A

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"APPLICATION OF GIS ON WATER RESOURCES"

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CERTIFICATE

This is to certified that the project entitled "**APPLICATION OF GIS ON WATER RESOURCES**" has been submitted to the Rajasthan Technical University, Kota fulfillment of the requirement for the award of the degree of Bachelor of Technology in "Civil Engineering" by following student of final year B.Tech. (Civil Engineering).

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ABSTRACT

Increasing public awareness, stricter measures and promulgation of new laws in the area of water resources have made the use of advanced technologies indispensable. Geographic information systems (GIS) are an effective tool for storing, managing, and displaying spatial data often encountered in water resources management. The application of GIS in water resources is constantly on the rise. In order to stress the importance of GIS in water resources management, applications related to this area are addressed and evaluated for efficient future research and development. Fundamentals of GIS are summarized and the history of the GIS evolution in water resources is discussed. Current GIS applications are presented including surface hydrologic and ground water modeling, water supply and sewer system modeling, storm water and nonpoint source pollution modeling for urban and agricultural areas, and other related applications. Future research and development needs are presented, based on these reviews.

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1. INTRODUCTION

Water resource applications of GIS are concerned with the hydrologic cycle and related processes. They are multi-faceted because: (1) many of the problems involve interactions between the hydrosphere, atmosphere, lithosphere, and biosphere; (2) solutions must serve competing groups of users; and (3) many of the important hydrologic processes have local, regional, national, and global dimensions (Naiman at 1997; National Research Council 1999). Moreover, it is sometimes difficult to translate research outcomes into management strategies because much of the fundamental hydrologic research is conducted at specific sites or on small plots and many of the management strategies are focused on watersheds and/or administrative jurisdictions

The immediate challenges in the water resource domain are:

- To identify the ways in which GIS can facilitate more effective and/or more efficient water resource management.
- To develop GIS-based methods that address specific water resource challenges and problems.
- To train the next generation of water resource scientists, engineers, and policy analysts to sustain the continued evolution and appropriate use of GIS-based water resource applications.

These challenges are substantial and a range of solutions will be required because of the dramatic change in watershed management that has occurred during the past 5-10 years. There has been a shift from large government-directed regulatory programs towards local initiatives with government providing some support. The main participants are land owners, often organized into associations, such as the Land care programs in Australia and New Zealand or watershed associations here in the US (EPA has already over 4,000 such associations registered). This will have a profound impact on the GIS tools that are being developed for water resources management. The target is no longer large government organizations with professional staff and we will need tools for retrieving and analyzing watershed information that can be used by people who are not specialists and are located in many different places. That means that a wider range of different tools at different levels are needed, from complex and sophisticated to very simple ones. These tools will need to operate at the watershed level in the future as well. The National Research Council (1999), for example, recently argued that watersheds as geographic areas are the natural organizing units for dealing with the management of water and closely related problems.

Viewed this way, water resource assessment and management are inherently geographical activities. Some combination of GIS and simulation models will be required to improve our knowledge in these areas. GIS offers powerful new tools for the collection, storage, management, and display of map-related information, whereas simulation models can provide decision-makers with interactive tools for understanding the physical system and judging how management actions might affect that system (National Research Council 1999). The five subsections that follow illustrate some of the ways in which GIS has already been used to advance water resource management.

2. GIS IN WATER RESOURCES

GIS is, however used in various activities involving water management. Water management using GIS is beneficial for monitoring water resources.

- **List of Uses of GIS in Water Resources**

1. Storage and management of geospatial data
2. Hydrologic management
3. Modelling of groundwater
4. Quality analysis of water
5. Water supply management
6. Sewer system
7. Storm water control and Floods disaster management

2.1. Storage and management of geospatial data:

Geographic information Systems keep data and records about water sources. The data collected about water resources is stored on servers in different parts of the world. Some of the information is usually as a result of processing done on data collected by GIS. Huge amounts of data related to water resources can thus be stored for shared access with the help of GIS. Big externally launched geospatial satellites that are always on motion and rotating near the earth's atmosphere are integrated with GIS and then used to help in inter-continental data and information dissemination. The satellite provides wireless data access to all base stations that request for the geospatial data. Most Geographic Information systems also offer cloud-based platforms. This means that geospatial centers in any part of the world can have access to data stored in any of the GIS servers. This pervasiveness and flexibility of data and information access is part of the applications or uses of GIS.

2.2. Hydrologic management:

Studies on the water have shown that water is in most cases under motion, or changes its state and pressure with time. GIS comes to play a big part in keeping track of these water conditions. Hydrologists are thus among the biggest beneficiaries of Geographic information systems. Various studies on the water can be accomplished using well-engineered GIS. Hydrogeology, for example, is a discipline that investigates groundwater together with its storage, occurrence, and motion characteristics. The nature and characteristics of water stored underground or one which is on the surface either stagnant or in motion can be entered into GIS as data, stored and retrieved for future processing by the geographic Information System.

2.3. Modeling of groundwater:

Groundwater Modeling involves the hydrologists trying to understand groundwater behavior and characteristics**.** Bearing in mind the scarcity of water so much study can be done to protect water catchment areas. GIS can also help in the creation of models and designs to help utilize underground water responsibly. Soil properties and other geographic features are natural to investigate using GIS in relation to ground water. Digital images on groundwater can then be created, for example, by the use of magnetic fields during investigations and case studies.

2.4.Quality analysis of water:

Not all water that exists on earth is safe for consumption by human beings or animals. Taking unsuited water can lead to adverse health conditions. Through GIS, studies on a slope, drainage features, and land utilization patterns can be used to predict whether the water in a given area is safe. Due to the ability of GIS to handle large amounts of data sets, sample data can be processed, stored as well as reports generated. These reports can be used by the relevant organization or even the government to make future study and regulations on water and to determine whether the water is safe for human consumption.

2.5. Water supply management:

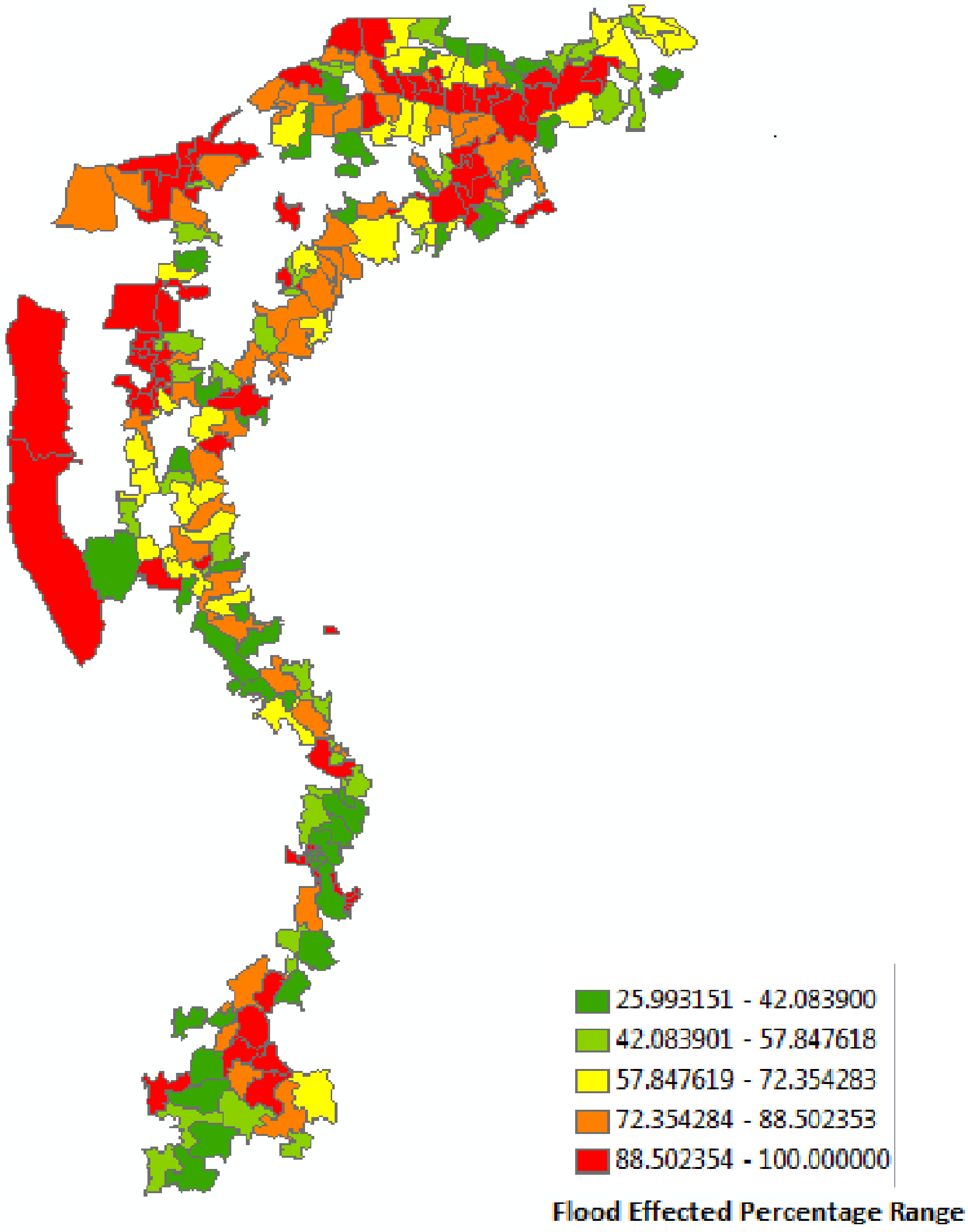
As we have seen earlier rain is a handy resource that no government or individual can afford to waste. Water supply pipes are laid on the ground and can be monitored on a real-time basis. Leaking water system components can also be identified and fixed on a real-time basis, which is much possible due to the integration of supply systems with GIS.

2.6. Sewer system management:

Most of the human waste in most parts of the world are treated and conveyed to water bodies. However, strict and accurate supervision of sewer lines must be periodically made. Failure to manage the sewer system well can lead to diseases outbreaks that lead to degrading the country’s economy. GIS has also played a commendable role in sewer system management. Treatment of sewage can also be done with the help of GIS. Proper and mapping techniques that are delivered by these information systems on sewer lines are also important as they prevent damaging waste pipes during construction of structures like buildings, roads, railways among many others.

2.7. Storm water control and Floods disaster management:

During floods and storms, it is most likely, that water will accumulate in places inhabited by human beings. This can prove challenging for the rescue team to go into rescue operations with little information about the flooded areas. Geographic information System has to help emergency rescue teams to their services safely and professionally. Thus in such instances of flood disasters and harsh weather condition, GIS can be used to give statistics on affected areas, enable the government to plan evacuation as well as can be integrated with weather forecasting systems to offer an accurate prediction and decision making. Aerial views and simulation of the floods can also be made using special system components and tools that rely on Geographic Information Systems.



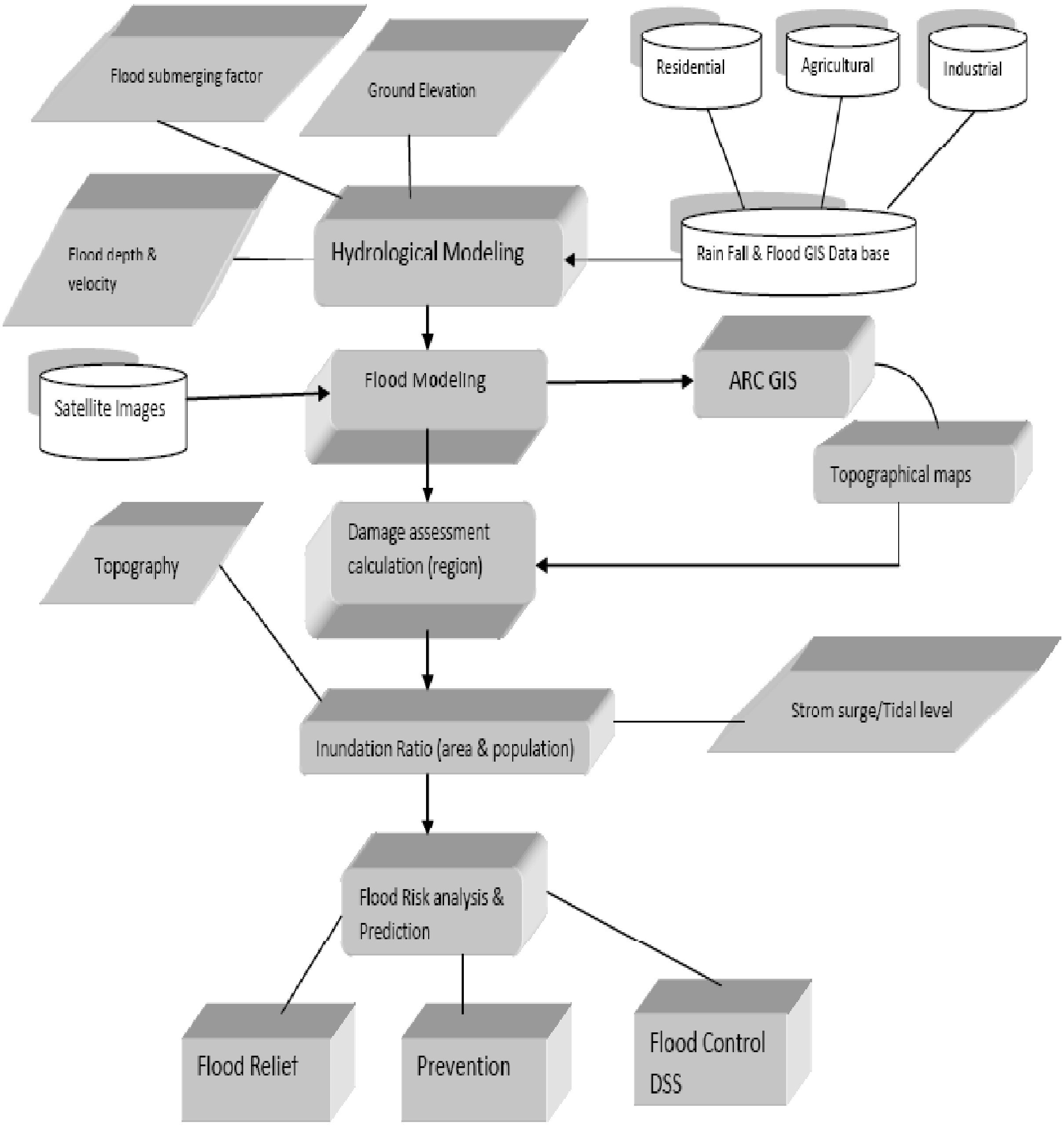


Figure 2: Flood Relief Analysis and Prediction

3. SOFTWARE USED FOR GIS IN WATER RESOURCES:

There are many software used for GIS in water resources. The use of software improves the transparency of water resources and environmental evaluations since the results can be shared, supervised and observations can be made. There are following software :

(a) GEOGRAPHIC INFORMATION SYSTEM

1. QGIS

2. SAGA GIS

(b) RIVER MODELING

3. HEC-RAS

4. IRIC

(c) HYDROLOGIC MODELING

5. HEC-HMS

6. SWAT

(d) HYDROGEOLOGICAL MODELING

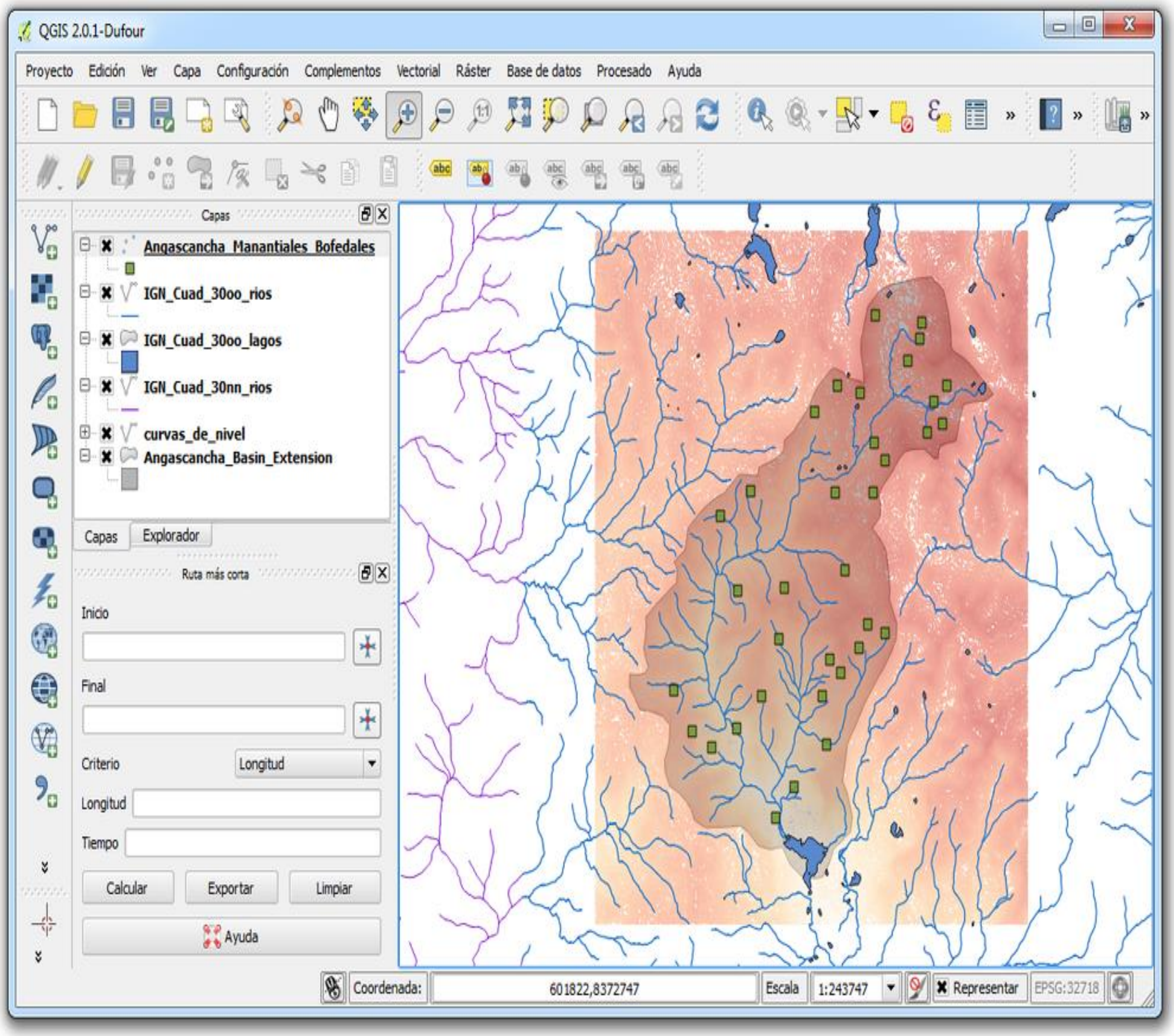
7. MODFLOW

8. MT3DMS

3.1 GEOGRAPHIC INFORMATION SYSYTEM

3.1.1 QGIS

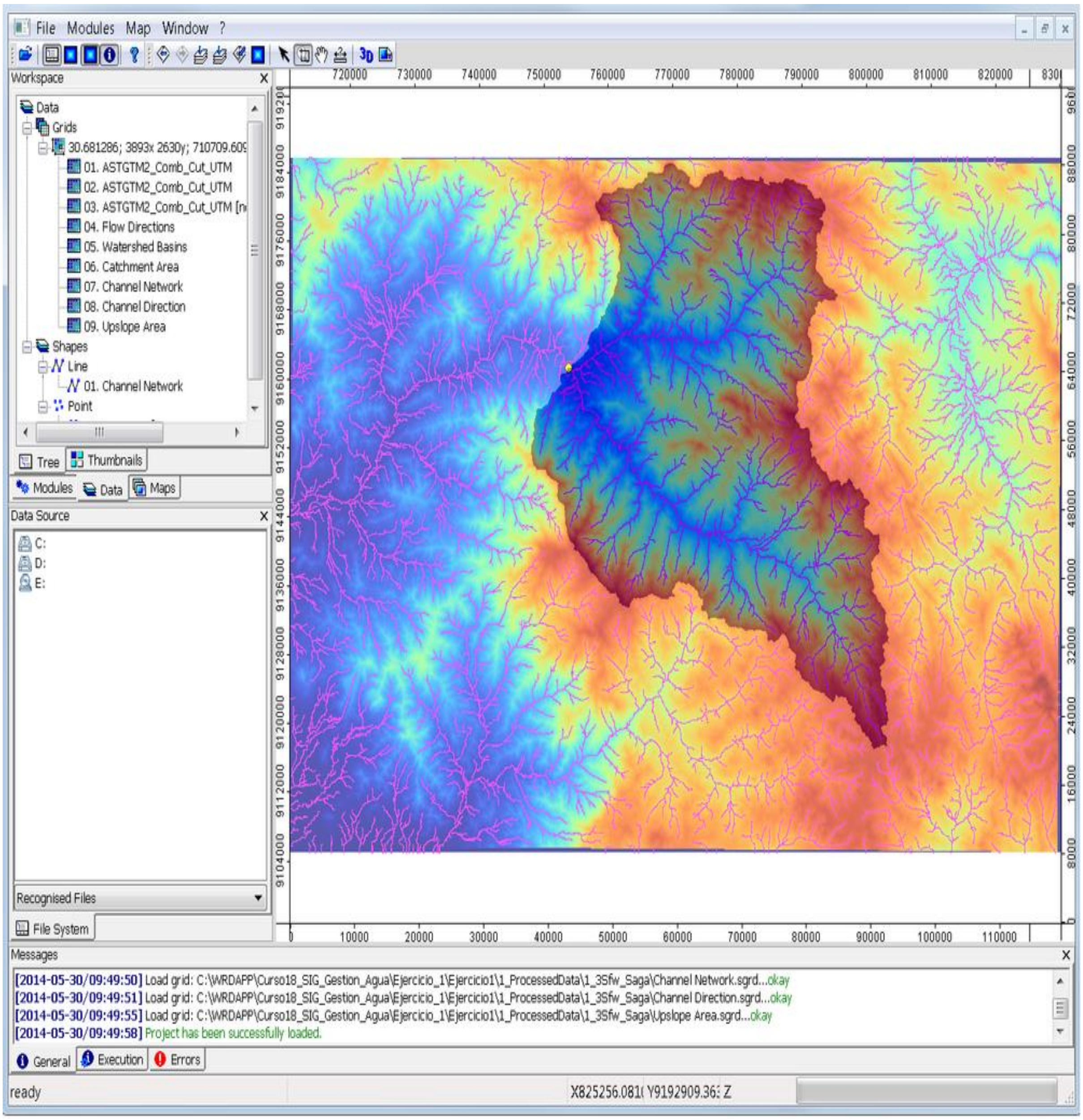
QGIS is the most popular GIS tool with an impressive trajectory and a vibrant community. It also even has a particular ecosystem of complements called “plugins”. QGIS is a completely open source alternative that reduces the cost barriers since it does not need a paid license and can be executed in any operative system.



3.1.2. SAGA GIS

SAGA GIS is a GIS platform oriented to spatial analysis. SAGA GIS is a simple but powerful tool, with a big library focused on spatial analysis and characterization of basins.

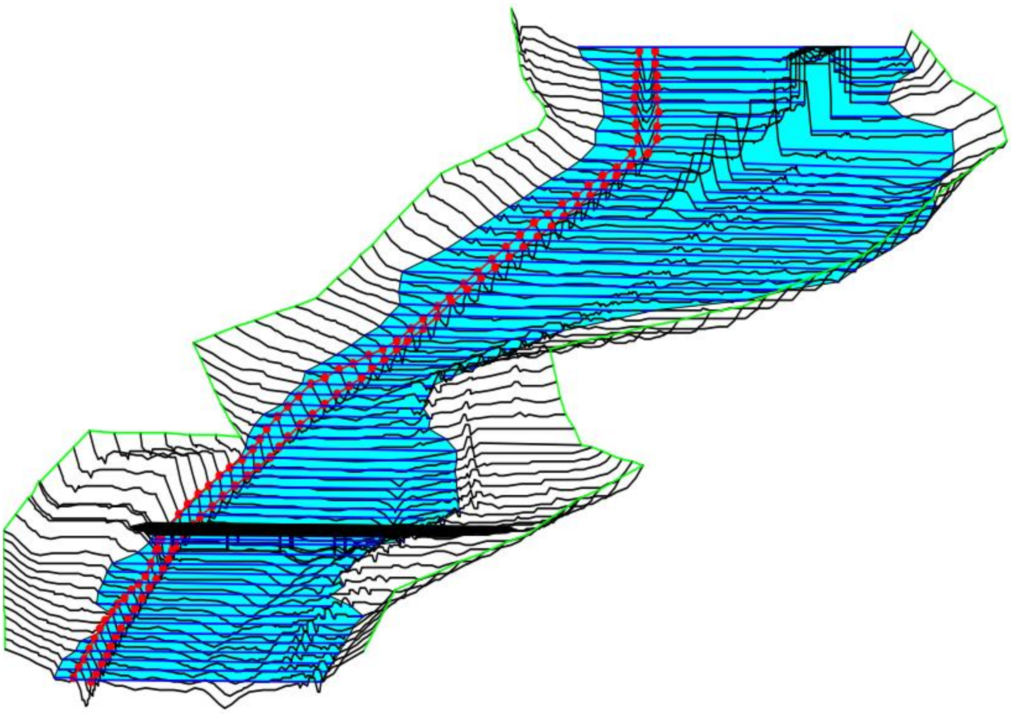
The interpolation options in SAGA GIS are better implemented than in other free and commercial software.



3.2. River modelling

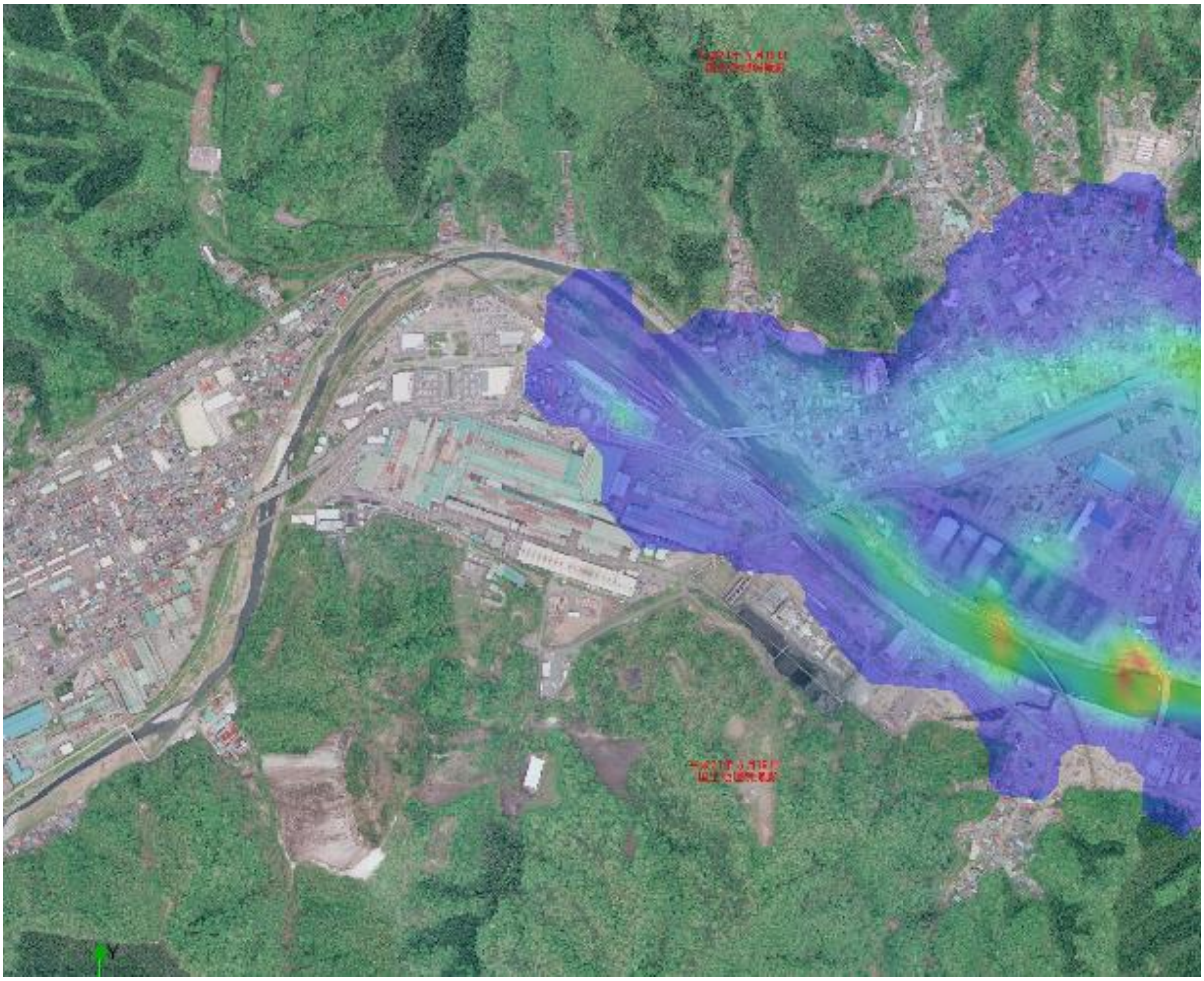
3.2.1. HEC-RAS

The numerical model HEC-RAS is developed by the U.S. Army Corps of Engineers. This model uses the gradient and topography to evaluate the flow depth, velocities and flooded zones. It is also useful to calculate sediment transport and water temperature.



3.2.2. IRIC

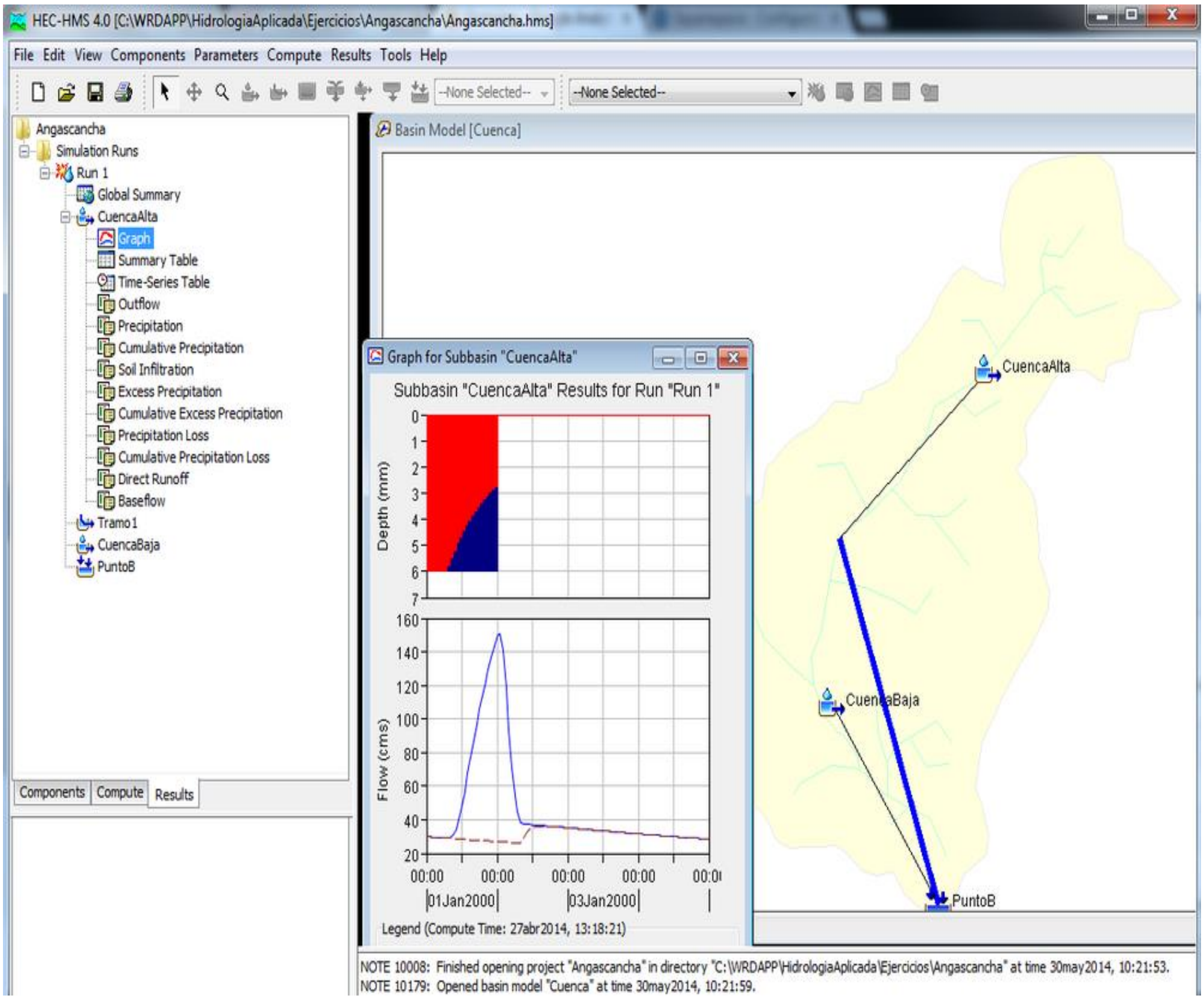
IRIC (International River Interface Cooperative) is a software developed with the purpose of offering a complete simulation environment of the riverbed and its results can be exported and used to analyse, mitigate and prevent disasters, through the visualization of the results of the river simulation.



3.3. Hydrologic modelling

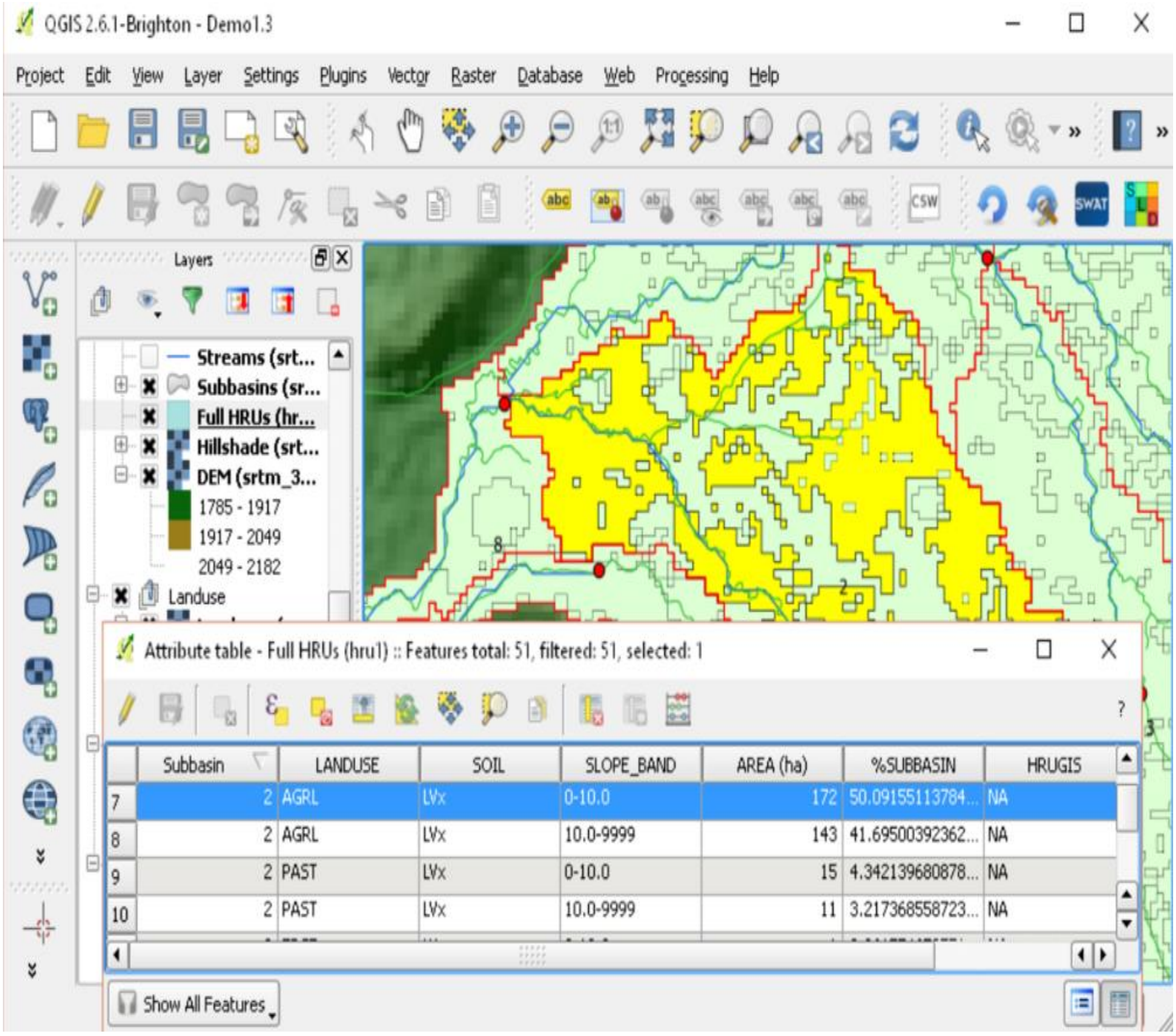
3.3.1. HEC-HMS

The Hydrologic Modelling System (HEC-HMS) is designed to simulate the hydrologic processes in basins. The software includes traditional procedures of hydrologic analysis, such as infiltration events, unit hydro-grams and routing. HEC-HMS also includes modules for evapotranspiration, snow melting and calculus of soil humidity.



3.3.2. SWAT

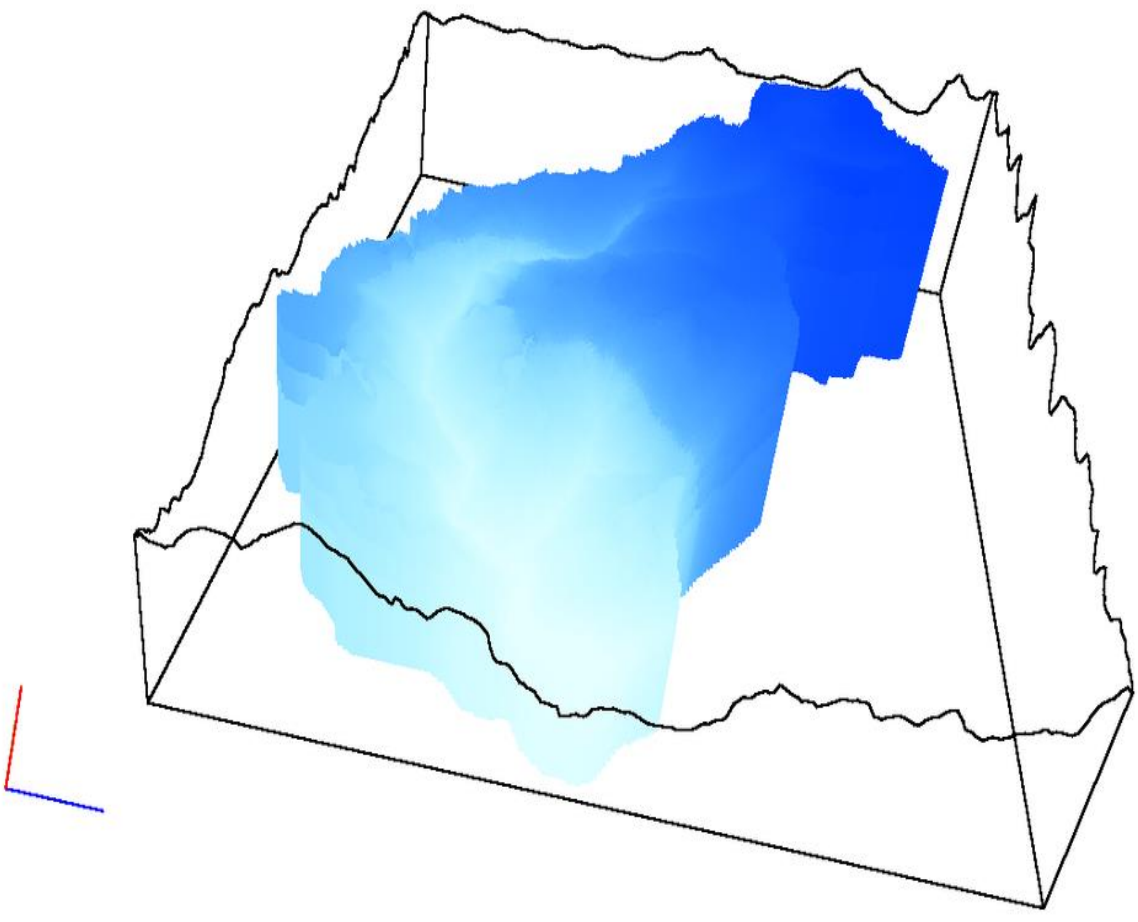
SWAT is a tool to evaluate soil and water at a basin scale. It is focused in precipitation-runoff modelling and transport of water and solutes through surface flow. It predicts the impacts of soil management practices in water resources and sediments



3.4. Hydrogeological modelling

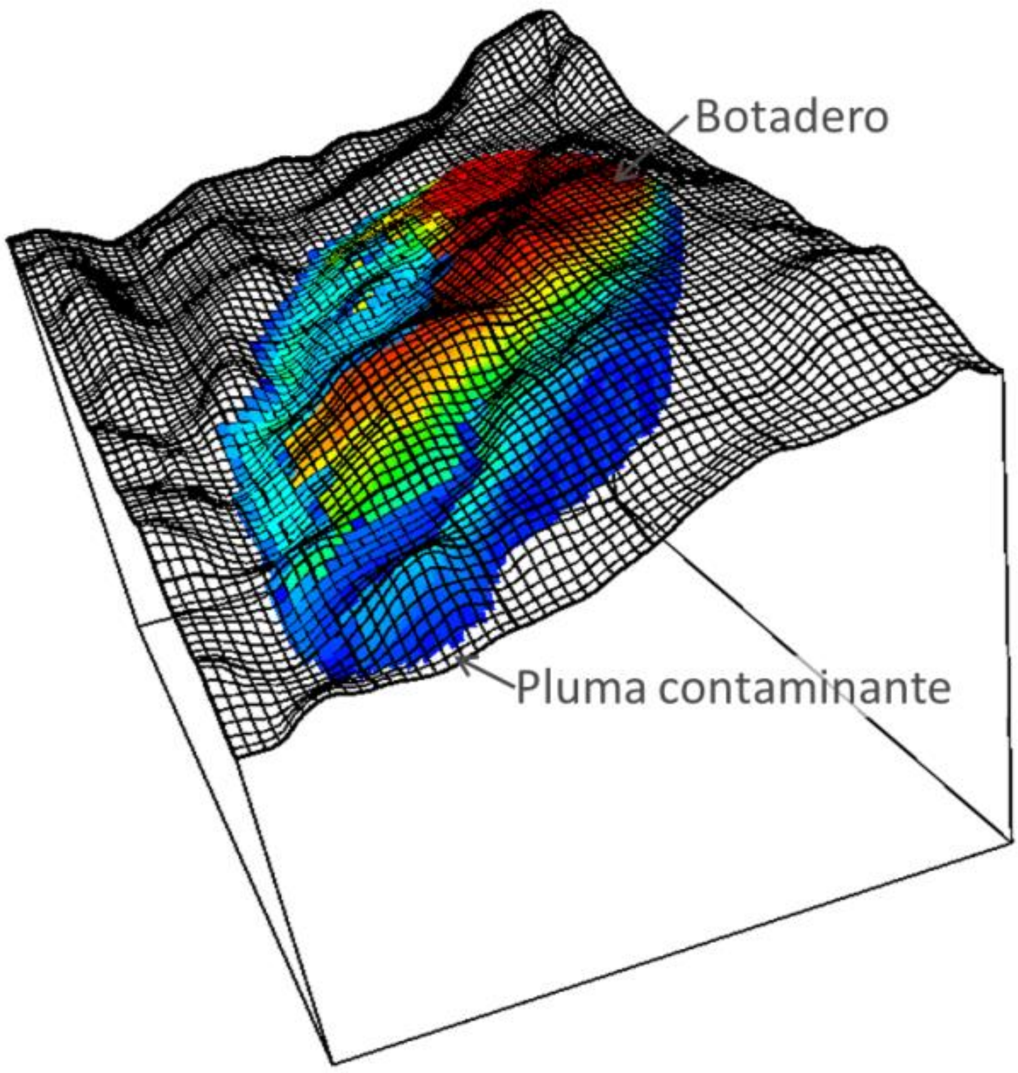
3.4.1. MODFLOW

This code performs groundwater modelling based on finite differences developed by the United States Geological Survey (USGS). It is capable of simulating groundwater 2D and 3D flux and simulate the principal physical processes related to the groundwater regime such as recharge, evapotranspiration, pumping, drainage, etc.



3.4.2. MT3DMS

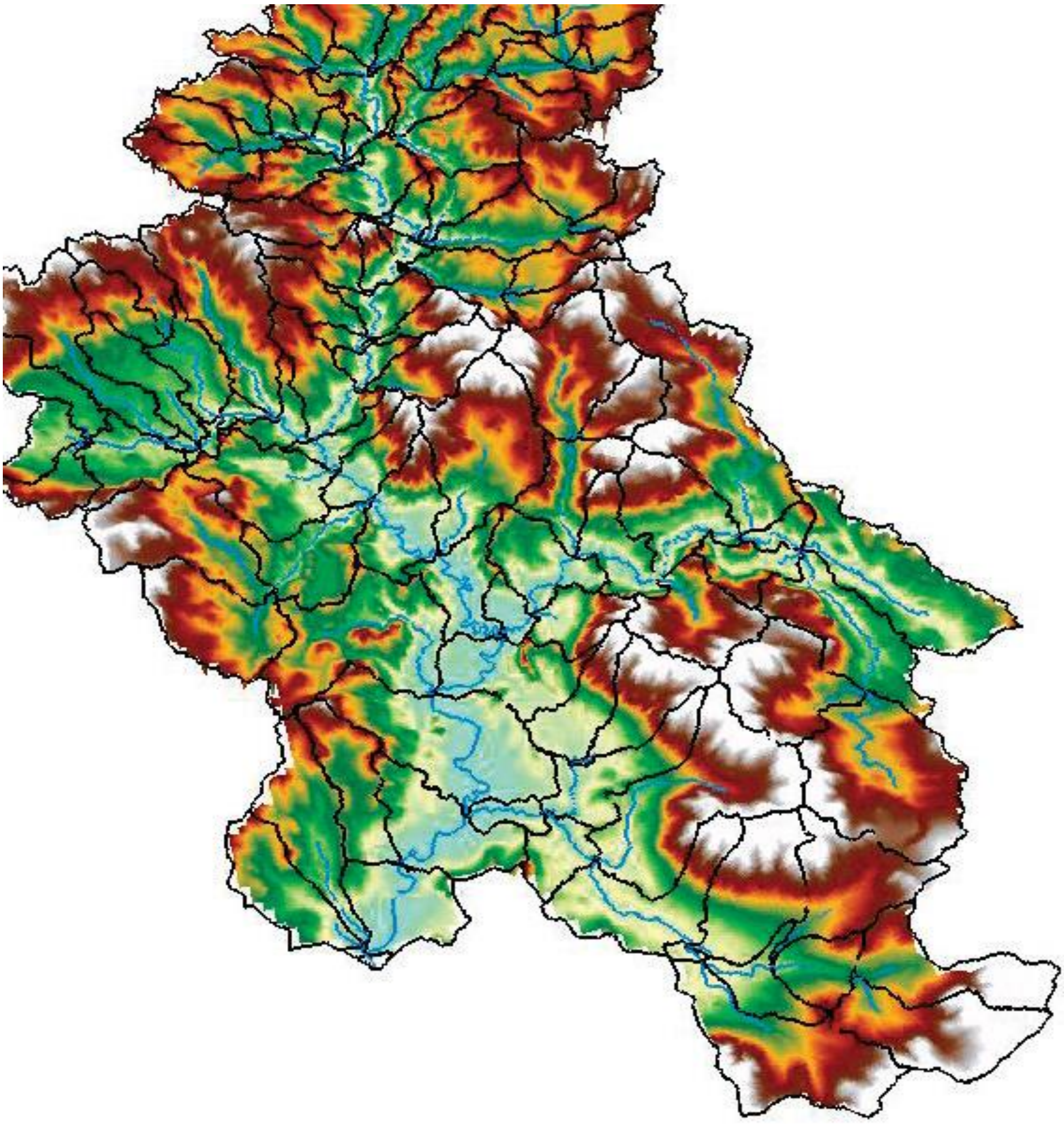
The MT3DMS package is a mass transport model coupled to a flux model in MODFLOW. The MT3DMS code simulates advection, dispersion/diffusion and chemical reactions of adsorption/absorption of contaminants in groundwater.



4. Arc Hydro: GIS for Water Resources

4.1. Why Arc Hydro?

Water resource managers use geographic information system (GIS) technology to visualize and analyze hydrologic data for tasks such as assessing water quality, estimating water availability, planning flood prevention, understanding the natural environment, and managing water resources.



A Template Data Model for Water Resources

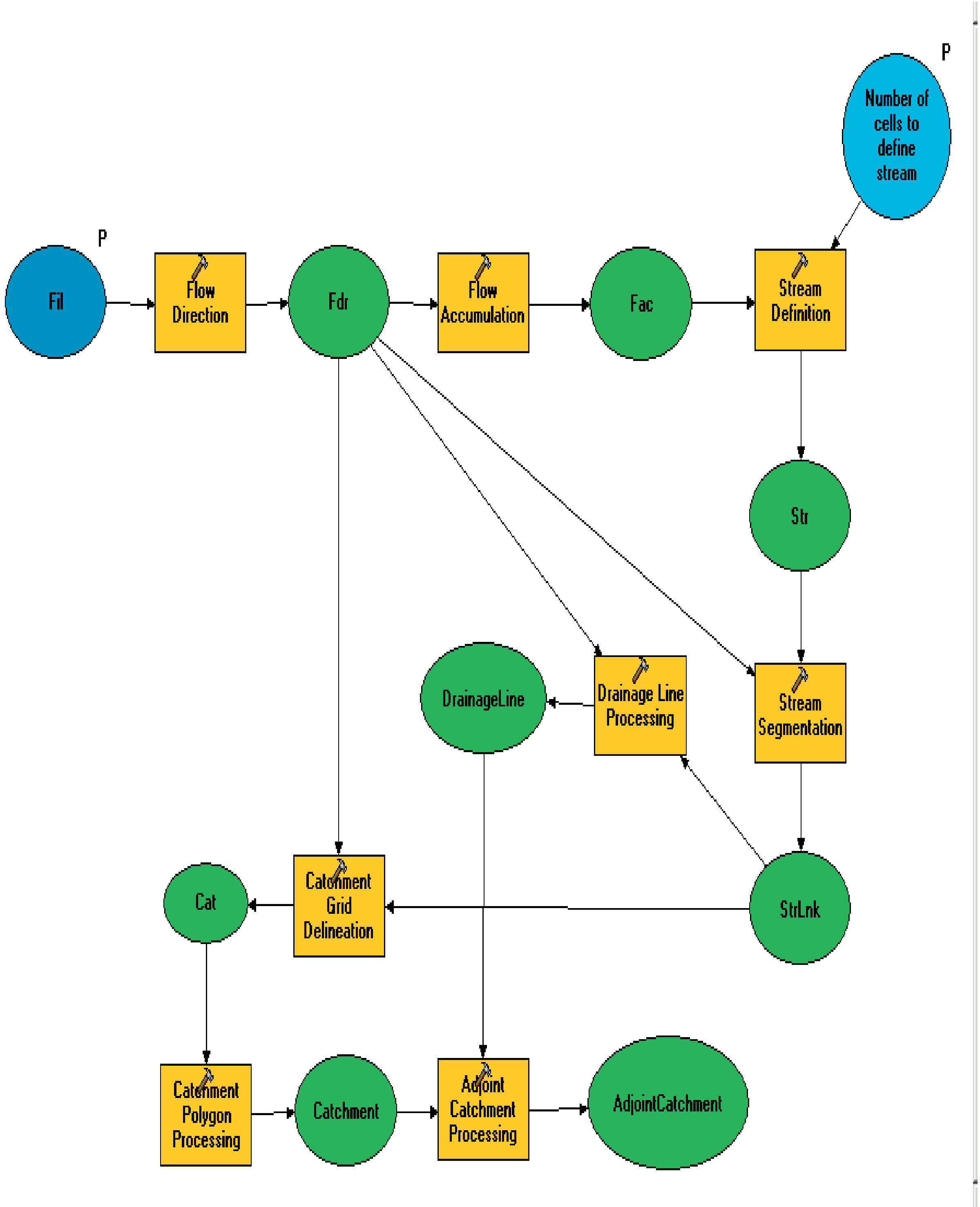
Arc Hydro is the starting point for water resource analyses with Esri® ArcGIS® software. Download the free Arc Hydro data model and tools via the Hydro resource center at resources.arcgis.com/en/communities/hydro.

4.2. What is Arc Hydro?

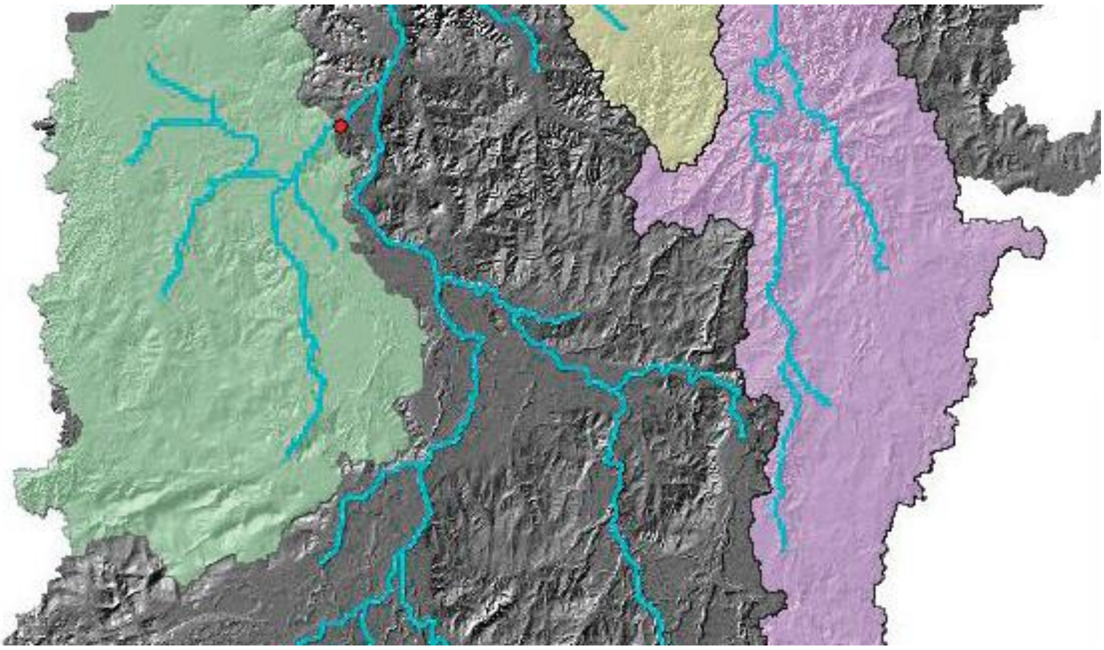
Developed by leaders from industry, government, and academia, Arc Hydro is a GIS data structure that links hydrologic data to water resource modeling and decision making methods. Using Arc Hydro helps you build a dataset that can be integrated with water resource models. The Arc Hydro data model standardizes water data structures so that data can be used consistently and efficiently to solve water resource problems at any spatial scale. It gives you a starting point for building your own data model and integrates with the Arc Hydro tools. A Set of Tools to Support Water Resource Analyses The Arc Hydro data model is complemented by a set of tools for building Arc Hydro-compliant datasets and running the data model. Arc Hydro tools work within ArcGIS for Desktop, but some also require the ArcGIS Spatial Analyst extension. Use Arc Hydro tools to do the following:

- Generate and populate an Arc Hydro geo-database from vector and raster data sources.
- Establish relationships between core spatial layers.
- Apply geometric networks for upstream and downstream tracing and resource accumulation.
- Perform advanced water resource functions (e.g., watershed delineation and characterization).
- Develop node-link hydro schema.
- Use an XML data exchange framework for data integration with external models.

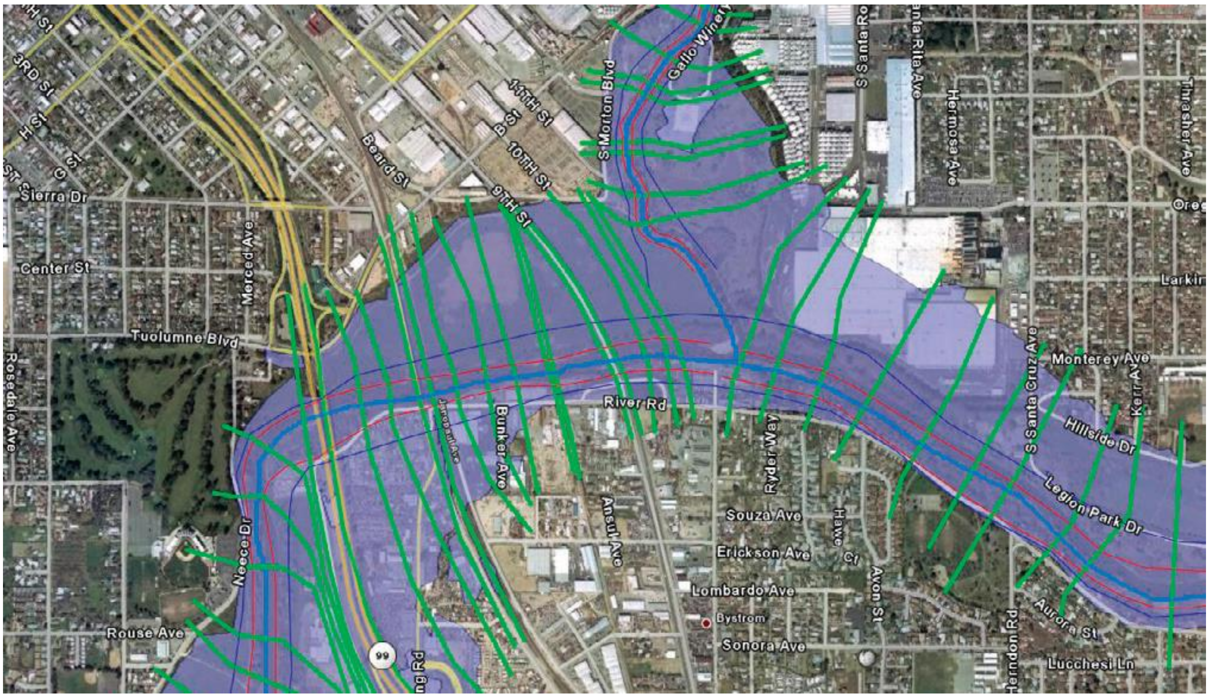
Arc Hydro offers toolbars, menus, and geo-processing tools that allow you to create an integrated data and modelling environment in ArcGIS. You can string together standard ArcGIS and Arc Hydro geo-processing tools to build your own water resource geo-processing models, which can be used in desktop and web environments.
Visualization of a Watershed Model Created Using the Arc Hydro Data Structure and Tools



Terrain Processing Work flow Using Arc Hydro Tools in Model Builder™



Water resources GIS data is stored in layers that can be selectively displayed to model a real-world watershed. This image displays four layers: shaded relief, watersheds, drainage lines, and watershed points.



Floodplain and Flood Depth Data on Top of Imagery and Street Basemaps

5. CONCLUSION:

Water provides variety purpose such as a source of water supply for domestic and industrial use, irrigated agriculture, livestock and mining activities. However by the increasing of the industrial development and anthropogenic activities the quality of water has decreased dramatically. Therefore, the monitoring programs using remote sensing and GIS are needed to threats all contamination occurs and provides the effective action at all levels. The remote sensing and GIS techniques are the effectiveness, cheaper and valuable tools in monitoring

Water quality parameter in coastal level and fresh water bodies (lakes, river, ground water, and reservoir) compared to in situ where measurement is restricted to selected sampling points. From the example of the past research by remote sensing and GIS techniques it was concluded that water quality parameter can be produced in the form of map using the algorithm or models by various platforms of satellite imagery with various resolutions such as Landsat, SPOT, IKONOS, IRS, CZCS, hyper spectral and Sea-WiFS. Newly developed hyper spectral imaging, which can simultaneously record up to 200+ spectral channels, is a much more powerful probe. Hyper-spectral imaging has greater potential because of its simultaneous collection of images covering many narrow, contiguous wavelength bands that allow various aspects of water quality to be measured and monitored.

Each water quality parameter such as suspended matter, phytoplankton concentration, turbidity, and dissolved organic matter has their own estimation reflectance within the range of 400-850 µm. In the future the solution to water quality issues can be solved rapidly using these technologies for sustainable water resources management.

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