, while the rest are focused on flood susceptibility and flood risk mapping. By examining the input criteria for the FSM/FRM production is interesting to notice that elements such as elevation, slope and river network are consistently examined across these studies, while variables like curvature and lithology are addressed in only a subset of them. (Table 2)

However, in terms of urban and social criteria, while land use and land cover (LULC) emerge as the predominant factor observed in the majority of papers, it can provide only a preliminary understanding of social parameters. While technical criteria represented the 74% of used factors in the totality of the papers, only 20% of factors are related with human infrastructures and, even less, 6% of factors have socio-economic character.

It's interesting to mention that analyses that include socio-economic criteria are found in high majority in articles of the last five years (only 3 articles included these types of criteria before, on 2008, 2012 and 2017), proving this increasing reconsideration on the matter of including social parameters. Although, they were still representing a minority of the FSM / FRM (34% of the articles included these types of criteria from 2019 to 2024).

Even though the majority of articles was focused on mostly technical analysis to produce the flood risk maps, there are some articles that searched deeper the socio-economic side of the vulnerability.

Ajtai et al. (2023) made a social vulnerability analysis for their FRM, searching the index and the value of each social characteristic. They agreed that social vulnerability is influenced not only by the inherent characteristics of a certain community, but also by location, spatial distribution, hazard type, and hazard characteristics. The interaction between all these factors leads to complex relationships that must be considered and carefully analyzed. [42]

Bulen and Miles (2024) defended that Participatory GIS (PGIS) can help bridge the gap between modelled and perceived flood risk by involving the local community in research and questioning them on their past flood experiences. They conducted a survey in Reading, a large town in Central Southern England, incorporating local communities into the Flood Risk Management (FRM) production using PGIS. The study found a high level of agreement between participatory mapping and flood model outputs, demonstrating that local communities, with prior flood exposure or flood risk education, possess valuable knowledge that can inform effective flood risk strategies. [43]

Discussion/Conclusion

Urban river floods pose significant challenges to communities worldwide. The perception of flood risk has evolved from viewing natural disasters as external threats to recognizing them as internal societal risks requiring an efficient socio-technical interdisciplinary approach. Sustainable and resilient urban futures demand tools that facilitate research for urban designers, policymakers, and stakeholders. The contemporary cities need to think beyond the technical solutions to prevent catastrophic events, and to truly understand the social dynamics of each place and the way that society interacts in the case of crisis in order to propose urban and political solutions that reflect the special needs of each place.

Aknowledging the diverse social factors influencing vulnerability—such as population experience with disasters, socioeconomic inequalities, gender norms, and political-cultural contexts—enables

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better identification of critical zones for urban reconsideration and development of targeted urban strategies. The society stands in the core of an urban environment, that defines its dynamics and evolution so it is critical to be an essential factor to be taken into consideration into the risk management strategies. The participation of the population in the descion making and the understanding of the social dynamics of each place is crucial in order to propose sustainable solutions. Geographic Information System has emerged recent years as an important tool, offering powerful capabilities in data visualization, analysis, decision-making support and fast and comprehensible maps production. GIS is software that can easily import, analyze and visualize various data, assess flood hazards, understand spatial dynamics, and communicate simply the results in a form of understandable basic maps. Stakeholders, such as urban designers and policymakers can exploit the multilayered nature of GIS technology in order to identify the urban priority areas for flood management strategies according to the socioeconomic priorities of the places.

The results of this literature review underline that despite the fact that the contribution of socio-economic factors in flood risk analysis can result in more precise flood maps, technical criteria remain predominant in flood risk assessments using GIS technology. Recent years indicate a progressive increase towards the integration of socio-economic data, proving an evolving recognition of the importance of social dimensions in flood risk management. However, this integration is still in its preliminary stages and requires further research.

The pursuit of urban resilience vis-à-vis climate hazards necessitates a comprehensive framework that combines natural and social dimensions. The incorporation of socio-economic data in map production is crucial for identifying vulnerable populations and urban areas, reassuring that flood risk management strategies are not only technically accurate but also socially equitable. Prioritizing the requirements and experiences of population and employing qualitative approaches, interdisciplinary collaboration, and participatory methods in the flood risk assessment is essential in order to create resilient and sustainable urban environments and mitigate the impact of natural disasters.

By analyzing the socio-economic fabric of urban areas, stakeholders can identify marginalized communities that are mostly affected by flooding events. Moreover, recognizing the socio-economic drivers of vulnerability enables the formulation of targeted interventions that address root causes rather than mere symptoms.

Interdisciplinary collaboration lies at the heart of effective flood risk management strategies. Reinforcing a collaboration and an efficient dialogue between experts from diverse fields (such as hydrology, urban planning, sociology, and economics) can result to the development of innovative solutions that integrate technical expertise and socio-economic insights for a better risk management. Furthermore, necessary are participatory methodologies that involve local communities in the decision-making processes related to flood risk management. By incorporating local knowledge, values, and experiences into planning, into a bottom-up approach, interventions are more likely to resonate with the needs and aspirations of affected communities and reinforce the resilience of the population.

In conclusion, the pursuit of urban resilience in the face of climate risks demands a holistic approach that integrates both natural and social dimensions. By centering on the needs and experiences of diverse urban populations, cities can become more adaptive, inclusive, and sustainable, thereby mitigating the impact of natural disasters and enhancing the well-being and resilience of their inhabitants.

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References

1. Miranda et al., "A GIS-Based Index of Physical Susceptibility to Flooding as a Tool for Flood Risk Management," Land, vol. 12, no. 7, p. 1408, Jul. 2023, doi: 10.3390/land12071408.
2. S. Samanta, C. Koloa, D. Kumar Pal, and B. Palsamanta, "Flood Risk Analysis in Lower Part of Markham River Based on Multi-Criteria Decision Approach (MCDA)," Hydrology, vol. 3, no. 3, Art. no. 3, Sep. 2016, doi: 10.3390/hydrology3030029.
3. Arrighi, "A Global Scale Analysis of River Flood Risk of UNESCO World Heritage Sites," Frontiers in Water, vol. 3, Dec. 2021, doi: 10.3389/frwa.2021.764459.
4. H. Desalegn and A. Mulu, "Mapping flood inundation areas using GIS and HEC-RAS model at Fetam River, Upper Abbay Basin, Ethiopia," Scientific African, vol. 12, p. e00834, Jul. 2021, doi: 10.1016/j.sciaf.2021.e00834.
5. N. Kourgialas and G. Karatzas, "Flood management and a GIS modelling method to assess flood-hazard areas—a case study." Accessed: Jan. 15, 2024. [Online]. Available: https://www.tandfonline.com/doi/epdf/10.1080/02626667.2011.555836?src=getftr
6. T. Longman and J. H. Walton, The lost world of the flood: mythology, theology, and the deluge debate. Downers Grove, IL: IVP Academic, an imprint of InterVarsity Press, 2018.
7. N. Gaiman, Norse mythology, First edition. New York: W.W. Norton & Company, 2017.
8. N. Skoulikidis, E. Dimitriou, and I. Karaouzas, The rivers of Greece: evolution, current status and perspectives. in The handbook of environmental chemistry, no. volume 59. Berlin: Springer, 2018.
9. M. Knoll, U. Lübken, and D. Schott, Eds., Rivers Lost, Rivers Regained: Rethinking City-River Relations. University of Pittsburgh Press, 2017. doi: 10.2307/j.ctt1qnw8gv.
10. M. Diakakis, G. Deligiannakis, and S. Mavroulis, "Floods in Greece, a statistical and spatial approach," Natural Hazards, vol. 62, Jun. 2012, doi: 10.1007/s11069-012-0090-z.
11. N. Evelpidou, C. Cartalis, A. Karkani, G. Saitis, K. Philippopoulos, and E. Spyrou, "A GIS-Based Assessment of Flood Hazard through Track Records over the 1886–2022 Period in Greece," Climate, vol. 11, no. 11, Art. no. 11, Nov. 2023, doi: 10.3390/cli11110226.
12. M. Diakakis et al., "An integrated approach of ground and aerial observations in flash flood disaster investigations. The case of the 2017 Mandra flash flood in Greece," International Journal of Disaster Risk Reduction, vol. 33, pp. 290–309, Feb. 2019, doi: 10.1016/j.ijdrr.2018.10.015.
13. "Public EM-DAT platform." Accessed: May 13, 2024. [Online]. Available: https://public.emdat.be/data
14. "Deadly Dubai floods made worse by climate change," Apr. 25, 2024. Accessed: May 08, 2024. [Online]. Available: https://www.bbc.com/news/science-environment-68897443
15. H. Herath and N. Wijesekera, "Transformation of flood risk management with evolutionary resilience," E3S Web Conf., vol. 158, p. 06005, 2020, doi: 10.1051/e3sconf/202015806005.
16. M. Anderson, "Vulnerability to disaster and sustainable development: Ageneral framework for assessing vulnerability." Washington DC: World Bank, 1995.
17. Wisner, Blaikie, Cannon, and Davis, At risk: natural hazards, people's vulnerability and disasters, 2. ed., Reprinted. London: Routledge, 2003.
18. J. Weichselgartner, "Disaster Mitigation: The Concept of Vulnerability Revisited," Disaster Prevention and Management - DISASTER PREV MANAG, vol. 10, pp. 85–95, May 2001, doi: 10.1108/09653560110388609.
19. J. Birkmann, C. Bach, and M. Vollmer, "Tools for Resilience Building and Adaptive Spatial Governance: Instrumente zur Förderung von Resilienz und adaptiver räumlicher Governance," Raumforschung und Raumordnung | Spatial Research and Planning, vol. 70, no. 4, Art. no. 4, Aug. 2012, doi: 10.1007/s13147-012-0172-0.

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20. B. Field, V. Barros, T. F. Stocker, and Q. Dahe, Eds., Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change, 1st ed. Cambridge University Press, 2012. doi: 10.1017/CBO9781139177245.
21. R. Bolin and L. Stanford, The Northridge Earthquake: Vulnerability and Disaster. London: Routledge, 1998. doi: 10.4324/9780203028070.
22. M. Priestley and L. Hemingway, "Disability and Disaster Recovery: A Tale of Two Cities?," Journal of Social Work in Disability & Rehabilitation, vol. 5, no. 3–4, pp. 23–42, Jan. 2007, doi: 10.1300/J198v05n03_02.
23. L. Quarantelli, "Problematical aspects of the information/ communication revolution for disaster planning and research: ten non-technical issues and questions," Disaster Prevention and Management: An International Journal, vol. 6, no. 2, pp. 94–106, May 1997, doi: 10.1108/09653569710164053.
24. R. Godschalk, "Urban Hazard Mitigation: Creating Resilient Cities," Natural Hazards Review, vol. 4, no. 3, pp. 136–143, Aug. 2003, doi: 10.1061/(ASCE)1527-6988(2003)4:3(136).
25. W. K. Burling and A. E. Hyle, "Disaster preparedness planning: policy and leadership issues," Disaster Prevention and Management: An International Journal, vol. 6, no. 4, pp. 234–244, Jan. 1997, doi: 10.1108/09653569710179075.
26. R. Hoffmann and R. Muttarak, "Learn from the Past, Prepare for the Future: Impacts of Education and Experience on Disaster Preparedness in the Philippines and Thailand," World Development, vol. 96, pp. 32–51, Aug. 2017, doi: 10.1016/j.worlddev.2017.02.016.
27. Z. Vojinović, "Flood risk : the holistic perspective : from integrated to interactive planning for flood resilience /."
28. M. Pelling, The vulnerability of cities: natural disasters and social resilience. London ; Sterling, VA: Earthscan Publications, 2003.
29. UN/ISDR, Living with risk. 1. Geneva: UN/ISDR, 2004.
30. B. Walker and J. Meyers, "Thresholds in Ecological and Social-Ecological Systems: A Developing Database," Ecology and Society, vol. 9, Dec. 2004, doi: 10.5751/ES-00664-090203.
31. Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (Text with EEA relevance), vol. 288. 2007. Accessed: Jan. 23, 2024. [Online]. Available: http://data.europa.eu/eli/dir/2007/60/oj/eng
32. L. J. Bracken et al., "Flood risk management, an approach to managing cross-border hazards," Nat Hazards, vol. 82, no. 2, pp. 217–240, Jun. 2016, doi: 10.1007/s11069-016-2284-2.
33. J.-J. Terrin and J.-B. Marie, Villes inondables: prévention, adaptation, résilience Rotterdam, Dordrecht, Dunkerque, Hambourg, Mayence, Lyon, Nîmes, Marseille, Toulouse. in La ville en train de se faire. Marseille: Parenthèses, 2014.
34. Mileti, Disasters by Design: A Reassessment of Natural Hazards in the United States. Washington, D.C.: Joseph Henry Press, 1999, p. 5782. doi: 10.17226/5782.
35. Darwin, B. Kombaitan, G. Yudoko, and H. Purboyo, "Application of gis on determination of flood prone areas and critical arterial road network by using chaid method in bandung area," MATEC Web Conf., vol. 147, p. 02007, 2018, doi: 10.1051/matecconf/201814702007.
36. D. Russell, C. P. Hawkins, and M. P. O'Neill, "The Role of GIS in Selecting Sites for Riparian Restoration Based on Hyderology and Land Use," Restoration Ecology, vol. 5, no. s4, pp. 56–68, 1997, doi: 10.1111/j.1526-100X.1997.tb00205.x.
37. ERSI, "History of GIS | Timeline of Early History & the Future of GIS." Accessed: Jan. 31, 2024. [Online]. Available: https://www.esri.com/en-us/what-is-gis/history-of-gis

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ISBN: 978-618-5765-02-6

38. S. Khan and K. Mohiuddin, “Evaluating the parameters of ArcGIS and QGIS for GIS Applications,” vol. 7, pp. 582–594, Jan. 2018.
39. Z. Masoumi, “Flood susceptibility assessment for ungauged sites in urban areas using spatial modeling,” Journal of Flood Risk Management, vol. 15, no. 1, p. e12767, 2022, doi: 10.1111/jfr3.12767.
40. Mustafa, M. Szydłowski, M. Veysipanah, and H. M. Hameed, “GIS-based hydrodynamic modeling for urban flood mitigation in fast-growing regions: a case study of Erbil, Kurdistan Region of Iraq,” Sci Rep, vol. 13, no. 1, Art. no. 1, Jun. 2023, doi: 10.1038/s41598-023-36138-9.
41. Samela, R. Albano, A. Sole, and S. Manfreda, “A GIS tool for cost-effective delineation of flood-prone areas,” Computers, Environment and Urban Systems, vol. 70, pp. 43–52, Jul. 2018, doi: 10.1016/j.compenvurbsys.2018.01.013.
42. Ajtai et al., “Mapping social vulnerability to floods. A comprehensive framework using a vulnerability index approach and PCA analysis,” Ecological Indicators, vol. 154, p. 110838, Oct. 2023, doi: 10.1016/j.ecolind.2023.110838.
43. J. Bullen and A. Miles, “Exploring local perspectives on flood risk: A participatory GIS approach for bridging the gap between modelled and perceived flood risk zones,” Applied Geography, vol. 163, p. 103176, Feb. 2024, doi: 10.1016/j.apgeog.2023.103176.

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