Summary

Geographical Information System (GIS) is used to capture, visualise, process, and evaluate spatio-temporal data. GIS is an extremely versatile instrument that can be applied to support various decisions related to water resources management – mapping land use, measuring catchment areas, realtime flows during floods, measuring access of potable water, etc. This Tool describes in detail the two key data models in GIS and discusses the potential of GIS towards supporting IWRM.

What is GIS?

GIS is a system that uses spatial and temporal data to process and create maps of all kinds. GIS analyses are useful to support decision making and is used in almost every industry, e.g., social scientists run analyses to understand food security in urban neighborhoods, surveyors use it to georeference old maps on the Global Coordinate System, hydrologists estimate approximate run off and size of catchment to design dams, etc.

To make GIS work, data is required. Spatial data can be gathered through variety of ways including slow and tedious topographical surveys or the much modern techniques of remote sensing such as images taken via drones, airplanes and satellites. Once spatial data has been gathered, descriptive information can be linked to draw various useful analyses as mentioned above.

Data Models in GIS

Spatial data can be captured and represented in two formats:

- Vector: Most maps featuring distinct points, lines or polygons fall under vector data within a set coordinate system that are typically based on latitudes and longitudes or a projected system consisting of northings and eastings. Vector data is useful in mapping real life objects such as trees (as points), roads and rivers (as lines) and buildings and lakes (as polygons) for accurate depiction of the extent.
- Raster: All data gathered through images falls under raster data. In this cases, the data is stored in form of pixels which in turn are dependent on the resolution of the image capturing device. Higher resoultion leads to more pixels and thus more detailed data gathering. The information is stored in terms of X, Y, and Z values on each pixel and features are detected based on similar values. Raster data can create significant errors in values if the resolution is not high enough and delineating exact boundaries of objects becomes difficult. However, it is useful in creating digital elevation models (DEMs) and has higher compatibility with remotely sensed data.

A big advantage of GIS is that it allows you to utilise and combine both, vector and raster data in order to run accurate analyses, e.g., a raster image of a flood can be mapped on a map of a city or a neighborhood to quickly understand the extent of the flood. Similarly, such data from previous years can be analysed together to forecast flooding and design flood shelters and flood mitigation structures, etc. A summary of the characteristics and visual representations of Raster Data Model vs Vector Data Models are presented in Figures 1 and 2.

Table 1. Raster Data Model vs Vector Data Model. Source: Bolstad (2016, 59)

Image

Characteristic	Raster	Vector
data structure	usually simple	usually complex
storage requirements	larger for most data sets without compression	smaller for most data sets
coordinate conversion	may be slow due to data volumes, and require resampling	simple
analysis	easy for continuous data, simple for many layer combinations	preferred for network analyses, many other spatial operations more complex
spatial precision	floor set by cell size	limited only by positional measurements
accessibility	easy to modify or program, due to simple data structure	often complex
display and output	good for images, but discrete features may show "stairstep" edges	maplike, with continuous curves, poor for images

Image

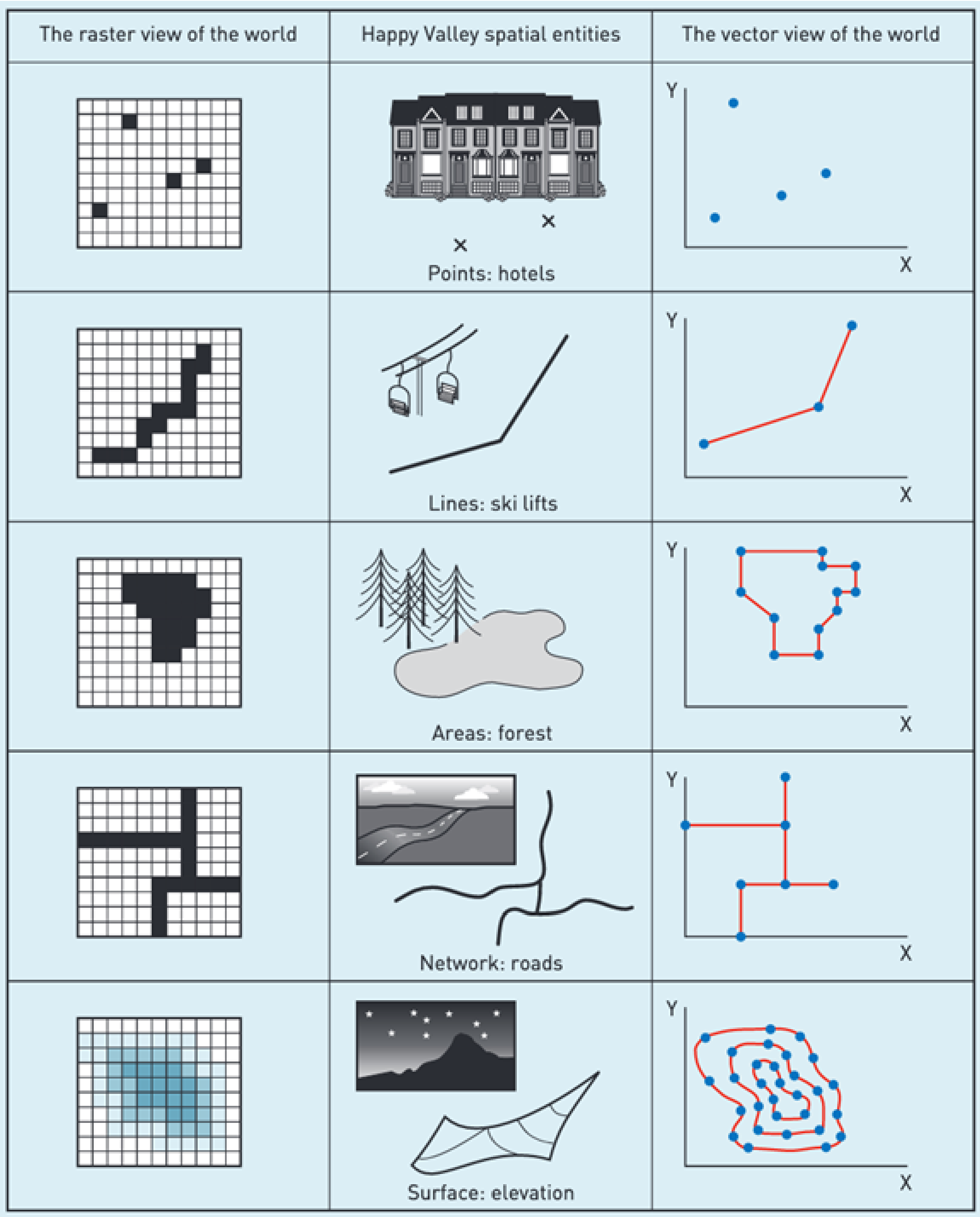

Figure 2. Raster Data Model vs Vector Data Model (ii) (source: Heywood et. al, 2006: 73)

GIS Software

Within GIS, several companies have developed software for different sectors as well as for branches within each sector. One of the most popular GIS software is the ESRI ArcGIS. This has a wide range of compatibility and has several functions like georeferencing maps, creating new maps, overlaying maps on top of each other and perform complex analysis. Furthermore, ArcGIS has an extensive map library that can be purchased and downloaded. QGIS is another open source software that has almost all the same functions as ArcGIS with the benefit of utilizing it without buying a license at the cost of some software stability and less options in terms of map libraries. Another popular application is Google Earth that allows a person to run rudimentary GIS analyses such as measuring distance and area etc. GlobalMapper, Surfer, Maptitude are other notable GIS applications that can be used for analysing spatial and temporal data.

The use of GIS applications becomes limited without data and sometimes data is hard to obtain. High resolution raster images and detailed vector shapefiles are often heavy priced and quite often not available for developing countries. The United States Geological Survey (USGS) Earth Explorer offers raster images of varying resolutions for free for limited time. Similarly, DIVA-GIS.org is another free source for GIS Data.

GIS Applications for Water Resources Management

GIS has a major role to play in water resources management as it can directly promote evidence-based decision-making by processing data into usable results. Some applications of GIS in the field of water resources management include:

- Groundwater management: GIS is commonly used to model aquifers, processing data about depth, salinity, and other biophysical water quality parameters (Jha et al., 2007). GIS can perform simulations about how contaminants move across aquifers (Rivett et al, 2021).
- Catchment management: GIS has been deployed to analyse river flows and the impact of different management options (Chandrashekar et al., 2015). GIS applications are often combined with participatory methods for integrated catchement management (Rollason et al., 2018).

- Irrigation: GIS softaware has been coupled with irrigation software to model irrigation scheduling and runoff scenarios (Kamal & Amin, 2019). It has also been used to monitor crop and land performance over time (Ćulibrk, 2014).
- Water sanitation and Hygiene (WASH): infrastructure such as boreholes and latrines are mapped using mobile based GIS software such as mWater. The Water Point Data Exchange (WPDx) is also a commonly used platform for sharing water point data in rural areas in developing countries.
- Flood management: GIS has been used in combination with remote sensing to model scenarios for floods, sea surge and sea level rise (Opolot, 2013). GIS can support mapping flood prone areas and are thus essential tool to consider when developing flood management plans (Tool C4.07).
- Drought management: Multi-temporal satellite data processed through GIS can help monitor and predict drought (Belal et al, 2014). The European Drought Observatory uses GIS modelling to produce maps highlighting precipitation patterns and drought forecasts. GIS tools are useful in the context of developing and implementing integrated drought management plans (Tool C4.06).

Thematic Tagging
Climate Ecosystems, Energy, Food (Nexus) Gender Private Sector Transboundary Urban Water services Youth

---

Source URL: *https://dev.toolbox.venthic.com/learn/iwrm-tools/geographic-information-system*