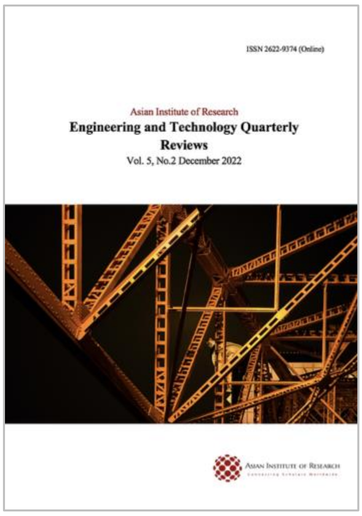

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Water Resources Management and Applications using GIS: An Overview

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Abstract
Due to the extensive use of geographic information system (GIS) concepts, planning and design for water resources are evolving. The effects of human activity are all around us in some places, and water resources are getting harder to find. In this situation, evaluating these resources, estimating consequences, and developing plans to lessen impacts and enhance sustainability while utilizing the finest technology available are all important. While geographic information systems (GIS) offer the best tools for managing water resources and other related issues like drought and flood risk, remote sensing offers the essential data for managing these resources. Also, GIS can be integrated with many techniques like artificial intelligence models and hydrological models. This paper aims to present a comprehensive survey of the best practices and uses of GIS technologies in water resources engineering includes, water resources mapping, rainfall-runoff measurements, flood forecasting, irrigation management, water quality and drought monitoring.

Keywords: GIS Technologies, Spatial Distribution, Forecasting, Management, Water Resources

1. Introduction

Mountain glaciers, snow, surface water bodies (lakes, rivers, and reservoirs), soil moisture, and ground water are the main human-accessible freshwater resources (Liu et al.2019; Chen et al. 2020; Yariyan et al. 2020). Pressures on water resources are growing globally due to their extremely uneven geographical and temporal distribution. On the other side, individuals might not be aware of the locations and quantities of regional water resources, particularly for isolated alpine glaciers and snow and deep constrained groundwater (Somers et al.2020). Managing the distribution of water to fulfill the demands of human civilizations and the natural environment, (quality and quantity) is the emphasis of water resources engineering, which analyzes and designs systems to do this. (Alexandratos et al. 2020). Because these systems maintain our way of life and the ecosystems on which we depend, water resources are vital to society.

The storage, modeling, manipulation, retrieval, analysis, and presentation of spatial data are all supported by geographical information system (GIS) software's, which are computer-based information systems (Burrough et al. 2015, Joshi et al. 2019). This is a typical definition that does not emphasize how GIS can be used to integrate data-management activities and decision-making within an enterprise. A broader perspective holds that a GIS's function is to manage the built and natural environments and to provide a framework to enable decisions for the wise use of Earth's resources (Blair et al. 2019; Masoudi et al. 2021). GIS integrates databases providing attribute data on the features and displays information as maps and feature symbols. Knowing where things are, what they are, and how they are related can be learned by looking at a map. In addition, a GIS can provide a list of all the network nodes, offer tabular reports on the map's attributes, and allow simulations of river flows, trip times, or pollutant dispersion. GIS is very flexible, especially in terms of geographical analysis and modeling (visualization and processing), and management. (Li et al. 2020; Fernández et al. 2020; Abedi Gheshlaghi et al. 2020).

Water management engineering has undergone a revolution because to geographic information systems (GIS), which offer robust tools for spatial analysis, data fusion, and decision-making. In this article review we want to emphasize the critical functions of GIS in water management engineering. Reviewing data collection, processing, modeling, and visualization for GIS applications in water management, we examine the current state of the water management engineering fields. We showcase case examples that show how well GIS may be used to address diverse water management issues, such as assessing water resources, managing floods and droughts, monitoring water quality, and planning infrastructure. In order to improve decision-making and sustainably manage water resources, our findings highlight the significant contribution that GIS makes to the efficiency, effectiveness, and sustainability of water management practices. As a result, we call for greater integration and use of GIS into water management engineering processes.

2. Research methodology

The current investigation uses more than 40 articles related to GIS applications (spatial analysis, data preprocessing, or creating maps etc.) in water resources engineering. All of them have the common point of using GIS environment integrated with modern techniques like artificial intelligence and hydrological modeling in order to evaluate and management all kind of water resources. The articles utilized in this study have been carefully chosen based on a number of criteria, including being recent (primarily after 2018), valid sources from reputable scholarly publications with high-impact journals factors as illustrated in Table 1 that show some of these articles comprises in six sections (Application Fields).

Table 1: Geographic information systems (GIS) and water resources engineering applications articles published in scientific journals

Application Fields	Specific Contents	Reference
Water resources mapping and management	surface water Mapping	Ashtekar et al.2019
	surface water Mapping	Li et al. 2021
	surface water bodies monitoring	Ali et al. 2019
	ground water Mapping	Judeh et al. 2021
	Groundwater potential mapping	Phong et al. in 2021
Rainfall and runoff measurements	Rainfall-Runoff Simulation	Al-Ghobari et al. 2020
	Runoff estimation	Matomela et al., 2019
	rainfall estimation	Sishah, S. 2021
	developed rainfall-runoff models	Ben Khélifa, and Mosbahi 2022
Flood forecasting	Flood forecasting	Annis et al. 2019
	Flood modeling	Costache et al. 2020
	Flood frequency estimation	Abd Majid et al. 2020
	Flood areas estimation	Kombaitan et al. 2018
	Flood areas estimation	Ighile et al. 2022
Irrigation water	irrigation quality suitability	Singh et al. 2018
	Irrigation management and data visualization	Abera et al. 2021
	Irrigation management through various spatial data supported tools.	Jiménez et al. 2021
	Classify areas for irrigation	Chikabvumbwa et al. 2021
water quality	surface water quality	Chen et al. 2020
	assessing water quality	Tharmar et al. 2022
	assessing the suitability of drinking water	Piyathilake et al in 2022

	Reclassified ground water quality	Abijith et al. 2020
Drought monitoring	Drought events predicting	Habibie et al. 2020
	Drought events predicting	Rojas et al. 2021
	Drought events classifications	Elhaeesahar and Masoudi 2019
	Studding drought affect	Asbury and Aly 2019

3. The art of GIS and water resources management

The modeling required for managing water resources has continued to advance attributable to quickly evolving computer technology. An accurate and controllable method of gathering and analyzing modeling parameters linked to water resources engineering is through the use of GIS. It can be described as a piece of software that effectively connects graphical data to attribute information kept in a database and vice versa. GIS has been used in many contexts, such as water resource mapping, rainfall-runoff monitoring, flood forecasting, irrigation management, and drought monitoring both with and without model interface. The next sections provide detailed reviews of these applications using some published articles. Six topics were selected and discussed based on some scientific manuscripts published in this field, as follows.

3.1 GIS for water resources mapping

Water resources maps have been developed based on many techniques where the GIS environments, remote sensing and artificial intelligence are three examples of these techniques (Zhang et al. 2019; Hussain et al. 2022). Studies conducted on the water resources have shown that these resources are in most cases under motion or change their state and pressure with time. In this paragraph, some published articles were chosen for illustrating this issue. Surfaces water can exhibit significant variation, shifting between the wet and dry seasons of the year as well as geographically. It is difficult to map such variability, especially for short-lived episodes. Even while accurate mapping will result in improved management of water resources and a clearer understanding of interconnection and the implications of land management decisions, changes in surface water have a substantial impact on people and biodiversity. In a 2019 study, Ashtekar et al. attempted to map the surface water dynamics in several areas of the Upper Krishna River basin, Maharashtra State of India. By using cloud-free Landsat data sets, this study analyzed the surface water dynamics of the Sub-upper Krishna basin (SUKB) over a 17-year period from 1999 to 2016 using the normalized difference water index (NDWI) method. To comprehend the dynamics of the surface water over the study period, change detection is carried out and mapped utilizing GIS operations. The outcomes demonstrated the value of both the GIS for change detection analysis and the NDWI technique for mapping surface water, especially when it comes to simultaneously identifying changes over time.

The monitoring, management, and preservation of landscapes and ecosystems, as well as the mitigation of natural disasters, depend on accurate maps of surface water bodies. An automated surface water mapping methodology for Germany was proposed by Li et al. in 2021 using artificial intelligence models coupled with the GIS environment. The suggested model, known as ResNet+SNIC, had a high accuracy score of more than 86%. This study offers thorough insights into how to investigate the GIS's synergy with contemporary methods in a large-scale surface water mapping work. Ali et al. 2019 attempted to identify urban surface water bodies and track changes in these bodies from 2000 to 2019 based on some remote sensing indices (Normalized Difference Water Index (NDWI) and Modified Normalized Difference Water Index (MNDWI)). They did this by using Geographic Information Systems (GIS) in conjunction with remote sensing data. In Makassar, one of Indonesia's most populous cities, this study was carried out. In the study region, urban surface water bodies have grown by about 129.8 ha during the past nine years, according to the result, which is displayed on a map based on a GIS environment.

Accurate mapping of the groundwater potential zones would help in properly recharging the aquifer for the best use of groundwater resources by maintaining the balance between exploitation and consumption. Judeh et al. (2021) conducted a study to create a spatiotemporal mapping of the Portability Groundwater Quality Index (PoGWQI) and Palatability Groundwater Quality Index (PaGWQI) in the West Bank, Palestine, using a geographic information system (GIS) and the kriging interpolation method (KIM). The Palestinian Water Authority (PWA) provided data from 79 wells that were the basis for the study. One of the factors in the data is fecal coliform (FC), along with nitrate (NO3), pH, chloride (Cl), sulfate (SO4), bicarbonate (HCO3), total dissolved solids (TDS), turbidity, and hardness. Through the results gained from this study, Water decision-makers in Palestine are very interested in using the suggested method to develop plans to safeguard water supplies. Another groundwater mapping study was carried out in basaltic terrain at Daklak province, Highland Centre, Vietnam, by Phong et al. in 2021. It used a combination of modified RealAdaBoost (MRAB), bagging (BA), and rotation forest (RF) ensembles with functional tree (FT) base classifier. The suggested model is a promising hybrid AI method for accuracy (GPM).

3.2 GIS for rainfall-runoff measurements

The structure of every watershed environment is highly influenced by rainfall, runoff, and soil moisture conditions. The rainfall-runoff process explains how water during a storm event transitions from rainfall to runoff (Das 2019). Because rainfall-runoff processes reveal the hydrological properties of a watershed, hydrologists must investigate them. There has been an increase in interest in many researches about the use of GIS and RS integration to determine runoff generated by rainfall from watersheds. It is common practice in hydrology to use GIS programs to create inputs for distributed rainfall-runoff simulation models. Additionally, GIS helps engineers to track and research the development of droughts and floods as well as identify any areas that most vulnerable to extreme rainfall-runoff conditions. There are other ways to estimate runoff, but the Soil Conservation Curve Number (SCS-CN) method is popular and consistently produces accurate results when compared to other approaches. This technique uses a hydrologic parameter to represent the potential for storm water runoff in a drainage area. It depends on the type of soil, soil moisture, and land use land cover information therefore GIS can play a good role for geospatial distribution of these data (Al-Ghobari et al. 2020).

In their research of the Bojiang lake watershed in China, Matomela et al. indicated the use of the SCS-CN method in conjunction with GIS and Remote Sensing (RS) techniques to estimate daily, monthly, and yearly runoff for ungagged watersheds. The development of an attribute table, the creation of a weighted curve number, and overlaying of several theme layers all took place in a GIS environment. When the correlation coefficient (r) was employed, the relationship results showed an average runoff of 17.78 mm and or around 7.18% of the annual rainfall for the period (2001–2016). Sishah in 2021 used the GIS-based SCS-CN runoff simulation model to calculate rainfall runoff in Ethiopia's Awash river basin. Inputs for the SCS-CN runoff simulation model included the Global Curve Number (GCN250), High Soil Water Retention (S), and Rainfall. In the study region, runoff varied from 83.95 mm/year to a maximum of 1,416.75 mm/year. On the other hand, newly created Global Curve Number (GCN250) data that was to be an input for the SCS-CN runoff simulation model was tested with Pearson correlation coefficient. This allowed for the validation of the anticipated runoff produced by SCS-CN using GCN250 as a model input against actual runoff measured from station gauges in the research region. Ben Khélifa and Mosbahi 2021 created rainfall-runoff models utilizing HEC-HMS software in order to predict the real peak discharges and reproduce hydrographs linked to the significant events that occurred in a small urban ungauged watershed situated in the North-East of Tunisia.

To create geographical data regarding the research area and calculate hydrologic parameters, a GIS environment was used. Hydrological modeling for runoff estimation uses SCS-CN because of its precise results and small data needs. Urban watershed monitoring is not practiced in Tunisia; therefore field observations cannot be used to calibrate the model. The peak flow of food for various return periods was therefore approximated and estimated using the Rational Formula. The results showed that the peak flow from the 2003 rainfall event had a 100-year return time, but the peak flow from the 2019 simulation had a 20-year return period. Given the scarcity of observed data, these findings are useful for comprehending the size of severe rainfall events and for building the appropriate storm water systems in metropolitan regions.

3.3 GIS for Flood forecasting

Due of the numerous occurrences of floods that classified as river floods, mud floods, dam floods and flash floods around the world and their deadly effects, there has been a significant trend in recent decades to build real-time flood prediction models for early warning to the public. River flooding is mostly caused by prolonged, intense rain that exceeds the soil's capacity to absorb it (Annis et al. 2019). A flood is primarily limited to abrupt changes in high stream flow levels and is brought on by above-normal stream flow, which causes inundation of places that are typically not covered by water. The combination of Geographical Information System (GIS) with flood modeling has enabled the geographical representation of floods with variable recurrence durations. Otherwise, the accuracy of input data and the incorporation of GIS methodologies with machine learning and statistical approaches have a critical impact on the efficiency of GIS processing (Costache et al. 2022).

Abd Majid et al. conducted a study in 2020 represented by review approach to illustrate the main factors influencing the frequency of floods in Malaysia based on GIS. This review is concerned with the Geographic Information System (GIS) efficiency. According to the findings, the floods that have hit Malaysia in recent years have increased the threat of flooding. The variation in flood risk from year to year is due to environmental changes brought on by human activities, this study contributes to the body of knowledge on the integration of GIS application with factors effected by flooding. This is crucial to developing spatial analysis for GIS as a tool for Malaysian flood mitigation. This review document contains recent researches on flood risk mapping using GIS that identifies gaps that could provide a distinct viewpoint on future research on flood risk mitigation. Moreover, Floods in the same country- Majalaya, Kombaitan et al. 2018, conduct a study aims to develop a GIS application model to estimate flood areas and road network disruption due to flooding. The flood analysis model makes use of an advanced decision-based rule tree by using GIS software to merge some procedures like (thematic data and an SPSS software module) to produce a decision tree technique that can be used for flood monitoring.

Ighile et al. produced a flood susceptibility map in 2022 using a constructed model based on (GIS, logistic regression (LR) and artificial neural network (ANN)). This work was carried out in Nigeria, where historical flood records (1985–2020), meteorological, topography, and land use data were used to train and evaluate this model. This study came to the conclusion that by integrating the approaches utilized in the model's creation, it was possible to anticipate the study area's flood-prone zones and map these areas for future decision-makers to use when preventing or reducing flood risks.

3.4 GIS for irrigation management

Both quantitative and qualitative factors are involved in the availability of water for irrigation. Moreover, irrigation quality is frequently disregarded. Irrigation water quality can be assessed using appropriate monitoring and evaluation methods, expertise, and judgment about the suitability of the water source (Singh et al. 2018). Irrigated agriculture is regarded as one of the world's biggest users of water and plays a significant and crucial part in satisfying the need for food from the expanding population (Abdelhaleem et al. 2021). The importance of GIS for irrigation water resources was covered by Abera et al. in 2021. They suggested that the majority of the data used to control and monitor irrigation water are intricate and geographically connected. The amount of irrigation water used was calculated using the expected irrigated land area of the Lake Tana basin in Ethiopia and the irrigation water requirements of the main crops grown with irrigation. According to this assessment, unless alternate water sources are discovered, the anticipated irrigation expansion cannot be supported by the current water supply. GIS provides efficient tools to deal with such data complexity. GIS also found to be very useful by the authors for spatial and temporal data visualization and mapping. This visualization and mapping usually help farmers and irrigation experts for better and faster decision-making. They also discussed the capability of GIS environment for water irrigation management through various spatial data supported tools. Model Builder and/or Python programming can be used to modify the GIS environment to fit with certain applications. The design and execution of an irrigation agent-based model (IABM) for the distribution of water in an irrigation district are presented by Jiménez et al. in 2021. By employing 25% of the allowable level of moisture depletion relative to the total amount of accessible water in each field, this model avoids as much as possible that the soil water stress grows and satisfies the needs of the greatest number of agents.

In most regions of the world, it is very typical to apply conventional site selection techniques for possible irrigation schemes. The ecosystem has suffered greatly as a result of the excessive reliance on these techniques, including (pollution, siltation, land degradation, and soil erosion). Conventional irrigation site selection is a difficult operation that takes a lot of time, money, and data sets to complete. Yet, improvements in geographic information systems offer a chance to quickly combine intricate systems with several data sets. Using hybrid spatial datasets, Chikabvumbwa et al., 2021 perform a study to locate prospective irrigation farming locations in Malawi's Kasungu district. Due to its capability of managing complicated and enormous volumes of datasets, the study found that the use of GIS in irrigation site selection is flexible and time efficient. Also, the maps that were created made it simpler to grasp the places that had been identified, aiding in the decision-making process for environmental management. Additionally, in an effort to limit soil erosion, enhance land management, and lessen pollution, this study provides helpful information on promoting the use of GIS to address site selection difficulties. The study recommends increasing the use of GIS in government sectors to enhance decision-making for the advancement of sustainable irrigation.

3.5 GIS for water quality

Remote sensing provides Water Quality (WQ) data with a high spatial and temporal resolution for thousands of surface water locations, while the ground water quality can be found by chemicals analysis tests. GIS can supports remote sensing and chemicals analysis test to evaluate the environmental problems and potential health risks through the analysis of changes in water quality and the detection of harmful algal blooms and diseases. To clarify the ability of geographic information systems in this field, the following studies were used, where Chen et al in 2020 makes a connection between the alteration of land use and its effects on the surface water quality of Mitidja river basin's north of Algeria. The relationship between land use change and the surface water quality index was addressed using GIS and statistical analysis based on three years of data. This used data represent the land use and surface water quality. The findings of this study demonstrate the physical and chemical regional variation of the river basin. Upstream water quality was superior to downstream water quality. The three categories of land use, urban residential land, agricultural land, and vegetation cover and the surface water quality indicators had a substantial geographical association. In order to clearly understand the variation in chemical composition across the entire Thamirabarani river, located in southern India, 12 spatial interpolation maps were created by Tharmar et al. in 2022 when they conducted a study that assesses and analysis the WQ in this river. The water quality of this river was investigated and classified into four categories based on twelve WQ parameters data for the period (2020 and 2021). Principal Component analysis (PCA) was used to classify these categories (Zone 1 = water alkalinity, zone 2 and 3= water effected by industrial wastes and zone 4= water effected by see water intrusion) that represent the variance coverage for the overall WQ.

The relationship between the prevalence of chronic kidney disease and the quality of drinking water was investigated by assessing the suitability of drinking water in Uva province, Sri Lanka (Piyathilake et al. in 2022). This study depends on 251 groundwater samples. The geographical location of these samples was determined and a map representing these sites was prepared using the Geographic Information System. After analyzing these samples from a chemical point of view, the water quality was classified into four categories. The study concluded, and through the statistical analysis of WQ, that there is a positive relationship between the spatial distribution between the locations of the samples taken and the areas of presence of patients with kidney failure. Spatial distribution maps were prepared for the results of the study, as these maps will help decision makers prepare appropriate solutions to improve water quality or find new sources of drinking water in areas that suffer from high incidence of this disease. Moreover, it can be found in lava tunnels in basalt rocks and cavities in limestone. Due to its favorable characteristics, including stable temperature, widespread availability, low vulnerability to contamination, low development costs, and drought dependability, groundwater is regarded as one of the most important and valuable water resources for use by the general public, agriculture, and industries. Abijith et al. categorized the ground water in India's Ponnaniyaru watershed in 2020 and divided it into five categories (Very poor, Poor, Moderate, Good, and Very good).

3.6 GIS for drought monitoring

Humanity has been impacted by drought than any other natural disaster over the previous 40 years, including significant portions of the population, livestock, and livelihoods. According to recent forecasts, drought events are predicted to become more frequent and intense as a result of climate change, also due to the threat it poses to our planet, drought is one of the biggest problems of our day (Habibie et al. 2020; Rojas 2021; Hashim and Sayl 2021). It also presents a huge potential for big data analysis because it raises new issues with data (meteorological, hydrological, and land use/land cover), modern methodologies (AI, RS, GIS, and statistical analysis), and evaluation (monitoring, performance accuracy and, spatial distributions). In reality, monitoring a drought requires a large amount and a variety of data that are produced and must be processed quickly (data velocity) with a high level of authenticity were these data can be processed using ideal deferent procedures.

Anew model of drought hazard was made for Khuzestan province, Iran by Elhaeesahar and Masoudi in 2019 using GIS. The results of this study stated that there were five different drought hazard classes (none, minor, moderate, severe, and very severe. The final drought vulnerability map was created by superimposing three criteria maps using geographic information systems (GIS), and the final hazard classes were established using hazard scores that were calculated using the essential key factores. The final vulnerability map revealed that places under the slight hazard class are significantly more sparsely distributed than the 29% of the province's severe hazard zones, which were found in the research area's northern and central regions. In 2019, Asbury and Aly combined remote sensing and Geospatial Information System (GIS) technologies to study how drought affected 10 different surface water reservoirs in San Angelo and Dallas, USA. This geospatial study illustrates the social advantages of using RS and GIS to look at geo-environmental issues linked to significant climate change.

4. Results and Dissection

The great benefit of applying GIS in the field of water lies in the fact that it enables workers in the water field (hydraulic and hydrology) to link geographical information such as water basins with graphic information such as rainfall, water level height, and using this information with each other to conduct analyzes to benefit including the construction of dams and reservoirs, and also helps in studying the state of groundwater, excessive ground water pumping, seawater intrusion, irrigation water, drought monitoring and water quality. For gathering, storing, querying, investigating, managing, and visualizing spatial data, a GIS environment was developed. Geospatial data includes both the geographic position and the characteristics of spatial features. In addition to geospatial data, GIS also includes other components like (hardware, software, people, and organizations). At all levels, GIS is used by individuals, groups, businesses, government agencies, academic institutions, and researchers.

5. Conclusion

An efficient technology that enables us to obtain results through spatial and visual interpretation is the geographic information system. The use of GIS technology, as discussed above, dramatically improves hydrologic studies of surface and ground water. The GIS's data processing and manipulation capabilities effectively manage the large amounts of spatial data linked to watershed characteristics and parameters, and its effective mapping features provide a clear visual representation of all connected aspects. The specialized GIS applications examples in water resources engineering are discussed according to several publish papers as:

Hydrologic and hydraulic models that replicate how water behaves in a watershed are created and operated using GIS. This assists engineers in forecasting concerns with drought, flooding, irrigation managements and water quality. Rainfall-runoff models help to quantify the amount of runoff resulting from a rainfall event. Since the runoff depends largely on watershed characteristics, GIS can play a very important role in rainfall-runoff modeling. Integration of hydrological models with the spatial data provides distributed information about the hydrological processes. Various researches have successfully integrated the GIS with hydrological models by storing the hydrological data in GIS environment. Flood susceptibility mapping is essential for preventing flood disasters because it can pinpoint the most vulnerable areas and forecast potential susceptibility hotspots giving emergency response and evacuation authorities more knowledge for planning and responding in extremely high susceptibility areas. Using GIS, digital maps of areas that are likely to be inundated during a flood event are produced. Planners and emergency managers utilize this data to pinpoint high-risk locations and make preparations for mitigating actions.

In planning for water supply, GIS is used to map water infrastructure, including reservoirs, pipelines, and treatment facilities. Engineers can use this information to locate places at danger of water shortages and to plan the construction of new infrastructure to handle anticipated growth. Also, in groundwater modeling, engineers may develop digital representations of groundwater resources when using GIS, which help them better, understand how groundwater moves through aquifers and foresee the effects of pumping on water quality and levels. When engineers try manage the water quality, using GIS is a better procedure to visualize data on water quality, including temperature, dissolved oxygen levels, and nutrient concentrations. This aids engineers in locating regions that are vulnerable to contamination and in formulating plans for lowering water pollution. Also to maximize irrigation water efficiency and reduce water waste, GIS was used to create irrigation management strategies to find the best amount of irrigation water for each crop using different type of data like soil types, crop types, and weather data etc. The overall conclusion of this review state that GIS is an effective tool for managing geographic data associated with water resources, enabling engineers to analyze water resource data, which in turn aids in managing and safeguarding this vital resource.

References

Abd Majid, N., Razman, M. R., Syed Zakaria, S. Z., Ahmed, M. F., & Zulkafli, S. A. (2020). Flood disaster in Malaysia: Approach review, causes and application of geographic information system (GIS) for mapping of flood risk area. *Ecology, Environment and Conservation*, *27*(May), 1-8.

Abdelhaleem, F. S., Basiouny, M., Ashour, E., & Mahmoud, A. (2021). Application of remote sensing and geographic information systems in irrigation water management under water scarcity conditions in Fayoum, Egypt. *Journal of Environmental Management*, *299*, 113683.

Abedi Gheshlaghi, H., Feizizadeh, B., & Blaschke, T. (2020). GIS-based forest fire risk mapping using the analytical network process and fuzzy logic. *Journal of Environmental Planning and Management*, *63*(3), 481-499.

Abera, A., Verhoest, N. E., Tilahun, S., Inyang, H., & Nyssen, J. (2021). Assessment of irrigation expansion and implications for water resources by using RS and GIS techniques in the Lake Tana Basin of Ethiopia. *Environmental Monitoring and Assessment*, *193*(1), 1-17.

Abijith, D., Saravanan, S., Singh, L., Jennifer, J. J., Saranya, T., & Parthasarathy, K. S. S. (2020). GIS-based multi-criteria analysis for identification of potential groundwater recharge zones-a case study from Ponnaniyaru watershed, Tamil Nadu, India. *HydroResearch*, *3*, 1-14.

Alexandratos, S. D., Barak, N., Bauer, D., Davidson, F. T., Gibney, B. R., Hubbard, S. S., & Westerhof, P. (2019). Sustaining water resources: Environmental and economic impact. *ACS Sustainable Chemistry & Engineering*, *7*(3), 2879-2888.

Al-Ghobari, H., Dewidar, A., & Alataway, A. (2020). Estimation of surface water runoff for a semi-arid area using RS and GIS-based SCS-CN method. *Water*, *12*(7), 1924.

Ali, M. I., Dirawan, G. D., Hasim, A. H., & Abidin, M. R. (2019). Detection of changes in surface water bodies urban area with NDWI and MNDWI methods. *International Journal on Advanced Science Engineering Information Technology*, *9*(3), 946-951.

Annis, A., & Nardi, F. (2019). Integrating VGI and 2D hydraulic models into a data assimilation framework for real time flood forecasting and mapping. *Geo-spatial Information Science*, *22*(4), 223-236

Asbury, Z., & Aly, M. H. (2019). A geospatial study of the drought impact on surface water reservoirs: study cases from Texas, USA. *GIScience & Remote Sensing*, *56*(6), 894-910.

Ashtekar, A. S., Mohammed-Aslam, M. A., & Moosvi, A. R. (2019). Utility of normalized difference water index and GIS for mapping surface water dynamics in sub-upper Krishna Basin. *Journal of the Indian Society of Remote Sensing*, *47*(8), 1431-1442.

Ben Khélifa, W., & Mosbahi, M. (2022). Modeling of rainfall-runoff process using HEC-HMS model for an urban ungauged watershed in Tunisia. *Modeling Earth Systems and Environment*, *8*(2), 1749-1758.

Blair, G. S., Henrys, P., Leeson, A., Watkins, J., Eastoe, E., Jarvis, S., & Young, P. J. (2019). Data science of the natural environment: a research roadmap. *Frontiers in Environmental Science*, *7*, 121.

Burrough, P. A., McDonnell, R. A., & Lloyd, C. D. (2015). *Principles of geographical information systems*. Oxford university press.

Chen, D., Elhadj, A., Xu, H., Xu, X., & Qiao, Z. (2020). A study on the relationship between land use change and water quality of the Mitidja watershed in Algeria based on GIS and RS. *Sustainability*, *12*(9), 3510.

Chikabvumbwa, S. R., D. Sibale, and S. W. Chisale. "Irrigation site selection using hybrid GIS-based approach." *International Journal F Human Capital in Urban Management* 6, no. 2 (2021): 149-158.

Costache, R., Hong, H., & Pham, Q. B. (2020). Comparative assessment of the flash-flood potential within small mountain catchments using bivariate statistics and their novel hybrid integration with machine learning models. *Science of The Total Environment*, *711*, 134514.

Das, S. (2019). Extreme rainfall estimation at ungauged sites: Comparison between region-of-influence approach of regional analysis and spatial interpolation technique. *International Journal of Climatology*, *39*(1), 407-423.

Elhaeesahar, M., & Masoudi, M. (2019). GIS analysis for vulnerability assessment of drought in Khuzestan province in Iran using standardized precipitation index (SPI).

Fernández Moniz, P., Almeida, J. S., Pino, A. T., & Suárez Rivero, J. P. (2020). A GIS-based solution for urban water management. *Water International*, *45*(6), 660-677.

Habibie, M. I., Ahamed, T., Noguchi, R., & Matsushita, S. (2020, December). Deep learning algorithms to determine drought prone areas using remote sensing and GIS. In *2020 IEEE Asia-Pacific Conference on Geoscience, Electronics and Remote Sensing Technology (AGERS)* (pp. 69-73). IEEE.

Hashim, H. Q., & Sayl, K. N. (2021). Detection of suitable sites for rainwater harvesting planning in an arid region using geographic information system. *Applied Geomatics*, *13*(2), 235-248.

Hussain, A., Madan, R., & Kamboj, V. (2022). Applications of remote sensing and GIS in hydrological and hydrogeological studies: integrated watershed management. In *Addressing Environmental Challenges Through Spatial Planning* (pp. 237-251). IGI Global.

Ighile, E. H., Shirakawa, H., & Tanikawa, H. (2022). Application of GIS and Machine Learning to Predict Flood Areas in Nigeria. *Sustainability*, *14*(9), 5039.

Jiménez, A. F., Cárdenas, P. F., & Jiménez, F. (2021). Smart water management approach for resource allocation in High-Scale irrigation systems. *Agricultural Water Management*, *256*, 107088.

Joshi, N., Bista, A., Pokhrel, I., Kalra, A., & Ahmad, S. (2019, May). Rainfall-Runoff Simulation in Cache River Basin, Illinois, Using HEC-HMS. In *World environmental and water resources congress* (Vol. 2019, pp. 348-360).

Judeh, T., Bian, H., & Shahrour, I. (2021). GIS-based spatiotemporal mapping of groundwater potability and palatability indices in arid and semi-arid areas. *Water*, *13*(9), 1323.

Kombaitan, B., Yudoko, G., & Purboyo, H. (2018). Application of GIS on determination of flood prone areas and critical arterial road network by using CHAID method in bandung area. In *MATEC Web of Conferences* (Vol. 147, p. 02007). EDP Sciences.

Li, H., Zech, J., Ludwig, C., Fendrich, S., Shapiro, A., Schultz, M., & Zipf, A. (2021). Automatic mapping of national surface water with OpenStreetMap and Sentinel-2 MSI data using deep learning. *International Journal of Applied Earth Observation and Geoinformation*, *104*, 102571.

Liu, J., Gao, Z., Wang, M., Li, Y., Yu, C., Shi, M., ... & Ma, Y. (2019). Stable isotope characteristics of different water bodies in the Lhasa River Basin. *Environmental Earth Sciences*, *78*, 1-11.

Masoudi, M., Centeri, C., Jakab, G., Nel, L., & Mojtahedi, M. (2021). GIS-based multi-criteria and multi-objective evaluation for sustainable land-use planning (case study: Qaleh Ganj County, Iran) “landuse planning using mce and mola”. *International Journal of Environmental Research*, *15*, 457-474.

Matomela, N., Tianxin, L., Morahanye, L., Bishoge, O. K., & Ikhumhen, H. O. (2019). Rainfall-runoff estimation of Bojiang lake watershed using SCS-CN model coupled with GIS for watershed management. *J Appl Adv Res*, *4*(1), 16-24.

Phong, T. V., Pham, B. T., Trinh, P. T., Ly, H. B., Vu, Q. H., Ho, L. S., ... & Prakash, I. (2021). Groundwater Potential Mapping Using GIS-Based Hybrid Artificial Intelligence Methods. *Groundwater*, *59* (5), 745-760.

Piyathilake, I. D. U. H., Ranaweera, L. V., Udayakumara, E. P. N., Gunatilake, S. K., & Dissanayake, C. B. (2022). Assessing groundwater quality using the water quality index (WQI) and GIS in the Uva Province, Sri Lanka. *Applied Water Science*, *12* (4), 72.

Rojas, O. (2021). Next generation agricultural stress index system (ASIS) for agricultural drought monitoring. *Remote Sensing*, *13* (5), 959.

Sishah, S. (2021). Rainfall runoff estimation using GIS and SCS-CN method for awash river basin, Ethiopia. *Int. J. Hydrol*, *5*, 33-37.

Singh S, Ghosh NC, Gurjar S, Krishan G, Kumar S, Berwal P. 2018. Indexbased assessment of suitability of water quality for irrigation purpose under Indian conditions. Environmental Monitoring and Assessment 190 (29): 1–14.

Somers, L. D., & McKenzie, J. M. (2020). A review of groundwater in high mountain environments. *Wiley Interdisciplinary Reviews: Water*, *7* (6), e1475.

Tharmar, E., Abraham, M., Prakash, R., Sundaram, A., Flores, E. S., Canales, C., & Alam, M. A. (2022). Hydrogeochemistry and Water Quality Assessment in the Thamirabarani River Stretch by Applying GIS and PCA Techniques. *Sustainability*, *14* (24), 16368.

Yariyan, P., Avand, M., Abbaspour, R. A., Karami, M., & Tiefenbacher, J. P. (2020). GIS-based spatial modeling of snow avalanches using four novel ensemble models. *Science of the Total Environment*, *745*, 141008.

Zhang, F., Yushanjiang, A., & Jing, Y. (2019). Assessing and predicting changes of the ecosystem service values based on land use/cover change in Ebinur Lake Wetland National Nature Reserve, Xinjiang, China. *Science of the Total Environment*, *656*, 1133-1144.