
2. GIS hardware and software for fisheries and aquaculture

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While it is recognized that many individuals or groups wishing to utilize GIS for fisheries management or research will do so using existing information technology (IT), it is important that a broad general knowledge exists on the wide range of possible system components. In this chapter, attention is directed towards the essential hardware and software needed to support GIS operations, and these infrastructure components are discussed under suitable headings. As the IT sector continues to make rapid advances, it is recognized that much of the information in this chapter may soon become outdated, certainly in terms of cost and performance. However, rapid advances will “produce significant gains in work productivity, increase our basic understanding of natural systems, help fisheries professionals detect patterns and develop working hypotheses, provide tools to rationally manage scarce natural resources, increase our ability to organize, retrieve and document data and data resources, and in general encourage clear thinking and more thoughtful analysis of fisheries problems.” Megrey and Moksness (2009, p. 2). Although the choices with respect to the hardware used for GIS are very wide, they are relatively easy to make in that precise definitions already exist in terms of equipment function and capability. In contrast, the choices regarding software tend to be more complex. This is because software can be almost infinitely adapted so as to obtain any desired output, with this being achieved through multiple GIS packages, tools, cost variations, functional range and user preferences in terms of the required quality of the output. One software option that is only briefly explored is that of doing all or most GIS work via the use of Web-based GIS software. At present, this is still a relatively complex route to obtaining required functionality, with users being restricted to what is available online and users may not have sufficient bandwidth for efficient Internet delivery. However, this is a route to GIS that needs to be explored over the coming decade, and information is provided for investigating this option.

Necessary hardware components of a GIS system can be conveniently discussed under the three headings of: (i) hardware for inputs of required digital data; (ii) hardware for data processing and storage; and (iii) hardware for obtaining GIS output. The hardware required for capturing the essential digital data consists of four main types, one of which (data loggers) is discussed in the following chapter, as it comprises a range of general digital collection devices that are best considered under the heading of data collection methods. The first main hardware type is computing systems designed for data collection. These comprise a range of handheld “tablet” or “palmtop” computers that are frequently “ruggedized” for

use in adverse physical conditions. This equipment is typically multifunctional, in that it not only serves data gathering purposes but the data can also be processed and used directly in other software packages including GIS. Internet connections may also be readily available. The second type of data input hardware is scanners. These are devices that capture data through the use of a photosensitive head, with the captured data being stored as regular rows of “pixels” having values according to light or colour intensities recorded. Scanners vary greatly in size (typically being able to scan from A4 to A0 sizes); in their method of scanning (with either the photosensitive head moving or the scanned sheet moving in front of this head); and in the degree of detail recorded. Scanned images may be useful either as the “backdrop” or as superimposed imagery, or as the on-screen image for digitizing. The final type of data input hardware is digitizers. These are essentially devices that allow for the digital capture of graphic lines on a map along with their geo-coordinates and their meaning. Digitizers vary from small “tablet” size to very large table size. They work on the basis of the user following, via the use of a cursor, desired lines on a map, which is mounted on the tablet or table. The cursor is continually clicked and the location of these clicks is recorded in the computer to which the cursor is linked. Today, most digitizing is done “on screen”, whereby the cursor follows a scanned image on the computer screen instead of using a stand-alone digitizer.

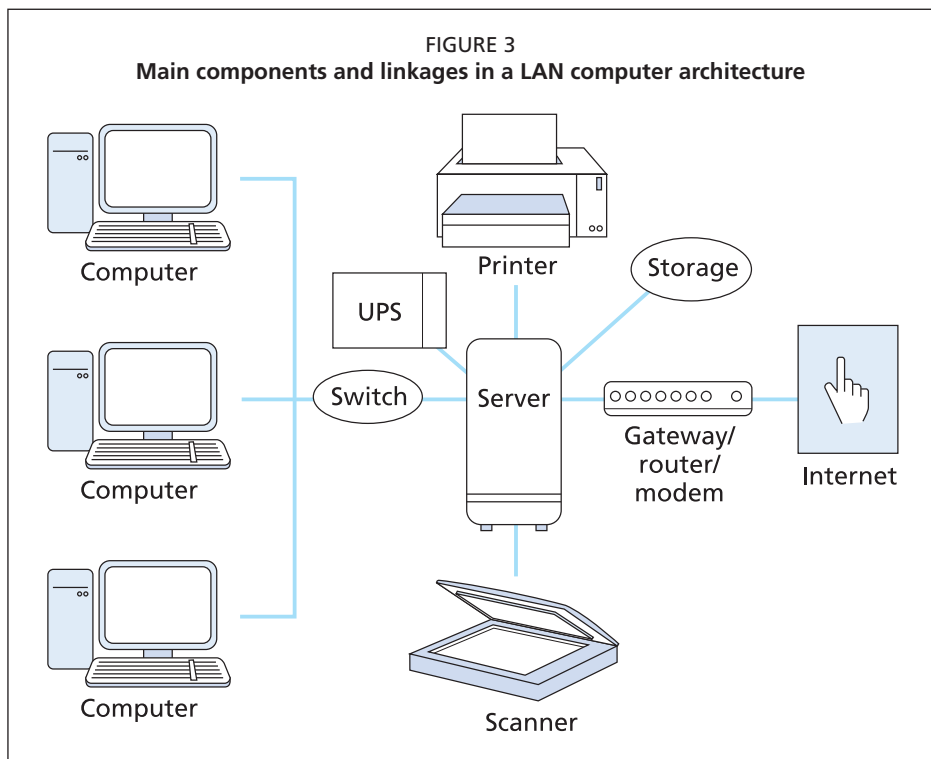
The main hardware devices for processing and storage of digital data are computers. The huge advances in all facets of computing, including cost reductions, have been discussed in Chapter 1, so here it is only necessary to outline some specifics of computers relating directly to GIS use. Today, GIS work is mostly performed on desktop computers, though a small amount of “higher-end” or data-intensive processing might be carried out on large mainframe computers. However, there is an increasing move towards using so-called mobile devices, such as laptops, tablets, palmtops, notebooks and personal digital assistants. In many cases, work in the field might be accomplished by these mobile devices, with the work being transferred to a desktop computer for higher-end processing. For GIS work, it is particularly important that desktop computers are of a high capacity in terms of storage, screen size and processing capabilities, as data and performance requirements for graphically related mapping might be very large. More details on computer specifications are given in the full technical paper, as are details regarding linked peripheral considerations (operating systems, keyboards, USB ports and other attachments). Although all computers have internal digital storage capabilities, there is a range of other data storage devices such as external hard drives, optical disk drives, memory sticks and linked file servers, most of which can be used as secure back-up storage. Two other important items of hardware that are discussed are uninterruptible power supply, which is necessary in case of power disruptions, and wireless routers or modems, which allow access to the Internet and thus to external communications.

Although GIS output comes in several forms (maps, text, tables and multimedia) and can be delivered via disks, the screen, the Internet and in hard copy, direct output from hardware can either be for temporary “ephemeral” use (soft copy) or

of a permanent (hard copy) nature. The computer screen is the output medium for ephemeral images. These images can be deleted, added to, altered, sent to another computer or filed. Filed images can be saved on any of the storage devices listed above, using various file formats, and then retrieved for future use, e.g. pasted into other files or used for multimedia purposes or transmission via the Internet where they might enhance selected Web sites. Permanent hard copy output is produced via a wide range of plotters and printers. Plotters essentially produce output by drawing lines on paper or film to make up an image. They typically vary in size from A4 to A0 and are limited to six or eight colours. Compared with printers, output will be very slow, and for this reason their use is rapidly declining. Printers come in several varieties, the most important being inkjet and laser, and they too produce output of varying size. Some of the advantages over plotters are the huge range of colours that are available, the speed of output, and the fact that their high-resolution potential (measured in dots per inch) can enable high-quality output.

The hardware combination required for successful GIS work can vary greatly, and the actual configuration of the hardware assembled is termed the system architecture. The architecture finally assembled will be a function of the hardware that may be inherited, the capital outlay available, the purposes of the GIS, the size of the organization doing the work, plus knowledge of what is available and any personal preferences. As an organization takes on more complex work, the configuration of hardware is likely to become extended. At its minimum, the architecture will comprise a personal area network, which might consist of IT basics such as a computer, screen, keyboard, printer and perhaps a scanner, plus the necessary linkage hardware for getting access to the Internet. The next level of architecture might be a local area network (LAN). Figure 3 gives some idea of a LAN configuration, though there could be almost infinite variations to this basic model in terms of actual devices and hardware capacity. As well as the hardware mentioned above, there is likely to be a central server that feeds data and software to individual computers, and also has extensive data storage capacity, an uninterruptable power supply and high-speed access to the Internet. At the highest level of architecture, a wide area network (WAN) contains the ability to link many and varied LANs at perhaps a national or international level. For fisheries GIS work, this may be important because work will often be progressing in scattered and perhaps isolated institutions. Over a period of years it is likely that many institutions will slowly be migrating towards WAN functionality.

Turning to GIS software considerations, it is important to mention that the discussion is restricted only to software that might be of direct use and not to any of the other software that may conveniently and usefully be linked to GIS, i.e. operating systems, databases, spreadsheets, graphics, digitizing and remote sensing software. Discussion is also restricted to software that is readily available in the marketplace, and thus options of developing or writing new purposeful software are not discussed. The software discussed can be conceived as either proprietary, specialist marine, or as free and open source software. Proprietary software is software that is readily available, usually from international software companies, and that has been developed to perform a large number of GIS analyses and functions.



There are perhaps a dozen major GIS packages, and this technical paper provides further details on five main products: ArcView (ESRI); Idrisi (Clark Labs); MapInfo (Pitney Bowes); GeoMedia (Intergraph); and Manifold (CDA International). All the main packages perform a similar range of basic GIS functions, though they may vary greatly in their costs, total functional range, their usability, licensing arrangements, add-on modules, the extra services or support provided, and user agreements. The visual output will also vary greatly. None of the proprietary GIS packages have been developed specifically for fisheries or aquaculture work, though all of them can be suitably deployed for this. There has been a strong tendency for certain GIS software to become dominant and this dominance is reinforced when training is carried out using these specific packages; thus, most trained labour is only available having specific GIS software experience.

Most GIS software has been developed for various forms of terrestrial use, and the software serves this function well. It has been, however, more difficult to develop specialist marine or marine fisheries GIS because the market has never been large and because the marine environment is more complex for most mapping and spatial analyses purposes. This contrasts with the use of GIS for inland aquaculture, where the activity is another type of terrestrial land use. Despite the challenges of developing GIS for fisheries purposes, this technical paper describes many small-scale initiatives to develop software applications that are capable of carrying out assorted marine and/or fisheries spatial analyses. Recently, there have been some attempts at developing specialized multifunctional

fisheries-related GIS software packages, and two of these are described. The first of these (Mappamondo GIS) has a reasonable GIS functional range, making it useful for a range of selected spatial analyses, but the second (Marine Explorer) could be defined as a comprehensive marine fisheries GIS. The full functional capabilities of this package are described and briefly discussed.

A significant part of this chapter on hardware and software is devoted to an analysis of a sector of the software market that is probably underutilized, certainly with respect to its use in fisheries and aquaculture. This refers to the use of free and open source (FOSS) GIS software. Conventional software is too easily taken for granted because it may have been extensively promoted and marketed or used in training or educational institutions. However, dependence on known software can deprive users of the flexibility to adopt an open-minded approach to resolving spatial problems. There are now a wide range of ad hoc applications, many of which are based on FOSS software. The emergence of FOSS can be viewed as part of a wider movement towards making freely available a much larger range of computing software, and this is particularly advantageous for GIS users who are on a limited budget. Most open source software comes with the rights to using the source computer coding, meaning that the software can be manipulated, changed or extended for use under any particular circumstance. A large community of users has developed around the FOSS ideals, and there are support groups, specialist conferences, libraries of applications, etc., which may be based around particular programming languages, thematic applications, types of user organizations, or based in particular geographic areas. Other developments in the FOSS arena include the establishment of the Open Source Geospatial Foundation to oversee the interests of FOSS developments and the creation of internationally recognized operating standards for the software. Users who might wish to take advantages of the cost savings offered through FOSS will have to consider whether this use outweighs possible negative factors associated with the fragmented nature of the FOSS community, the need for fairly advanced operating skills, and the fact that it might be necessary to cope with the use of many potentially diverse software applications. This technical paper outlines all the main advantages and disadvantages of pursuing the FOSS route to GIS work, provides details on a selection of the major FOSS GIS packages, and gives cautionary guidance on the selection of specific FOSS software.