4. Implementation of GIS

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4.1 INTRODUCTION

Readers who have read or referred to the first three chapters will now understand the importance of GIS to fisheries and aquaculture, and they will appreciate the demands of using GIS in terms of hardware, software and the data that may be required. Thus, they are likely to be suitably equipped to make a decision as to whether and how GIS may contribute to their fisheries and/or aquaculture work, even though they are unlikely to know their precise requirements. If the decision is to move ahead and acquire GIS capability, then the relevant means will be explained in this chapter. It should be noted that this chapter describes GIS implementation procedures required for the management of an average fishery area or for various aquaculture purposes; implementation requirements for a very small or for very large and more complex GIS can be adjusted accordingly.

Some words of caution are needed before embarking on GIS acquisition. Getting GIS properly implemented is an extremely important part of the total GIS adoption process. The lead editor of this technical paper recalls visiting a fisheries organization in a developing country some two decades ago with the purpose of assessing that organization's possible needs and usage for GIS. Some considerable time was spent during the visit trying to establish if other GISs were "up and functioning" in the country; it turned out that many organizations had already purchased systems that covered a wide range of GIS application areas.[95] However, a more detailed investigation of the status of these GISs revealed that in fact only one other GIS was actually working. Most of the other organizations had heard of the potential benefits of this spatial analytical tool and they moved quickly to obtain the software. But insufficient homework had been carried out; for example, little consideration was given to where their data would come from, where local support could be obtained, what the requisite hardware requirements were and who was available to actually work the system. This was a salutary lesson for the author as well as for the organization concerned. As Bernhardsen (1999; p. 321) has noted regarding GIS implementation: "Projects are often technology driven, and technology takes the upper hand, ahead of the tasks it has to perform. The results may be an unprofitable over-investment in hardware and software at the expense of the primary tasks, which remain undone." In a paper, available on the Web at http://spatialnews.geocomm.com/features/mesa1, Hamil (2002) gives an excellent account of why many GIS implementations fail, and Box 4.1 describes some common pitfalls for GIS implementation. It is clear from the information in the box that success for GIS implementation depends upon there being a very interested, cooperative and well-managed computing environment, whose personnel will require a degree of "spatial intuition" as well as task dedication and persistence.

A further introductory point to consider is that the introduction of a complex technology such as GIS into an organization is certain to have repercussions, which may substantially affect current working practices. DeMers (2009b) suggests the following changes that may need consideration:

[95] It is useful to know of other GIS functionality in a local area because this can often prove to be a useful source of support.

- Change in priorities. If GIS becomes productive, then the priorities of the organization might wish to take advantages of any improvements made.
- Change in the organizational hierarchy. According to the success of GIS work, changes might need to be made as to the relative importance of GIS work within the total work ambience of an organization.
- Change in workflow. GIS will cause changes in who does what, how they do it, and when it gets done. People doing the work might need new or different skills. This could lead to changes within the employment structure of the organization.
- Change in the types and amounts of products. Output from GIS may be very different than that conventionally produced, for example, in terms of mapping, animations and reports.
- Changes in training needs. With technological advances occurring rapidly, especially in an area such as GIS, then undoubtedly allowance will need to be made for frequent training updates.
- Change in the financial distribution. GIS cannot be acquired cheaply. The organization needs to understand the budgetary effects and the possible knock-on effects among the existing workers who might not be involved in GIS.
- Changes in working spatial allocation and design. A computing environment means that working conditions and space allocation might be entirely altered.

BOX 4.1

Some common pitfalls contributing to the failure of GIS

Common pitfalls that most often contribute to the failure of a GIS implementation strategy include:

Failure to identify and involve all users. Users in an operational GIS environment consist of operations, management and policy levels of the organization. All three levels should be considered when identifying the needs of users.

Failure to match GIS capability and needs. A wide spectrum of GIS hardware and software currently exist, so it is difficult to make the right choice. The right choice will be the GIS that provides the required performance (no more, no less) for the minimum investment. The success of a GIS implementation is particularly sensitive to the right hardware and software choices.

Failure to identify true costs. GIS acquisition costs are relatively easy to identify. However, they represent a small fraction of the total cost of GIS implementation. Ongoing costs are substantial and include hardware and software maintenance, staffing, systems administration, data acquisition, data updating, custom programming and consulting fees.

Failure to conduct a pilot study. The GIS implementation plan is concerned with many technical and administrative issues and their related costs. Three of the most crucial issues are database design, data acquisition and maintenance, and day-to-day operations. The pilot study will allow the gathering of detailed observations, provided it is properly designed, allowing effective estimations of the operational requirements.

Giving the GIS implementation responsibility to another information technology (IT) department. Because of distinct differences in GIS from conventional IT systems, the GIS implementation team is best staffed by non-data processing types. Specialized skills of the "GIS analyst" are required at this stage. Reliance on conventional IT personnel who lack these skills will ensure failure.

Failure to consider technology transfer. Training and support for ongoing learning for in-house staff and for new personnel is essential for a successful implementation. Staff at all levels should be familiar with the role of the GIS in the organization. Education and knowledge of the GIS can only be obtained through ongoing learning exercises. Nothing can replace the investment of hands-on time with a GIS.

Source: Buckey (2012).

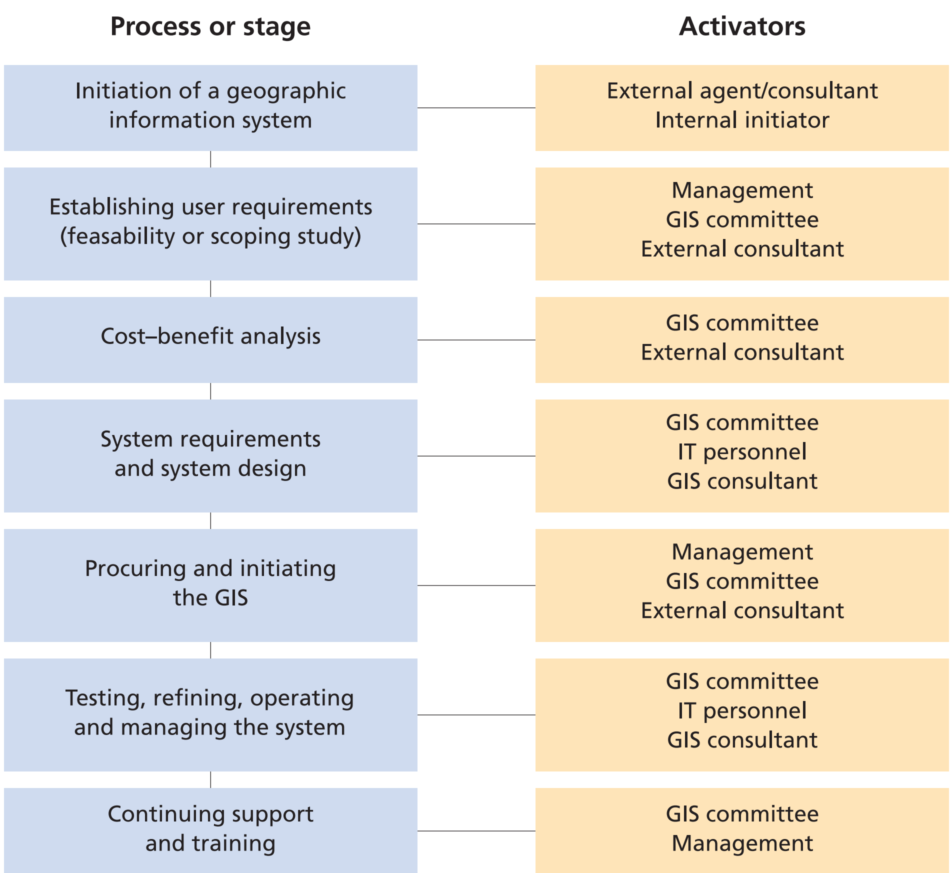
As this list makes clear, people management skills need to be enhanced because human resource satisfaction is vital to any successful organization.

A set of recognized procedures is useful to follow when pursuing GIS implementation, and they are illustrated in various general GIS texts (see, for example, Bernhardsen, 2002; Harmon and Anderson, 2003; Lo and Yeung, 2002; Yeung and Brent Hall, 2007; Longley *et al.*, 2011). Moreover, Ramasubramanian (1999), Taleai, Mansourian and Sharifi (2009), and the following Web sites, also give valuable insights into GIS implementation:

- GISLounge: http://gislounge.com/implementation-of-a-gis;
- Environmental Systems Research Institute (ESRI): http://support.esri.com/index.cfm?fa=projectCenter.gateway&pageID=3&activeTab=1;
- GIS Implementation in the Grassroots: www.urisa.org/files/Siebervol12no1-2.pdf.

More recently, and specifically for fisheries and aquaculture, Aguilar-Manjarrez, Kapetsky and Soto (2010) and Carocci *et al.* (2009) provide some general guidance on GIS implementation to support ecosystem approaches to aquaculture and marine fisheries, respectively. However, to date, there is no single recognized GIS implementation model because this varies enormously between different thematic areas for GIS and between organizations of different sizes or purpose. Figure 4.1 illustrates the main processes (stages) and their activators as currently recognized. It may not be necessary to carry out the processes in exactly the order mentioned and, clearly, some of them can be carried out in parallel. Each of these processes is now discussed in turn.

FIGURE 4.1
The main processes and activators involved in GIS implementation



Source: Adapted from Meaden and Do Chi (1996).

4.2 INITIATION OF A GIS

The idea of using GIS to help resolve problems or challenges in fisheries or aquaculture areas must come from somewhere. The impetus initially comes from an external source. This source may be an article in a journal or trade magazine; it may be from an exhibition or conference; it could be as result of networking or talking to others working in fisheries and/or aquaculture management or research; or perhaps as a recommendation from an external agent such as a consultant or a GIS software house; or, indeed, it might also be from reading a publication such as this technical paper. Whatever the source, there must have been an individual within a group or an organization who perceived the idea of investigating or utilizing GIS as a means of progressing whatever research or management was taking place in their workplace. This individual is called a "champion", i.e. someone who in this case will champion the cause of GIS. A "champion" is usually the person within the organization who initially has the idea of GIS use and adoption and who in some way pursues this and fosters its growth and development within the organization.[96] The champion may be in a managerial position, though it is just as likely to be a middle-level employee who is more involved with the day-to-day practical activities within the group or organization. However, what is imperative is that champions have recognized the potential that GIS has to offer and that they are able and willing to do whatever it takes to promote the future use of GIS. Champions are also likely to know at least some of the potential benefits of GIS and the types of tasks that it could perform, and it is also likely that they will be proactive in that they will be looking for further opportunities to utilize GIS.

At this stage, the full implementation of GIS will probably not have been considered. GIS will be seen simply as an innovative idea to the champion. There are probably many cases where an idea has been perceived but, because the prospective champion lacked the vision or the required impetus, the idea never materialized. But if the champion has vision, then he or she will think about the required actions that need to be taken for promoting the use of GIS. More than likely the idea of using GIS will first be discussed among colleagues, and then sooner or later the idea will make its way to the decision-making level of the organization.

Many readers may note that the GIS initiation process described above is not what occurred within their organization. They probably had GIS imposed upon them, maybe from a senior-level staff member within their group, or perhaps from the distant "head office". In many ways, this situation is undesirable, and it will depend upon how the "imposition" is handled. Thus, when introducing a new and innovative technology, one that will involve substantial changes in working practices, it is vital that management does this with care and consideration and, indeed, it is often good practice to identify a potential "champion" within the workplace, someone who can nurture the future development of GIS within the organization in a way that will be sympathetic to the personnel concerned.

4.3 ESTABLISHING USER REQUIREMENTS (A FEASIBILITY OR SCOPING STUDY)

Once the possibility of using GIS has been "championed", then clearly the feasibility of GIS adoption needs to be determined, i.e. is the use of GIS likely to be a sensible route to take? The feasibility of using GIS varies greatly between organizations in terms of not only their needs, but also according to their familiarity with information technology, the skills of their personnel and management, the resources available, and whether the use of GIS will help attain the goals of the organization or group. Several authors have highlighted the fact that user requirements have been the most neglected aspect

[96] It is likely that a large number of GISs will have been adopted through the enthusiasm of such an individual.

of information system development (Hadzilacos and Tryfona, 1996; Lo and Yeung, 2002). There are various ways of carrying out a needs assessment, all of which might be termed a feasibility (or scoping) study, and which will be variably applicable according to individual situations. Four useful ways of conducting a feasibility study are through:

(i) **A GIS committee.** The champion or a senior manager should establish a small committee of interested personnel who are given the responsibility for investigating the potential that GIS has to offer. One important task will be to consult with other organizations who have successfully adopted GIS, and possibly to invite an expert who can give a talk or demonstration on general GIS capabilities.

(ii) **Survey questionnaire or interview.** For smaller organizations, the champion or management should circulate a questionnaire to relevant personnel to help identify key issues (e.g. aquaculture siting and zoning), and to assess their GIS capacity and their likely needs for GIS. This information might also be gathered in the form of structured interviews.

(iii) **Holding special workshops, seminars or demonstrations.** In most information technology (IT) sectors, special workshops are organized so that any interested party can participate in exploring the idea of adopting GIS.

(iv) **An external consultant.** It can be invaluable to recruit an external GIS specialist who can ascertain the needs for a GIS, and whether a GIS can be afforded and sustained. Although this might be expensive, the specialist should have extensive background and thus be aware of the wide range of considerations to setting up a successful GIS. It is important that the external consultant has both knowledge of GIS and of fisheries or aquaculture. It is likely that a consultant or adviser can point out an additional array of spatially based problems that GIS might resolve.

Organizations can carry out any combination of the methods listed above. Readers can also raise their awareness of GIS potential and GIS needs through reading up on these subjects, either through some of the general texts suggested in Chapter 1 or through searching for information on the Internet. Attending exhibitions or conferences are also advantageous, as they are opportunities to meet people who have knowledge of GIS and of any pitfalls to its use.

What types of general questions need to be asked in undertaking a scoping study[97]? Box 4.2 gives some main areas for questioning and makes clear that there are a large number of areas that need to be researched before a GIS can be considered. A major point to note is that there are various operational alternatives for GIS implementation. These can be briefly explained as:

- **Using a "headquarter's GIS".** Here, GIS is envisaged as an important function that can best be accommodated as a centralized activity at an organization's headquarters. This will usually be as a result of GIS being a major decision-making tool – one that needs to be accessible to management and to offices where data and IT systems reside.
- **Having on-site localized GIS.** In many cases, GIS might be functioning as a tool within a specific department, research station or outlying office. Within a larger organization, GIS might operate on several local sites.
- **Contracting work to a GIS company or consultant.** For organizations where the cost–benefit analysis (see Section 4.4) shows GIS to be of only marginal value, it could be sensible to contract the work out to specialists. For GIS, this might enable considerable cost savings in terms of operating and maintaining the system as well as in some of the capital costs.
- **Sharing or collaborating in the GIS work with a similar organization.** In the sense that there are a large number of minor organizations, small fishery

[97] At this stage of GIS implementation, it will only be necessary to ask general questions concerning GIS adoption, though there should be some knowledge of the types of work to be undertaken.

departments, small research departments, small states or regions, all of which might have a limited amount of fisheries or aquaculture work, a sensible plan might be to work cooperatively and/or to share facilities and support.

There are no right or wrong implementation alternatives and the means chosen will reflect particular local circumstances. Thus, it is important not to proceed with full GIS adoption if there is insufficient demand relative to the costs and effort of establishing GIS capability. The outcome of the feasibility study should be in the form of a short document, with much of the information being transferable to, or incorporated in, the system's design report (see Section 4.5).

BOX 4.2
Examples of questions to be asked in a feasibility study

- What are the key issues relating to the management and further development of the fisheries and/or aquaculture sector?
- Which of these issues are fully or partially spatial?
- What might a GIS reasonably do for the organization?
- What geographic area should be covered?
- Should GIS be shared with others?
- Should the GIS operate across the whole organization?
- What georeferenced data does the organization have?
- What data are needed?
- Will the organization need to use a customized GIS?
- Is there likely to be a longer-term need for a GIS?
- Will there be good access to support and training?
- Will there be time for existing personnel to do GIS work?
- Will existing personnel accept the introduction of GIS?
- To what extent will GIS satisfy information needs?
- Would funding be available for any longer-term GIS work?
- Does the organization have the right methods for doing GIS work?
- Are there better ways of achieving the information that is needed?
- How much will each employee need to learn about GIS?
- Where can reliable external advice be obtained?
- Can a GIS be integrated to the existing IT functioning?
- Who will champion the GIS work in the future?

4.4 COST–BENEFIT ANALYSIS

If it seems likely that the need is there to justify GIS adoption, this should still not proceed until some kind of cost–benefit analysis has been pursued. This basically involves undertaking an exercise that attempts to balance the total costs of acquiring the system against the benefits that will be gained from deploying a GIS, i.e. do the advantages of adopting GIS outweigh the disadvantages? To exemplify a range of capital costs that might be required, Box 4.3 illustrates some recent costs involved in installing the main components of a GIS system in the People's Republic of Bangladesh as part of an FAO field project. This system was able to utilize existing computers, and note that up to five seat licences were acquired to be used by a team of about five people. Although this information exemplifies real capital costs, they will be highly variable according to the scale of the GIS operations envisaged and according to any existing hardware and software that may be available.

BOX 4.3
Example of some costs involved in a recent (2009) implementation of GIS for aquaculture work in Bangladesh

Equipment (for TCP/BGD/3101)	US$	Quantity	Total US$	
HP Colour LaserJet 5550 dn	4 218	1	4 218	
Oki C830 Dn A3 Colour Laser printer	2 165	1	2 165	
Adobe Photoshop CS4 v11, English version (inclusive CD)	397	5	1 985	
Idrisi Taiga (software)	1 250	5	6 250	1 licence
External hard disk GB 250	91	5	455	
Global positioning system (GPS)	105	3	315	
ArcGIS 9.3 ArcView Concurrent Use Licence	1 925	1	1 925	UN price
ArcGIS 9.3 Spatial Analyst Concurrent Use Licence	1 375	1	1 375	UN price
ArcGIS 9.3 ArcView Single Use Licence	825	5	4 125	UN price
ArcGIS 9.3 Spatial Analyst Single Use Licence	1 375	5	6 875	UN price
	TOTAL		**29 688**	

Source: FAO training course on "Use of Geographic Information Systems for Aquaculture planning and Management", held 25–29 October 2009, as part of the FAO field project entitled "Developing a national shrimp seed certification system" (TCP/BGD/3101).

Terminology:
Concurrent use licence. A concurrent use licence permits execution of the software on any computer on the network. A concurrent use licence allows a product to be licensed such that multiple users can gain access to the software concurrently through a shared pool of licences administered by a central licence manager. The number of concurrent licences determines the number of users who can run the applications concurrently. However, each user only accesses a licence when it is needed as a concurrent use licence is not locked to a single computer and, as such, can "float" on a network.
Seat licence. The number used to specify the amount of concurrent instances of the software that can be used at one time. Most often, seats represent users at individual computers. However, seats may also represent the concurrent number of servers or connections in use.

Source: ESRI (2012b).

It is important to note that neither "costs" nor "benefits" can be simply quantified in financial terms; they are likely to be more nebulous "values", such as "gaining access to qualitative maps" or gaining any specific information that will be of value to decision-making. It is widely recognized that true cost–benefit analyses in GIS are difficult to perform in terms of obtaining objective results (Maguire, Kouyoumijan and Smith, 2008).[98] In fact, Obermeyer (1999) suggests that the potential costs and benefits of implementing GIS fall into two categories: tangible (economic) and intangible (institutional). Table 4.1 illustrates Obermeyer's findings. The author suggests that the intangible costs and benefits are generally more important than the tangible, and this makes the adoption decision more difficult.[99] It is also the case that benefits may take a long time to accrue for GIS work, so there may be an initial period where the costs far outweigh the benefits. An additional problem with cost–benefit analysis is that the ratio between the two can vary greatly according to the time period over which equipment is depreciated, and with GIS work the value of the output obtained will vary greatly from project to project. Nevertheless, it is important that these considerations are made because the analysis may provide the best information as to whether GIS adoption should proceed. If the necessary expertise exists, a cost–benefit analysis can be performed internally, but it is often advisable to hire experienced analysts for this task.

[98] A detailed synopsis of this publication can be obtained from http://roi.esri.com; this publication is one of the few attempts to quantify cost–benefits for GIS use.
[99] Because of their subjectivity, cost–benefit analyses can be thought of more as an art than a science.

TABLE 4.1
Summary of main costs and benefits associated with GIS

Category	Costs	Benefits
Economic (tangible)	Hardware	Reduce costs (e.g. of staff)
	Software	Greater work productivity
	Training	Increased revenues
	Additional staff	New market services
	Additional space	Expanded market potential
	Data	Rapid access to output
	Maintenance	Decrease in contracted services
Institutional (intangible)	Interpersonal shifts	Quality visual products
	Layoff of staff	More accurate analytical data
	Staff anxiety	Improved client relationships
	Neglect of other projects	Improved morale of workforce
	Increased vulnerability – computers	Better information flows
		Enhanced sense of achievement

Note: Most reduced costs accrue because the addition of GIS adds to the outputs from staff and equipment, e.g. there will be greater productivity.
Source: Adapted from Obermeyer (1999).

Output from a cost–benefit analysis is frequently in the form of a spreadsheet or a small report. This information may be used by senior management in prioritizing GIS adoption against competing funding needs, or it might allow GIS to be immediately ignored as a non-viable option for that specific organization. Longley *et al.* (2005b) note that there have been surprisingly few cost–benefit analyses published with respect to GIS implementation. This is most likely because it is a difficult task in the sense that so many of the costs and benefits are either intangible or they are difficult to separate out from other costs, e.g. staff may be working on non-GIS tasks, as will computer time allocations. A detailed set of GIS cost–benefit considerations can be found in Bernhardsen (1999), at the NYS GIS clearinghouse (www.nysgis.state.ny.us/coordinationprogram/reports/montana), and at the European Commission (www.gisig.it/best-gis/Guides/chapter9/nine.htm). A cost–benefit analysis is strongly advised because it will allow an organization to get an early feeling for what may be involved with a GIS implementation. If the task is too difficult, then it may be possible to simply produce lists that detail the advantages and disadvantages of GIS adoption.

4.5 SYSTEM REQUIREMENTS AND SYSTEM DESIGN

If the benefits of operating a GIS within the organization clearly outweigh the costs, then the implementation can move to the system design stage. The outcome at this stage should be creating a report entitled "GIS system design", which not only provides answers to the types of questions posed in Box 4.2, but which also demonstrates the conceptual design of the complete system in terms of hardware, software, personnel, data sources and databases, and includes factors such as the architecture of the GIS, where it might be housed and how the management structure might operate. The purpose of the "GIS system design" report is to serve as a comprehensive guide showing that all aspects of GIS implementation have been considered, as well as to inform management of the total intentions and requirements for GIS implementation. It is very important that managers know what the GIS involves. The report can further be made accessible to external suppliers who might be contributing towards assembling the GIS.

The “system design” report can be a major task because it will involve a range of expertise and a wide range of considerations. Thus, the sections on hardware, software and data needs can be extensive and tricky to complete without additional advice. If an in-house GIS expert is not readily available, then it is recommended that external advice be sought. It is recognized that many GISs being implemented for fisheries or aquaculture purposes may be starting at a relatively simple level and, indeed, in most situations this scale of entry to GIS is recommended. This might be reflected in a relatively basic system design document. However, whatever the scale of GIS adoption is, it is still recommended that the main sections of a system design report should include those shown in Box 4.4.[100] If future GIS work is successfully accomplished, there could be a rapid expansion of the system and various allowances must be made for this, e.g. personnel, rooming, additional capitation and software upgrades. For further information on GIS system design, see Lo and Yeung (2002), Harmon and Anderson (2003), Heywood, Cornelius and Carver (2006), Yeung and Brent Hall (2007), or in Peters (2008), which is available at www.esri.com/library/whitepapers/pdfs/sysdesig.pdf and which provides comprehensive information.

BOX 4.4
The main sections of a “GIS system design” report

- **Introduction** – Detailing what the overall objectives for a GIS are, how this might help meet the “mission statement” of the organization and the results of the cost–benefit analysis.
- **GIS accommodation** – Details of rooming requirements and user site location(s) for the system.
- **GIS projects to initiate** – A summary of each of the GIS tasks that are already envisaged for the projected system, possible future projects, how projects might help meet the organization’s needs.
- **Personnel requirements** – Including number of personnel, level of appointment, job descriptions, possible training, and possible needs for external help.
- **Data needs and sources** – Include existing data held, data modifications, new data sets required, data sources, database design, data storage, data management and database model to be deployed.
- **Hardware requirements** – To include numbers and specifications of computers, range of peripheral hardware, system’s architecture, network communications, possible hardware suppliers, plus a review of existing hardware capacity.
- **Software requirements** – Functions required from software, software proprietary options, range of software required, including operating systems, word processing, spreadsheets, databases, plus the GIS software and software support.
- **Management needs and system’s organization** – How GIS will fit into the organization, how it will be managed, work allocation, possible cooperative use of facilities, lines of responsibility and who will receive GIS output.
- **Availability of support** – Accessibility and range of back-up support, documentation and literature, plus support needs.
- **Level of capitation and running costs** – Estimations of all capital costs, estimations of staff and data costs, estimations of ongoing running costs, such as rent, power, peripherals, and possible sources of funding, amortizing period for hardware and software.
- **Constraints, challenges and risks** – Any recognized constraints or risks should be declared at this point (some of these might be indentified in the cost–benefit analysis).
- **Proposed implementation dates** – This might include target dates for each stage of GIS implementation.

[100] It should be noted that the “GIS system design” report is not the same as the “GIS implementation” plan (which is discussed in Section 4.6).

4.6 PROCURING AND INITIATING THE GIS

If following feedback from the GIS system design the decision is made to adopt GIS, then there are fairly standard procurement procedures that ought to be used in order to ensure successful installation of GIS. This stage is concerned with putting together an "implementation plan", which is really an extension of the system design report (Box 4.4). In this way, full GIS implementation can proceed in a structured, planned and efficient manner. In addition to the system design information, the implementation plan will include factors such as the manner of GIS introduction (see boxes below), the geographical area coverage for the GIS, the timing and cost schedule for implementation, quality control, any organizational matters, need for pilot studies, plans for support and training (see Section 4.8), system maintenance and security arrangements. A GIS committee should develop this plan with demonstrable support from management and perhaps with advice from external consultants. Once the plan has received managerial approval, then it can be followed or used as the means of GIS introduction. In order to get a feel for what implementation plans may cover, examples of two actual implementation plans are included as Box 4.5 (a and b). Although both of them involve the introduction of GIS for either departmental or county administrative purposes, they were chosen to illustrate the wide number of matters that could be considered, thus illustrating that there are no hard and fast rules for implementation planning and that it needs to be carried out in some detail. Each of these plans extended to about 30 pages.

BOX 4.5(a)

Example of GIS implementation plan for a fisheries department

EXECUTIVE SUMMARY ....
- CHAPTER 1 – OVERVIEW AND METHODOLOGIES ....
- CHAPTER 2 – GENERAL SYSTEM DESIGN ....
  - Database philosophy ....
  - Graphics definition ....
  - Interfaces to other systems ....
  - Recommended commercial off-the-shelf products ....
    - GIS software ....
    - Enterprise RDBMS ....
  - Customized software options ....
  - Recommended hardware configuration ....
  - Network considerations ....
    - Wide area network solution ....
    - Local area network solution ....
  - Internet/intranet options ....
  - Field access data options ....
- CHAPTER 3 – PROJECT SCHEDULE ....
  - System implementation schedule ....
- CHAPTER 4 – PROJECT BUDGET ....
  - Hardware ....
  - Software ....
  - Peripherals ....
  - Data conversion/development/collection ....
  - Application development ....
  - Staffing ....
  - Training ....
  - Additional consulting ....
  - Other costs ....
- CHAPTER 5 – ADDITIONAL FINDINGS AND RECOMMENDATIONS ....

Source: Baker GeoResearch (2003).

BOX 4.5(b)

Example of GIS implementation plan for county administration purposes

Source: Brown county GIS department (2005).

There are four basic adoption strategies for GIS, plus a number of combinations of these, any of which can occur at very different scales of GIS operation:

(i) In-house development using a "slow-growth" approach. This is likely to be the common approach adopted for most fisheries and/or aquaculture GIS work. Here, a system is simply developed (built up), perhaps from a small beginning. This has the distinct advantage that initial costs may be quite low and that the GIS workers or team can learn as they progress. The early stages of growth may need a lot of external assistance, but GIS development can be "paced" according to needs, funds and personnel available.

(ii) In-house development using a "big-bang" approach. This approach requires that an existing in-house team works on developing the fisheries or aquaculture GIS according to the implementation plan. A date is usually set in advance indicating when the system will be "unveiled", or ready for use. It should be tested beforehand, but from the date that it is unveiled employees will know that the GIS is available as a complete working system.

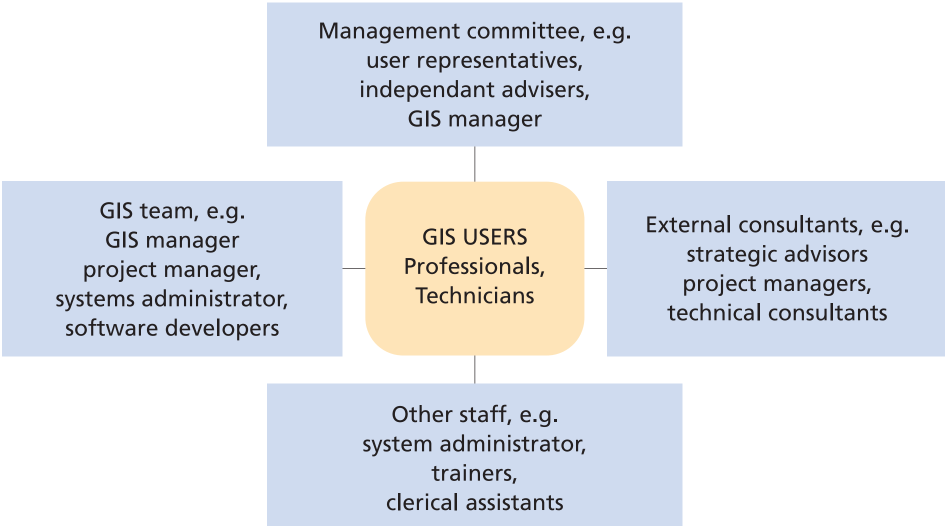
(iii) Contracting out GIS work. As indicated in the preceding paragraphs, it might be considered that there is insufficient GIS work to maintain internal capacity, so the GIS work is contracted out.

(iv) Purchase of a turnkey system. Adoption of this implementation strategy means that the desirability for GIS has been established, but the in-house capacity to implement it is almost non-existent. The organization, therefore, "outsources" its GIS requirements to a specialist external GIS provider that is able to deliver a complete working system to the organization. There needs to be some considerable transition in the sense that the system would need to be explained to relevant personnel via courses of instruction, and a range of other support would be required for periods of up to a year or so. This "turnkey" adoption approach is probably rare today, mainly because there is already a wide degree of IT familiarity and investment in most organizations so the basis for GIS is already established.

If adoption strategies (iii) or (iv) above are selected, then it is clear that GIS will need to be procured from an external source. Most large companies will have official policies for buying, purchasing, ordering, procuring, etc., and the organization's procedures will need to be followed. If the GIS implementation itself is large in scale, then there might be tendering arrangements to be made, i.e. where companies providing GIS might be invited to participate in a bidding or tendering process. As part of this process, the external GIS company may be required not only to provide details on delivery times, system functionality and costs, but it will also be asked to provide sample GIS output to illustrate how its system can best provide materials that help to resolve a spatial problem (or a set task). This process is known as benchmarking, and it is a very useful part of the tendering process. There will also be a range of contractual arrangements to be made, including maintenance and post-supply support.

Whatever implementation plan is followed, it is important that the plan has been carefully considered, that management has given its full blessing, and that a competent individual is in charge of the implementation. This last point is vital because a new "system" will be implemented, and it is one that involves a range of mixed technologies all working properly and efficiently together. As Figure 4.2 illustrates, it may also involve a wide range of staff both within and external to the organization, and within any organization there will be a range of specific procurement and installation tasks that might need to be included that will be organization specific (see tasks shown in Boxes 4.4 and 4.5 a and b). GIS is also an investment that may be expected to show results quite quickly, and these should be seen as positive and genuinely helpful to problem solving within the remit of the organization. Any implementation plan will need to be prepared for flexibility in the sense that many changes are likely to occur during the development and adoption period. Box 4.6 provides a useful checklist of some major issues to consider when implementing a GIS, and Lo and Yeung (2002) give a detailed explanation of the implementation issues. Finally, it should be noted that implementation may be a long and perhaps difficult process. This largely depends on the adoption strategy being used and on the scale of the GIS being implemented. All personnel involved will need to be aware that there are likely to be effects on the organization, and some of them may be quite profound such as institutional restructuring, job insecurity, rationalization and possible redundancies (Bernhardsen, 1999; Heywood, Cornelius and Carver, 2006). Despite these potential negativities, the great majority of organizations will find GIS acquisition to be beneficial.

FIGURE 4.2
Varying staff roles of groups who might be involved in GIS implementation



Note: Figure 4.2 could apply to most types of GIS adoption approach, although only a large organization is likely to have all of these groups.

BOX 4.6
Checklist of important issues when implementing a GIS

- **Plan effectively** – Carefully review GIS goals and objectives, and use available project management tools, e.g. Gantt charts.
- **Obtain support** – Get support from all key stakeholders, and executive-level support within the organization. Carry out public relations exercises within the organization, and arrange meetings of interested personnel.
- **Communicate with users** – Communicate with users from the very start of the GIS project.
- **Supply frequent updates on the progress being made** – Give dates for expectation of results and endeavour to stick to them.
- **Anticipate and avoid obstacles** – Be prepared for any problems relating to hardware, software, data, time frames, funding, training, etc, knowing where to seek support.
- **Avoid false economies** – Pay staff fair wages. Build a team culture so that staff enjoy working at the organization. Cutting down on hardware or software specifications may not pay in the longer term, i.e. as workloads increase. Allow for rapid rates of hardware and software depreciation. Hardware should be amortized over four years.
- **Ensure database quality and security** – Always maintain high-quality data, making sure that it is backed up and secure from corruption or hacking. Have disaster recovery plans ready.
- **Accommodate GIS within the organization** – Manage the GIS work so that it fits in with the working culture of the organization. Try to do all the work in-house if possible so that it can be monitored carefully.
- **Avoid unreasonable time frames** – An underestimation is frequently made of the time needed for GIS to be implemented and for the GIS to achieve valuable results.
- **Do not underestimate funding requirements** – Securing sufficient funds may be a major challenge. Core funding is essential, and to secure this a sound business plan will be necessary. Additional funding needs are liable to be uncertain, i.e. operational budgets can change dramatically over a short time period.
- **Prevent "meltdown"** – There are many reasons why GIS work may dry up completely. Try to work out the causes of this, making sure that workflow planning is well entrenched.

Source: Adapted from Longley *et al.* (2005b).

4.7 TESTING, REFINING, MANAGING AND OPERATING THE SYSTEM

Once the fisheries or aquaculture GIS has been installed, there are a number of procedures that must be put in place to ensure that all parts of the system operate in an efficient manner, procedures that comply with the system design. Here, factors such as testing the GIS are considered in terms of the initial output that can be obtained, making sure that the hardware architecture adheres to its design functions, ensuring that personnel are familiar and content with their roles, having workflow patterns planned and attending to security matters. If the importance of all of this can be acknowledged and acted upon, then it is likely that the system will achieve longer-term continuity (see Section 4.8). Further details on most aspects of operating and managing GISs and GIS projects can be found in several GIS textbooks (see Section 4.8) and Croswell (2009), and at:

- GIS Development: www.gisdevelopment.net/technology/gis/techgi0041.htm;
- ESRI: www.esri.com/news/ArcUser/0205/managinggis.html;
- Current science: www.ias.ac.in/currsci/jan252009/211.pdf;
- Proceedings of the Spatial Information Research Centres 8th Colloquium http://divcom.otago.ac.nz/conferences/geocomp97/cd-rom/sirc96/papers/key1.pdf.

4.7.1 Testing and refining the system

Once the GIS is installed, it is useful to subject the system to some small pilot projects. These should be simple, but designed so that they test as wide a range of the total system as possible. Here, not just the GIS output from each project is considered, but also how the system functions in terms of all items of hardware, including their connectivity; whether data are effectively structured, filed, stored and accessed so that the data are readily accessible and thus contributing to valid GIS output; are staff readily able to fulfil their planned roles; and is the software such that it not only performs what was anticipated but the output achieved is visually and conceptually useful? It should be part of the role of perhaps a small GIS committee to oversee this pilot work, but in the case of a small GIS operation a single GIS operative might do all of these tasks. Even in this situation, the operative should consult with colleagues as to the viability of the output that has been produced. It is almost certain that the pilot work will throw up challenges that need to be addressed, and a good implementation plan will have allowed for this, probably under some sort of contingency planning. It would be fair to say that members of a GIS team must be prepared to face a good deal of initial frustration during the pilot project stage, and learning curves are likely to be sharp and extensive. The extent of frustration can be greatly ameliorated if the GIS team has in place the necessary means of coping with a wide range of contingencies. These would include access to manuals or helplines, technical support from hardware and software suppliers, and access to an external GIS consultant or to more experienced GIS workers at another location. The first few months of GIS operation, therefore, are almost certain to involve constant adjustments and refinements in working practices, and it will be the manager's role to make sure that staff can accommodate and adjust to uncertainties and change.

4.7.2 Championing and managing the system

It would be impossible to conceive that any GIS project could be launched and sustained without enthusiastic backing from either or both of the "champion" (see Section 4.2) and at least one member of the organization's management. It is important to look here at the supporting role that management should make to GIS within the organization: Section 4.8 looks more broadly at the overall support and training required by the GIS team. In effect, there has to be a manager who is willing to take over from the champion. The manager must be an individual who can clearly see the benefits that GIS use will bring and must also be conversant with its use and be willing to strongly support the work of a GIS person or unit within the organization. This support is likely to be reflected in the appropriate time, attention and resources being given to the demands of GIS. Longley *et al.* (2005b) identify the following management support areas that are critical to successful GIS outcomes:

- **Customer support.** A member of the GIS team needs to be designated by management to perform customer support advice and services. In the case of GIS in a fisheries or aquaculture environment, the customers will be both internal to the organization or they may be "upstream", perhaps working at senior government levels. If clear, decisive and cooperative support is given, then customers will be happy, and happy customers give repeat business.
- **Operations support.** Managers need to decide how the GIS operation is to be supported in terms of system administration, maintenance, security, technology acquisitions, etc. Where larger GIS units exist, then someone within the unit will be appointed to fulfil leading and decision-making roles.
- **Data management support.** Managers must be in a position to ensure that access to the best data possible is available. Larger organizations should appoint a database administrator to oversee standards of data accuracy, integrity and compatibility with existing data holdings. The administrator should also be charged with securing future data requirements and with ensuring that adequate storage and database management facilities exist.
- **Applications development and support.** Though most applications will be developed at the start of projects, there are likely to be ongoing and future needs to develop small additions to existing software routines. It might be necessary to secure the technical assistance of external software companies or from an internal IT facility. Care must be taken that languages used are open languages[101] that may have a long lifetime.
- **Project management.** GIS projects may often be complex in terms of both the range of subject matters covered and in terms of the means of executing the work. This is especially the case in fisheries and aquaculture, i.e. as these are multifaceted enterprises that operate in complex environments. The project manager must be able to establish precise user requirements, to participate in systems and project design, and to ensure that projects are completed on time, within budget and are delivered at an acceptable quality.
- **GIS staff.** The exact roles played by staff in a GIS project will vary greatly, mainly according to the size of the institution and the size and scope of the project being undertaken. This means that staff functions will vary in an almost infinite way. Figure 4.2 gives examples of some of the staffing roles. It is usual for senior managers to play an active role in GIS projects, and this is because they should be very familiar with the project aims and be in a position to secure project needs including, importantly, data and staff. The manager should also play a vital role in liaison with external parties and in systems administration. A larger organization may be in a position to appoint a specific GIS manager. Among other things, the manager should be chosen for his/hers "human resources skills" because it is certain that the management of larger-scale projects will need the necessary competence to successfully maintain harmonious working relationships among people who will have a wide range of competencies and experience. Most likely the skills of the manager will be the greatest factor towards achieving GIS project success.

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[101] Open computer languages provide a uniform programming environment for software developers to write efficient, portable code for high-performance computer servers, desktop computer systems and handheld devices.

4.7.3 Working patterns and task allocation

In the situation where GIS is operating at a very small-scale, with perhaps only one or two people being involved directly with GIS, then considerations of work patterns and task allocation are almost non-existent, i.e. one person does everything or two people decide who does what dependent on their skills, time, availability, etc. It is almost inevitable that in a small department each employee will soon need to become multiskilled and adaptable. As soon as a department employs three or more people, then much more thought has to be given to appropriate allocation of task resources. A normal pattern in these situations would be to have a leading person who is multifunctional – someone who knows quite a lot about almost everything – and this person could be the one who liaises with customers,[102] plans work schedules, supervises data processing, writes up reports and who generally directs operations. The other two or three staff will typically take on specific roles, such as: (i) an information technician/ technologist and GIS operative who is responsible for actually doing the GIS work; (ii) someone in charge of data acquisition, compiling, database management, etc.; and (iii) someone who does the clerical work for the leading person.

An essential element to GIS project work is project flow and work pattern arrangements. GIS can be capital intensive and can incur high running costs, mostly in terms of labour, rent and other overheads. This being the case, it is essential to ensure continuity of work while trying not to incur work overload. To maintain project flow at a satisfactory level takes a great deal of careful planning, but a steady workflow situation can rarely be maintained. This is a problem that affects GIS possibly more than most other business routines because projects can vary enormously in their scale, data can be very hard to secure quickly, and in certain situations many of the software routines can be challenging to execute smoothly. On top of this, there are inevitable workflow interruptions such as staff sickness, staff redeployment, staffing changes, plus the fact that output demands from the GIS projects can keep changing as a greater range of circumstances is investigated and the fact that urgent requests are frequently made. The difficulties of maintaining satisfactory project flows can never entirely be overcome, but experience shows that many jobs take much longer than anticipated; therefore, it is useful if possible to build in at least 20-30 percent "over-run" timing when planning project workflows. If the time is not required, then there is always the backlog of training, reading, experimenting, etc., to be done, and data sets are in continual need of updating or extending.

4.7.4 System safekeeping and security

It is well established that in computing environments the business of data security is a vital ingredient of the operation. Despite this, most readers will have heard of stories or occasions where data have not been secured. For example, data may have been lost, IT systems may have been "hacked into" (illegally entered), data may have been passed on to unauthorized people, and equipment may have been lost or stolen. The costs and consequences of a breakdown in security can be vast in terms of data losses, time wastages, leaks of confidential information and actual financial losses. Thus, it is necessary to continually reinforce the message about safekeeping and system security.

The causes of data loss are varied and they include system failures, operational faults, and deliberate and illegal activities. Electricity blackouts are probably the most frequent system failure and thus the single largest cause of data loss. However, with the range of electrical and/or electronic equipment being used for GIS, there are also certain to be computer and other system failures at some point and these may also include fire damage. There will be occasions where data have not been filed correctly and where data have been unintentionally deleted. Older data can simply deteriorate

[102] "Customers" could be other departments, aquaculturists, fishery managers, etc, i.e. anyone who might be commissioning the GIS work.

through materials decay or data cannot be easily transferred from one media to another. Operational faults (usually human errors) may be unexpected, but over a period of time they are almost certain to occur. Illegal activities can occur when unauthorized persons gain access to data, mainly because passwords have been deliberately passed on or because "hackers" have managed to gain entry to computers.

To safeguard GIS files and other data, a number of measures are, or should be, put into place. Most people know that to log onto their computer a password is required. However, most people do not change their password periodically and, therefore, their password can become known by others through various means. Frequent changes in password are advised, and many organizations have systems in place that require monthly password changes. Sometimes, this is particular to certain software systems e.g. to e-mail, or various network connections require their own passwords to enter their system. To prevent data loss from non-deliberate events, a number of precautions should be taken. As mentioned in Section 2.2.2, there are various hardware devices for the storage of back-up files and data e.g. external hard drives, CD–ROMs, DVDs, memory sticks, and back up of all important work and data should become a regular routine. Systems are available that allow for continuous back-up of all computer generated work. To prevent losses from power supply interruptions, an uninterruptable power supply device should be installed. If useful old files are being retained that are stored on potentially degradable media, then these should be urgently copied to more modern and convenient back-up devices.

As well as the forms of security and data mentioned above, measures might need to be taken to ensure that access to certain information is only allowed among designated personnel, and management will usually make arrangements for this via adjustments to the computer operating systems. It will be important that a regular agenda item for any GIS committee meeting will be security arrangements. It might also be worth investigating the costs of insuring against equipment or data losses, as replacements can be very expensive.

4.7.5 System maintenance

The use of GIS means that those operating the system are likely to spend the great majority of their time undertaking a range of GIS projects, in this case projects involving fisheries or aquaculture. However, if the GIS operative were only to give attention to the practical GIS work, then the hardware or software systems themselves may eventually experience difficulties when the systems start to malfunction. As with almost any other practical system, GIS needs to be maintained in optimum working order.[103] System maintenance refers to the range of activities necessary to sustain the ability of the system to function as required, and it is a task that may involve the whole GIS team including outside technical support. It is normal for any organization to build system maintenance routines into the work schedule for its GIS. A system that is well maintained is likely to suffer from far fewer error problems, and the system will, therefore, retain a far higher productivity rate. Lo and Yeung (2002) calculate that system maintenance may now significantly affect GIS operating costs.

Basically, there are two approaches to systems maintenance: reactive and proactive.

(i) **Reactive maintenance.** This is maintenance that occurs as a reaction to something that has gone wrong. From a GIS perspective, it is imperative that arrangements are in place to cope with a malfunction. Clearly, this may be unforeseen and it can affect any part of the system. Personnel within the organization should be tasked with responsibility for overseeing different segments of the system, though with respect to a small organization one person is likely to have to manage all

[103] This is analogous to having a vehicle regularly serviced. If the vehicle were to be driven for long periods of time, the mechanical systems would eventually start to break down. Periodic servicing helps to prevent this.

contingencies. Typically, reactive maintenance involves GIS users trying to correct malfunctions themselves; asking for assistance from colleagues; knowing who to make contact with externally in respect to every part of the system (hardware and software); and knowing what alternatives might exist to circumventing the problem – perhaps on a temporary basis until any fault is remedied.

(ii) Proactive maintenance. Because systems will inevitably break down eventually, it is sensible to make provision for this before any malfunction occurs. This is typically done through the signing of service agreements (or maintenance contracts) with hardware and software suppliers. Under these agreements, there may be annual servicing provision for hardware, but for software there are a wider range of agreements that include free provision of software upgrades, and perhaps a limited period in which assistance is freely given for software problems. As well as securing against GIS malfunctions, some proactive maintenance will be deployed in making adjustments to the system that may be caused through changing technology and user requirements – this is known as adaptive maintenance (Pressman, 1997). And additional proactive maintenance will be directed towards improvement and enhancement of the functionality of the GIS. Effective proactive maintenance requires that at least one GIS person must be kept thoroughly up to date with GIS and its trends and developments.

As well as systems maintenance to hardware and software, the maintenance of data must be considered. This must be an ongoing task to which someone is permanently assigned. The extent of data maintenance will depend on the data storage capacity or capability of the GIS. Maintenance of data may include a number of tasks:

- systematic error editing;
- temporal updating of data;
- matching of data sets to the management spatial area and to time/space resolution requirements;
- seeking additional data from a wider range of sources;
- reviewing database structures or storage systems;
- metadata upkeep (see section 5.5).

As the GIS work moves from project to project, there is inevitably going to be demands for additional data. This means that storage capacity will quickly grow, but it also means that data sets will accrue, which may not be needed for some time. Decisions need to be taken on what to do with these data. Personnel in charge of data will find that data management tasks can rapidly expand and allowances should be made for this with respect to costs and timing provision.

4.7.6 Coping with organizational change

As with the introduction of most new technologies, the introduction of GIS will bring a period of change. This change can impact on internal organizational structures as well as the organization's relationship with external suppliers and customers. More specifically, Heywood, Cornelius and Carver (2006) report the following main changes that may affect an organization following GIS introduction:

- Changes in job descriptions as employees are obliged to take on different roles. While the organization may recognize that this is bound to impact on job satisfaction, it is often difficult to ensure that any staff redeployments will be in the best interest of each person concerned. There may inevitably be winners and losers in new staffing structures and in staff reallocations.
- Levels of responsibility are certain to be affected. Some people may get job promotions that might not seem fair to other employees.
- The functioning of GIS may positively act to break down barriers in an organization, as its procedures encourage personnel involvement from a wide cross-section of the organization.

- GIS can foster increased contacts with the wider external community. This is because the demands of GIS are such that assembling the inputs of hardware, software, personnel and data makes essential demands in terms of networking and establishing a wide circle of contacts and customers.
- The relationships between different departments within an organization may change as GIS finds its own level and makes more or less demands on each department. The effect can be so great that the whole organization may have to change in order to accommodate GIS.
- Where GIS has literally "taken-off" within an organization, internal restructuring has often been dramatic. In some cases, the rate of change has led to insecurity and uncertainty about the future.

The complex interplay of technical, human and organizational factors will almost certainly have both positive and negative effects and the extent and manner of these effects will involve very careful management if GIS is always to be viewed in a positive light. It will certainly be necessary to be very open with all employees, explaining in detail what is involved and who might be affected. Box 4.7 provides details on "Eason's principles" (Eason, 1988), which represent means of easing the introduction of new technology into existing organizational structures.

BOX 4.7

Eason's principles for introducing new technology into an organization

- **Serve the organization's needs rather than just provide technical support.** Make the introduction of GIS a fully integrated part of the functioning of the organization rather than a peripheral activity.
- **Give employees the ability to make the system work.** Allow employees to feel that they can each contribute to the system if they so wish. If not, they may be unwilling to support the introduction.
- **Integrate the new technology into a planned organizational workflow change.** Because organizations typically have their own structure, structural changes should produce as little disruption as possible.
- **Make employees stakeholders in the system.** For example, individual employee objectives or responsibilities can be tied to GIS success. Employees who benefit from innovation are likely to support it.
- **Ensure that the system meets the organization's goals or solves a problem.** Incorporating new technology because it is perceived as "trendy" may cause the organization to stray from its stated mission.
- **Meet the needs of individual employees.** The system will have a greater chance of success if it makes the workload easier and reduces stress. The workplace becomes a more enjoyable environment.
- **Provide education and training for management and other employees.** Managers need to be very conversant with the technology. The more that employees know about GIS, the more that they can understand and integrate with it.
- **Plan a progressive form of evolutionary growth.** Because GIS adoption may bring new technological and software innovations, plan for the changes in an evolutionary way so as to avoid major disruptions in workflow patterns.
- **Complement existing design principles and organizational change methods.** The more closely the new approach functions like the old, the more quickly both management and employees will adapt to change.

Source: Adapted from Eason (1988) and DeMers (2009b).

4.8 CONTINUING SUPPORT AND TRAINING

The stage has now been reached when the implementation of the GIS has been explained and the system tried and tested to make certain that everything is functioning correctly. But the account of GIS implementation is not finished here because the GIS will need to continue to function into the indefinite future. This section is concerned with keeping the whole GIS team up to date with progress and developments in GIS and knowing where team members can turn to for help and guidance. It is assumed that lead members of the team have basic knowledge of GIS, probably at a university-degree level. Degree-level courses are not discussed here because there are now a large number of full- and part-time courses available and they can readily be found by using Web-based searches. FAO provides a number of hyperlinks to formal training, such as commercial training and on-campus training (www.fao.org/fishery/gisfish/id/1035). However, shorter GIS courses that individual team members may need are discussed. It will also be important to realize that most of the support will come in terms of aids to informing and improving the GIS work being completed, though much support may be needed in terms of the fisheries and/or aquaculture side of the work.[104] This section concentrates almost exclusively on the former, though some mention is made of "fisheries GIS" support materials. Basically, support, training and guidance can be thought of in terms of four main perspectives:

- **Needs for support and training.** This refers to the purpose of the support and training, and it may involve the need for GIS users to update themselves in terms of getting to know a new version of a software package or of a hardware device, etc.; this could mean taking a refresher course. It may also include the need to expand the range of GIS-based knowledge in terms of acquiring a wider range of GIS and other skills, or it may frequently refer to the need for specific problems to be addressed and resolved.
- **Sources of support and training.** This refers to the types of organizations or individuals who are in a position to deliver support and training. Here, there would be a wide range of sources, including those listed in Box 4.8.

BOX 4.8
Some main source categories for GIS guidance and support

Examples of sources for support and training for GIS include:

- **Software houses** – Most leading software houses provide a wide range of additional back-up and help, including online courses, upgrade information and case studies. Some categories of support may need to be paid for.
- **Universities or colleges** – These institutions typically may provide varying length courses on a range of GIS topics.
- **Publishers** – Provide information on new books, journals, etc.
- **Non-governmental organizations** – For example, FAO provides varying forms of GIS guidance through both hard copy publications and its GIS portals, e.g. GISFish (www.fao.org/fishery/gisfish).
- **Professional GIS organizations** – Many countries have GIS organizations whose remit is to disseminate knowledge on GIS and this is done through many of the mediums discussed in this section.
- **Consultants** – For specialized tasks, consultants may prove to be a valuable source of GIS guidance.
- **Equipment suppliers** – There will inevitably be problems associated with any of the hardware and peripheral equipment used for GIS, so sources of advice are essential.

[104] If GIS technicians are not guided by fisheries and/or aquaculture experts, they may not be able to analyse or interpret the results from any GIS output.

- **Medium of delivering support and training.** The concern here is with how support and training is provided or given. This will include a range of delivery methods, e.g. via manuals, the Internet or in person, some of which form the subheadings used in the rest of this section.[105]
- **Types of support and training needed.** It is clearly in the GIS user's interest to know the range of different types of support that may be available.

This section is only concerned with support and training that is specifically aimed at GIS functionality, i.e. support will also be needed and available for hardware and for the peripheral software packages, such as database management systems, but space precludes consideration of these. It will be vital that users know exactly where (and what) support can be obtained for any part of the GIS system.

4.8.1 Instruction manuals and exercises

The manuals that are applicable to GIS generally and those more specifically aimed at fisheries or aquaculture are both considered in this section. Although most manuals are originally supplied in hard copy formats or on CD–ROMs, they can now be downloaded either from the software house itself or from other suppliers.[106] Manuals are aimed at providing both instructions on the use of GIS and for resolving problems that users might experience while attempting specific functions. FAOs Fisheries and Aquaculture Department Aquaculture Branch (FIRA) Global Gateway to Geographic Information Systems (GIS), Remote Sensing and Mapping for Fisheries and Aquaculture site (www.fao.org/fishery/gisfish) is a rich resource of information on publications and case studies demonstrating the benefits of these tools to resolving issues in fisheries and aquaculture. Aguilar-Manjarrez, Kapetsky and Soto (2010) provide a description of selected case studies illustrating a range of such virtual tools. Previous issues of the FAO Aquaculture Newsletter[107] describe activities on GIS, remote sensing and mapping at FIRA.

This heading includes a range of different types of published material:

- **GIS hardware and software manuals.** All manufacturers of hardware components for GIS use will provide instruction manuals that are model specific. Each proprietary software house produces an instruction or operating manual that aims to show how the software can be used,[108] with some software producers now only supplying manuals online, e.g. IDRISI (Clark Labs). Manuals are typically very extensive and the user invariably becomes familiar with only a small proportion of the total content. The software will usually have a "Help" facility that aids the learning process. For GIS users who opt to use open source software, details on supporting this software may be found in Neteler and Mitasova (2008) or Kropla (2005).
- **GIS software "illustrative" manuals.** Some of the software houses, for example, Clark Labs (IDRISI) and ESRI, have produced manuals that are in addition to the basic operating instructions. These mainly recount GIS case studies and/or the main GIS functionality that together usefully illustrates potential applications for their own software. The following are examples of these manuals and/or workbooks: Mitchell (2005); Brewer (2005); Allen (2009); Warner and Campagna (2009); Kennedy (2009); and both the GeoNetwork (http://geonetwork-opensource.org/) and BostonGIS (www.bostongis.com/?content_name=spatialite_tut01)

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105 It is clear that the type of training needed may be delivered from any of the range of persons or organizations involved, by any of the mediums of delivery.

106 See, for instance, Free eBook Download (www.ebooksquad.com/search/arcgis+user+manual+download) and WareSeeker.com (http://wareseeker.com/free-idrisi-andes-manual-pdf).

107 Electronic copies of the FAO Aquaculture Newsletter (FAN) are available at www.fao.org/fishery/publications/fan/en. See examples of GIS related activities at FIRA in: FAN 35, pp.13–19; FAN 37, p. 33; FAN 38, pp. 32–33; FAN 41, p. 11; FAN 42, pp. 24–25, pp. 36–38; FAN 44, pp. 8–11; FAN 46, pp. 8–9; pp. 36–37; FAN 47, pp.24–25; FAN 48, pp.14–15, p.20, pp. 48-49, p. 55; FAN 49, p. 39).

108 See, for instance, Eastman (2003).

Web sites provide details of tutorials, documentation and software relating to open source software. Box 4.9 provides information on a useful set of workbooks (based on ESRI's ArcGIS software) that start from a very basic level.

BOX 4.9

Instruction manuals in ESRIs "Our World GIS Education" series

Environmental Systems Research Institute (ESRI) has produced a book series designed to enhance GIS learning for students at all levels. The books provide detailed information about GIS; suggested curriculums for teaching; worked exercises; and a range of other resources. Books in this "Our World GIS Education" series include:

Thinking Spatially Using GIS: Our World GIS Education, Level 1 Spatial thinking concepts and skills are cultivated and basic GIS software skills are taught including map reading and pattern recognition skills.

Mapping Our World Using GIS: Our World GIS Education, Level 2 Investigation and geographic inquiry is explored while basic GIS software skills are solidified.

Analyzing Our World Using GIS: Our World GIS Education, Level 3 The geographic inquiry and analysis skill set is extended to include data acquisition with a lesson using ArcGIS Spatial Analyst.

Making Spatial Decisions Using GIS: Our World GIS Education, Level 4 Students undertake more independent study as they analyse real-world issues using GIS project workflows to ultimately draw informed conclusions.

Source: ESRI (2011b).

- **GIS exercise or tutorial manuals.** These manuals are produced for most of the main proprietary GIS software, though some software houses include exercises in their operating manuals. For these manuals, the accent is on working through prescribed, logically ordered exercises. For instance, ESRI has produced a range of exercise manuals covering each release of ArcView or ArcGIS, e.g. see Gorr and Kurland (2009) and other GIS exercise books are available, e.g. Clarke (2010). Access to general GIS tutorials, exercises or manuals can be found on many Web sites, for example:
  - Intergraph Security, Government and Infrastructure Forum: http://userforums.intergraph.com/support;
  - ESRI: www.esri.com/news/arcuser/avmodel.html and http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Tutorials;
  - Software.informer: http://software.informer.com/getfree-download-gis-tutorial-exercise;
  - GISLounge: http://gislounge.com/raster-tutorials/#more-654;
  - ESRI Conservation Program Resources: www.conservationgis.org/training/ConsStartKit.html.
- **Fisheries or aquaculture GIS manuals and exercise manuals.** A few GIS manuals and exercise manuals have appeared that specifically cover marine, fisheries or aquaculture related topics – see Table 4.2. In this table, only publications that show the user "how to use GIS" are listed, i.e. it does not list books or manuals that tell readers "about" fisheries or aquaculture GIS – these are shown in Section 4.8.3. Some of the manuals are becoming dated, though they still offer much useful background information. Some exercise manuals may be developed for specific versions of GIS software, so the user must be aware of this before ordering them.

TABLE 4.2

GIS manuals and exercise manuals specifically related to marine and inland fisheries or aquaculture

Author	Title	Publisher	Comments
Kapetsky, McGregor and Nanne (1987) www.fao.org/fishery/gisfish/id/gf92	A Geographical Information System to Plan for Aquaculture: A FAO-UNEP/GRID study in Costa Rica. FAO Fisheries Technical Paper No. 287.	Rome, FAO	Illustrates how GIS was used to identify optimum areas in Costa Rica for shrimp farms.
Meaden and Kapetsky (1991) www.fao.org/DOCREP/003/T0446E/T0446E00.HTM	Geographical Information Systems and Remote Sensing in Inland Fisheries and Aquaculture. FAO Fisheries Technical Paper No. 318.	Rome, FAO	Describes how the emerging technologies of remote sensing and GIS could be used to benefit inland fisheries and aquaculture.
Clark Labs (1996) www.clarklabs.org/products/unitar-workbooks.cfm#CoastalZone	Explorations in Geographic Information Systems: A Workbook Series. Vol.3 – Applications in Coastal Zone Research and Management	UNITAR, Geneva, Switzerland	Provides eight case studies showing GIS use in various marine and coastal environments, including marine fisheries and aquaculture
Meaden and Do Chi (1996) www.fao.org/DOCREP/003/W0615E/W0615E00.HTM	Geographical Information Systems. Applications to Marine Fisheries. FAO Fisheries Technical Paper No. 356.	Rome, FAO	Describes how GIS is being applied to marine fisheries. Includes case studies.
de Graff, *et al.* (2000) www.nefisco.org/GIS_table_of_contents.htm de Graff, *et al.* (2000)	Fish GIS: An Introduction to the Use of Geographical Information Systems and Remote Sensing in Fisheries Monitoring, Analysis and Management	Nefisco Foundation, Amsterdam, The Netherlands	Worked GIS exercises covering a range of fisheries and aquaculture topics based on Bangladesh. Uses ArcView GIS.
Verbyla, D.L. (2002)	Practical GIS Analysis	Taylor and Francis, London, United Kingdom	Using worked examples, the various analysis tools in a GIS, and the concepts behind them are explained.
Kam *et al.* (2008) www.worldfishcenter.org/rdproject/	Recommendation Domains for Pond Aquaculture. WorldFish Centre; Studies and Reviews 1848.	The WorldFish Centre, Penang, Malaysia	Provides aquaculture project outputs and GIS modules, including exercises and data on a DVD.
de Graff, *et al.* (2003) www.fao.org/docrep/006/y4816e/y4816e00.htm#Contents	Geographic Information Systems in Fisheries Management and Planning: Technical Manual. FAO Fisheries Technical Paper No.449.	Rome, FAO	Demonstrates, for biologists and fishery managers, the use of ArcView GIS for a range of inland fisheries and aquaculture purposes.
Jenness, *et al.* (2007b) www.fao.org/docrep/010/a1170e/a1170e00.htm www.fao.org/docrep/010/a0907e/a0907e00.htm	African Water Resource Database. GIS-based tools for inland aquatic resource management. CIFA Technical Paper. No. 33, Parts 1 and 2.	Rome, FAO	Includes some 5.5 GB of data, plus a set of data and custom-designed GIS-based tools, covering many aspects of inland fisheries and aquaculture. Uses ArcView 3.x. Concepts, application case studies and a technical manual and workbook are provided.
NOAA Costal Services Center (2006) www.csc.noaa.gov/training/	Coastal Applications Using ArcGIS	NOAA, United States of America	Includes problem-solving exercises to address a variety of real-world coastal issues using ArcView 9.1 technology.

4.8.2 Practical training courses

For many GIS participants, the preferred method of learning and enhancing their GIS skills is through "hands-on" or practical training. Fortunately, the means of acquiring skills in this way has greatly increased over the past decades and there is now a range of ways of acquiring GIS "hands-on" skills that should satisfy most people's requirements. Here, only shorter more specific GIS training courses are discussed, i.e. not undergraduate degree-type courses. Courses will either be focused on GIS more generally or on specific aspects of GIS, and there may be a few opportunities to attend GIS training courses specifically directed towards fisheries or aquaculture GIS. It is very important when selecting a course to make certain that the course not only meets training content requirements but that it also is delivered at the correct academic level.

Perhaps the most useful way of subdividing GIS training is through the two categories of "face-to-face" instruction or "online" instruction.[109] Although clearly the methods of delivery will be quite different, the material covered can be very similar, and it will be up to individuals to choose the method of training to suit their circumstances. Both types of courses are typically offered by colleges or universities and by the main software houses, though sometimes larger government organizations or private training agencies run courses. A myriad of courses are available ranging from those covering basic GIS principles to advanced analytical techniques. Table 4.3 gives examples of face-to-face and online training courses for both general GIS and for fisheries- or aquaculture-specific GIS.[110] More details on each of these training delivery methods are as follows:

- **Face-to-face instruction.** The chances of receiving face-to-face instruction depends almost entirely on either where you live or whether the time can be obtained for attending courses that are residential. Therefore, training courses are typically held in capital or larger cities where viable attendee numbers may be attained or assembled. This method of instruction has the significant advantage that individual guidance can be more easily delivered, something that greatly favours certain trainees. Face-to-face training is usually quite expensive, with some of the software houses charging about US$500 per day in developed countries, and in addition, most courses are specific to certain software. A major problem with some intensive training courses is that too much information is given in a fairly short amount of time and thus makes retention of course material difficult.[111] Fisheries- or aquaculture-specific GIS face-to-face courses are quite rare, though FAO has offered courses since 1985 and some larger specialist institutions (e.g. the University of Stirling, Scotland, and the National Oceanic and Atmospheric Administration, the United States of America) incorporate fisheries and/or aquaculture GIS into existing degree-level courses or they occasionally offer specialist GIS courses.
- **Online instruction.** An increasingly popular way of obtaining GIS-related training is through delivery of courses over the Internet. These might be thought of as "distance learning" courses, though distance learning itself predates the Internet. Online courses have been largely developed to meet the needs of working professional people. The sources of online training are usually the same as those for face-to-face training. Online instruction has the disadvantage that genuine face-to-face interaction is not usually possible, but it has the huge advantages that instruction can be received in the trainee's own home or place of work and that courses can be undertaken in the trainee's own time and at their own pace. From the training delivery point of view, there is also the advantage that, except for the marking or course assessment viewpoint, almost any number of students can be enrolled in a course. ESRI offers online training through their Virtual Campus,where dozens of courses on numerous topics can be accessed at the user's

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109 Sections of either type of training may also have instruction via manuals, video, CD–ROM and include a fieldwork element.

110 Some of the fisheries-specific GIS courses are one-off courses that were run in the past. The demand for fisheries- or aquaculture-based GIS courses is too small to allow for any regular courses to be established.

111 If possible, it is better to choose courses where instruction is spread over a longer time period (weeks or months).

TABLE 4.3
Examples of GIS and fisheries GIS training courses

Source/country	Type of GIS course	Uniform resource locator (URL) of training course
General GIS training		
FAO Aquaculture Branch and Marine and Inland Fisheries Branch; FAO, Italy	Provides a number of links to formal training opportunities and Internet training	www.fao.org/fishery/gisfish/id/1035 www.fao.org/fishery/gisfish/id/1032
NAACCR GIS Committee GIS training-related Web sites; United States of America	Wide miscellany of GIS-related training courses published by the North American Association of Central Cancer Registries	www.naaccr.org/filesystem/pdf/GIS%20 Training%20Web%20Sites.pdf
Sir Sandford Fleming College Web GIS Development; Canada	A one-semester Internet-delivered course on Web-based GIS delivery	www.webgisdev.com/home.htm,
ITC in association with United Nations University, University of Twente; The Netherlands	Distance learning GIS and remote sensing courses at various levels	www.itc.nl/study
Intergraph training course GeoMedia/ GeoMedia Professional training course; United States of America	A web-based course designed to teach Intergraph's Geomedia GIS	www.intergraph.com/training/ courseprofiles/tmap2117.aspx
Geo-Informatics and Space Technology Development Agency; Bangkok, Thailand	Organization of remote sensing and GIS training courses, seminars, workshops and conferences at national and international levels	www.gistda.or.th/en/index. php?option=com_content&view=articl e&id=15&Itemid=37
NYS GIS Clearinghouse. Training and Education; United States of America	Listing of general GIS training available	www.nysgis.state.ny.us/outreach/ training/
The US National Center for Geographic Information and Analysis; United States of America	Clearing house listing GIS training opportunities	www.ncgia.ucsb.edu/education/ projects/univ/unipubs.php
UNIGIS; International	Worldwide information on GIS distance learning courses	www.unigis.org/
GeoData Institute; United Kingdom	Range of scheduled or bespoke GIS courses – most are "face-to-face"	www.geodata.soton.ac.uk/ geodataweb/technologies/ gis/?link=subtheme.php&id=1050
University of Leeds; United Kingdom	Range of online distance learning courses	www.geog.leeds.ac.uk/odl/short-courses.htm
ASKEDU – Schools, certificates, courses, workshops; United States of America	Search facilities for locating appropriate GIS training courses worldwide	www.askedu.net/training_topic/k_ GIS_1.htm
Manifold; United States of America	A range of online video training courses for Manifold GIS	http://gisadvisor.com/index.html
Examples of fisheries or aquaculture training		
*FAO Aquaculture Branch and Marine and Inland Fisheries Branch; FAO, Italy	Provides a number of links to FAO manuals and courses conducted by FAO	www.fao.org/fishery/gisfish/id/1038 www.fao.org/fishery/gisfish/id/1020
2008 World Fisheries Congress; Japan	Two-day training on fisheries GIS	www.congre.co.jp/5thwfc2008/GIS_ courseB_agenda.pdf
Department of Fisheries and Aquaculture (Malta), in collaboration with University of Plymouth (United Kingdom) and COPEMED (FAO); Malta	Four-day course on fisheries GIS in 2001	www.faocopemed.org/old_copemed/ reports/gis/maltaCourse/day4.pdf
Northwest Environmental Training Center; United States of America	Three-day course on use of ArcView GIS for fisheries and wildlife purposes	http://nwetc.org/FILES/gis-400_10-08_oakland.pdf
University of South Florida; St. Petersburg, United States of America	A self-paced workshop teaching various fishery topics using ArcGIS.	www.stpt.usf.edu/gisWorkshop/PDF/ Self_Paced_fishery_I.pdf
National Oceanic and Atmospheric Administration (NOAA); United States of America	GIS courses on a range of marine and coastal issues	www.csc.noaa.gov/training/ coastalapps/
CARIS; Canada	CARIS offers extensive GIS training courses at its Canadian headquarters, plus a catalogue of other international courses	www.caris.com/training/catalogue.cfm
Mappamondo; Italy	GIS instructor-led training courses, some of which are fisheries based	www.mappamondogis.it/training.htm

* The FAO Aquaculture Branch and Marine and Inland Fisheries Branch conducts some GIS training, but only one to three times a year in different countries around the world to support a few FAO field projects when requested and when funds are available. The participants of the courses are usually those who are directly involved in an FAO project.

leisure. Additionally, ESRI offers "webinars", or seminars over the Web, and students can watch short demonstrations of GIS technology and ask questions to the instructors.

It can sometimes be difficult to locate GIS training courses. For general GIS training, it is most useful to consult the Web sites of the major software houses or the sites of universities where geography features as an important subject. In many countries, there are GIS organizations (see Section 4.8.5 below) that frequently publicize courses. The most successful way of locating training courses, however, is through the use of online search facilities. Training that is more specifically based on fisheries or aquaculture GIS is quite rare, and worldwide there are few courses each year. However, this is likely to change over the coming decade and readers are advised to consult the FAO GISFish Web site for details on future training opportunities.

Regardless of whether a person has used GIS before or has been a practitioner for years, education and training are the keys to creating or maintaining the skills necessary to be a proficient GIS operator. Each person has a preferred method of learning, whether it is Web-based training, classes taught by an instructor face-to-face, or by the student learning on their own. All are valid methods of education and vendors and academic organizations now offer all of these methods to the GIS community.

4.8.3 Other published information

As well as various manuals and exercise books that deal directly with GIS, there is a range of other publications that can provide invaluable support. While most of this support material will be in a book or hard copy format, some will be online versions of books and others will be in the form of CD–ROMs or videos and DVDs. The major focus in this section is with GIS materials rather than any material relating to fisheries or aquaculture. There are a number of main forms of published information, including textbooks, academic journals, trade magazines and conference proceedings. Here, the material is summarized under three headings:

- **General GIS books.** When the forerunner of this present manual was first produced in 1991, the total number of GIS books available was 14 (Meaden and Kapetsky, 1991). Typing "geographic information systems" into the "Books" section of www.amazon.com reveals that in mid 2012 there were more than 16 000 results listed – such has been the very broad and intensive growth in this subject area. However, a large proportion of these books are now "topic specific" and cover all the major GIS applications areas shown in Box 1.3. Readers seeking to gain a more comprehensive knowledge of GIS should look at the recommended introductory texts on GIS listed in Box 4.10. These books only provide a general summary of GIS, and therefore for people already working in GIS it is more likely that they will want to consult the manuals discussed in Section 4.8.1.
- **Fisheries or aquaculture GIS publications.** As mentioned in Section 1.4, the first fisheries and/or aquaculture GIS publications emerged in the mid-1980s. Since that time, there have been an increasing number of publications in this subject area, many of which could give important support to any GIS work. As well as the manuals listed in Table 4.2, any of the publications listed in Box 4.11 could prove useful. Table 4.2 lists manuals on "how to do fisheries and/or aquaculture GIS", whereas the publications listed in Box 4.11 tell the reader "about fisheries and aquaculture GIS" and not how to do this work. As well as complete publications on these subjects, there are other publications that devote single chapters to fisheries or aquaculture GIS.
- **Journals and trade magazines.** There is a wide range of professional, academic and trade publications that users can access to further their GIS knowledge. As with books, these sources mostly originate from the GIS software houses, from academic journal publishers or from a range of individual sources, and they can be in hard copy or digital formats. Academic publications on GIS tend to focus on the theory and emerging trends within GIS technology, and they provide a glimpse

into research that is shaping the field. However, it should be noted that most papers published in GIS-related academic journals are fairly sophisticated and they tend to be overwhelmingly devoted to GIS-based research topics. Trade magazines offer information on a wide range of trends as well as reports on the GIS industry as a whole. They are a resource for finding information such as reviews of new software releases as well as opinion articles on the state of the industry. Papers and articles about the use of GIS for fisheries or aquaculture research or management may appear in a wide spectrum of fisheries, ecosystems, marine or other journals, and these articles are much more likely to be both relevant and comprehensible. Box 4.12 provides a selection of journals and trade magazines that frequently have articles covering GIS applications to aquaculture. Access to journals can be difficult because they often involve quite expensive subscriptions, though individual papers (articles) can be bought for a fee. Some journals are free and the best way of ascertaining their access is through an online search.

BOX 4.10

Some introductory textbooks covering general GIS

Bernhardsen, T. 2002. *Geographic information systems: an introduction*. Chichester, United Kingdom, Wiley.

Bolstad, P. 2008. *GIS fundamentals: a first text on geographic information systems (3rd edition)*. Ashland, Ohio, United States of America, Atlas Books.

Chang, K-T. 2009. *Introduction to geographic information systems*. New York, United States of America, McGraw-Hill.

Clarke, K.C. 2010. *GIS Exercise workbook for getting started with geographic information systems.* Upper Saddle River, New Jersey, United States of America, Prentice Hall.

Crampton, J.W. 2010. *Mapping: a critical introduction to cartography and GIS*. Chichester, United Kingdom, Wiley.

Delany, J. & Van Niel, K. 2007. *Geographical information systems: an introduction*. South Melbourne, Australia, Oxford University Press.

DeMers, M.N. 2009a. *Fundamentals of geographical information systems (Fourth Edition)*. Hoboken, New Jersey, United States of America, John Wiley & Sons.

DeMers, M.N. 2009b. *GIS for dummies*. Hoboken, New Jersey, United States of America; Wiley Publishing Inc.

Harvey, F. 2008. *A primer of GIS: fundamental geographic and cartographic concepts*. New York, United States of America, Guilford Press.

Heywood, I., Cornelius, S. & Carver, S. 2006. *An introduction to geographical information systems (3rd Ed)*. Harlow, United Kingdom, Pearson Education Ltd.

Konecny, G. 2002. *Geoinformation: remote sensing, photogrammetry and geographical information systems.* London, United Kingdom, Taylor & Francis.

Lloyd, C. 2009. *Spatial data analysis: an introduction for GIS users*. Oxford, United Kingdom, Oxford University Press.

Lo, C.P. and Yeung, A.K.W. 2002. *Concepts and techniques of geographic information systems.* Upper Saddle River, United States of America, Prentice Hall.

Longley, P.A., Goodchild, M.E., Maguire, D.J. & Rhind, D.W. 2011. *Geographic information systems and science.* Chichester, United Kingdom, John Wiley and Sons.

Madden, M. 2009. *Manual of geographic information systems*. Annapolis Junction, Maryland, United States of America, ASPRS.

Obermeyer, N.J. & Pinto, J.K. 2008. *Managing geographic information systems.* New York, United States of America, Guilford Press.

Schuurman, N. 2004. *GIS: A short Introduction.* Malden, Massachusetts United States of America, Blackwell Publishing.

Skidmore, A. 2002. *Environmental modelling with GIS and remote sensing (Geographic Information Systems Workshop).* London, United Kingdom, Taylor & Francis.

Wing, M.G. 2008. *Geographic information systems: applications in natural resource management.* New York, United States of America, Oxford University Press.

Wise, S. 2002. *GIS basics*. London, United Kingdom, Taylor & Francis.

BOX 4.11

Examples of books published in the last decade on fisheries and/or aquaculture GIS

Aguilar-Manjarrez, J., Kapetsky, J.M. & Soto, D. 2010. *The potential of spatial planning tools to support the ecosystem approach to aquaculture.* FAO/Rome. Expert Workshop. 19–21 November 2008, Rome, Italy. FAO Fisheries and Aquaculture Proceedings No.17. Rome, FAO.

Breman, J.,eds. 2010. *Ocean Globe.* Redlands, California, United States of America, ESRI Press.

Breman, J. & Convis, C., eds. 2002. *Marine geography: GIS for the ocean and seas.* Redlands, California, United States of America, ESRI Press.

Carocci, F., Bianchi, G., Eastwood, P. & Meaden. G.J. 2009. *Geographic information systems to support the ecosystem approach to fisheries.* FAO Fisheries and Aquaculture Technical Paper No. 532. Rome, FAO.

Fisher, W.L. & Rahel, F.J., eds. 2004a. *Geographic information systems in fisheries.* Bethesda, Maryland, United States of America, American Fisheries Society.

Green, D.R. & King, S.D., eds. 2003. *Coastal and marine geo-information systems: applying the technology to the environment.* Dordrecht, The Netherlands, Kluwer Academic Publishers.

Hall, M.K., Walker, C.S., Weeks, J.A., Kendall, L.P. & Jenness, J.S. 2006. *Exploring the ocean environment: GIS investigations for the earth sciences, ArcGIS Edition.* Florence, Kentucky, United States of America, Brooks Cole Publishing.

Kapetsky, J.M. & Aguilar-Manjarrez, J. 2007. *Geographic information systems, remote sensing and mapping for the development and management of marine aquaculture*. FAO Fisheries Technical Paper No. 458. Rome, FAO.

Nishida, T., Kailola, P.J. & Hollingworth, C.E., eds. 2001. *Proceedings of the First International Symposium on GIS in Fishery Science.* Saitama, Japan, Fishery GIS Research Group.

Nishida, T., Kailola, P.J. & Hollingworth, C.E., eds. 2004. *GIS/Spatial Analyses in Fishery and Aquatic Sciences (Vol.2).* Saitama, Japan, Fishery-Aquatic GIS Research Group.

Nishida, T., Kailola, P.J. & Caton, A., eds. 2007. *GIS/Spatial Analyses in Fishery and Aquatic Sciences (Vol.3).* Saitama, Japan, Fishery-Aquatic GIS Research Group.

Nishida, T. & Caton, A., eds. 2010. *GIS/Spatial Analyses in Fishery and Aquatic Sciences (Vol. 4).* Saitama, Japan, International Fishery GIS Society.

Travaglia, C., Profeti, G., Aguilar-Manjarrez, J. & Lopez, N.A. 2004. *Mapping coastal aquaculture and fisheries structures by satellite imaging radar: case study of the Lingayen Gulf, the Philippines.* FAO Fisheries Technical Paper No. 459. Rome, FAO.

Valavanis, V.D. 2002. *Geographic information systems in oceanography and fisheries.* London, United Kingdom, Taylor & Francis.

Valavanis, V.D., eds. 2008. *Essential fish habitat mapping in the Mediterranean.* Dordrecht, The Netherlands, Springer-Science.

Valavanis V., Wright, D., Georgakarakos, S. & Kitsiou, D. 2011. *Marine geographical information systems: theory and applications (advances in geographic information science).* New York, United States of America, Springer Science.

Wright, D.J., eds. 2002. *Undersea with GIS.* Redlands, California, United States of America, ESRI Press.

Wright, D.J., Blongewicz, M.J., Halpin, P.N. & Breman, J. 2007. *ArcMarine: GIS for a blue planet.* Redlands, California, United States of America, ESRI Press.

Wright, D.J. & Bartlett, D. 2001. *Marine and coastal geographical information systems.* London, United Kingdom, Taylor & Francis.

Wright, D.J. & Scholz, A.J. 2005. *Place matters: geospatial tools for marine science, conservation and management in the Pacific Northwest.* Portland, Oregon, United Statesof America, Oregon State University Press.

BOX 4.12
Journals and trade magazines having GIS applications in aquaculture

The following are examples of publications that may feature articles illustrating how GIS has been applied to aquaculture research or management:

- Anatolia
- Aquaculture
- Aquacultural Engineering
- Aquaculture International
- Aquaculture News – University of Stirling
- Aquaculture Research
- Aquaculture and Fisheries Management
- Coastal Management
- Ecology of Marine Aquaculture
- Estuarine, Coastal and Shelf Science
- GIS World
- Hydrobiologia
- InterCoast Online
- International Journal of Remote Sensing
- Mapping Awareness and GIS Europe
- Revista AquaTIC

Source: Updated from Institute of Aquaculture, University of Stirling (2012).

4.8.4 Conferences, workshops and exhibitions

For many participants in practical GIS work, a more conducive form of support and training is through verbal or visual approaches rather than reading manuals or working through exercises. This is where conferences, workshops and exhibitions come to the fore. In these surroundings, participants are able to explore a wide variety of ideas, often at their own pace, and there is more or less complete freedom to delve into subjects of their own choosing and to the depth that they need. There are outstanding opportunities to gather and learn about emerging trends in GIS and to see how others are applying GIS technology in their organizations. For these reasons, especially conferences and exhibitions, they have become very popular in a wide cross-section of subject areas.

Attending general GIS conferences can be highly beneficial, though these mainly take place in major cities in developed world countries. Most conferences include exhibitions because the various vendors need to exhibit their latest software or hardware offerings, and it is largely through the exhibitions that conference attendance prices can be minimized. The authors believe that these exhibitions may provide the ideal platform to establish strengths and weaknesses of individual GIS components. The conferences typically offer a wide range of GIS-based papers, though many of them will have vendor specific content. Although many purchasing deals might be done at conferences and/or exhibitions, they should be the source of ideas rather than hasty purchases. Some of the larger conferences also include workshop sessions, which often take the form of introductions to specific vendor products.

As well as general GIS conferences, there are a number of either "user"[112] promoted or "vendor" promoted conferences that are typically based on a specific software or, indeed, on open source software. These can be particularly useful to GIS users who are committed to using the software that was decided upon during the implementation

[112] "User" groups will be either groups of GIS users that concentrate around a specific GIS software or are based in a specific geographic area.

planning. Conferences also provide the ideal venue for the extension of ideas and possibilities and for learning better ways of achieving desired GIS outcomes. They are sometimes based on a particular theme for each conference, and some conferences are aimed at an academic audience rather than the general public. As there are too many conferences to list, the reader should review Box 4.13, which gives examples of Web site information for both "user" and "vendor" promoted GIS conferences. For the most part, conferences are overwhelmingly held in the United States of America, though the "general conference" listings do cite many international and non-United States events and a Web search by continent reveals that a significant number of GIS conferences are promoted worldwide.

BOX 4.13

Web sites giving information on general and vendor-based GIS conferences

• **General conference listing**	http://gislounge.com/events www.conferencealerts.com/gis.htm www.unigis.org/resources/gisconf.htm http://gisandscience.com/category/conferences www.geo.uzh.ch/en/units/giva/events/conferences www.isotc211.org/events.htm
• **General GIS conferences in Canada**	http://canadiangis.com/events.php
• **Specific biannual conference**	www.ncgicc.com/CurrentActivities/NCGISConference/tabid/158 Default.aspx
• **Specific annual conference**	www.urisa.org/calgis/info www.pagisconference.org/ www.cartogis.org/autocarto
• **Combines remote sensing with a GIS conference**	www.igarss2010.org
• **Manifold users conference**	http://gis4everyone.com/Manifold2009/Presentations.htm
• **Intergraph vendor's conference**	www.intergraph2010.com
• **ESRI vendor's conference**	www.esri.com/events/uc/index.html
• **Open Source GIS conference**	www.opensourcegis.org.uk
• **The 2010 Open Source conference**	http://2010.foss4g.org
• **International academic GIS conference**	www.giscience2010.org

Conferences devoted solely to fisheries or aquaculture GIS are rather rare. One important series of fisheries GIS conferences is the one promoted by the Fishery-Aquatic GIS Research Group, based in Saitama, Japan. The first conference was held in Seattle, Washington, United States of America, in 1999, and since then there have been triennial conferences in Brighton, United Kingdom of Great Britain and Northern Ireland (2002), Shanghai, the People's Republic of China (2005), Rio de Janeiro, the Federative Republic of Brazil (2008), and in Wellington, New Zealand (2011). These important symposia cover all aspects of fisheries and aquaculture GIS, they attract an international audience, and conference proceedings are produced (the latest published is Nishida and Caton, 2010). A number of more local fisheries or aquaculture conferences or workshops have been organized, but they tend to be smaller scale, one-off events.

4.8.5 Other GIS users and professionals

The final source of support and training are various persons or groups that specifically aim to offer advice either freely or on a paid basis. They are a miscellaneous group comprising consultancy services, user support groups, software vendors and professional associations.

- **Consultancy services.** Consultancy is usually provided by individuals who either work privately for themselves or who may be hired on a temporary basis by larger organizations. They are usually experts in specific areas that are either quite broad or highly specialized. GIS consultants often provide rather broadly based advice and other services, though typically many of them now concentrate on individual GIS applications areas. GIS consultants can best be found through business and trade directories or through the professional GIS associations. Some examples of services that a consultant might offer include:
  - needs assessments;
  - system design and architecture;
  - data conversion;
  - data quality assurance and control (e.g. metadata preparation);
  - project management;
  - application development (e.g. database design and development, processing, analysis, modelling, and decision support);
  - mapping;
  - surveying;
  - technical support (software and/or hardware);
  - reporting (analysis, methodologies, etc.).
- **User support groups.** There are two main types of user support groups, i.e. GIS software dependent groups and more general discussion groups or forums. Nowadays, both groups operate via the Internet, and generally users need to register through an online log-in process. With either of these groups, the user basically becomes part of a network of GIS users who communicate freely by basically posing questions, providing answers and entering into discussions (forums). The groups are an excellent medium for problem solving because advice is usually volunteered freely. Examples of user or discussion groups are shown in Box 4.14. A search on Google using "GIS user groups" reveals a large number

BOX 4.14
Examples of GIS user and discussion groups

Manifold users directory	www.manipedia.eu/index.php?title=Main_Page
Manifold users forum	http://forum.manifold.net/forum
Intergraph user support group	http://userforums.intergraph.com/supportL
Listing of GIS discussion groups	http://home.earthlink.net/~rpminfonet/gislist.html
Online discussion lists	www.unigis.org/resources/gisdisclists.htm
Lists ArcGIS user forums	http://support.esri.com/index.cfm?fa=forums.gateway
IDRISI regional support centers	www.clarklabs.org/resources/resource-centers.cfm
Detailed listing of GIS support services	www.gisuser.com/content/view/3006/53
Listing of various GIS forums	http://forum.gislounge.com
Range of discussion and other support	www.geocomm.com
Online GIS discussion forum	www.diva-gis.org/forum/1
GIS India discussion group	http://bestdiscussiongroups.com/gr_gisindia_p1.htm
Wide range of international ArcGIS groups	http://groups.yahoo.com/phrase/esri-gis
GRASS user groups	www.ces.iisc.ernet.in/grass/community/usergroups.php

of such groups, with the great majority located in the United States of America. However, it does not matter where user group members are located, though larger user groups sometimes hold their own conferences or workshops, which usually take place in the United States of America.

- **Software houses.** This heading is included to remind readers that the software houses (vendors) should be a major source of support for all GIS work. Not only do they give advice regarding the use of their software, but it is also likely that users will take out some sort of time-limited contract during which questions can be submitted to the vendor, (this is back-up support in response to functional problems that may arise). As indicated above, vendors also offer support through organizing user groups for their products, through publishing a range of supporting and training materials, and through organizing or attending various conferences or exhibitions. Clearly, the range of support offered by each software house will vary greatly and this should be checked prior to investing in a GIS.
- **Professional GIS organizations.** There are a large number of professional and academic societies and associations that have emerged to act as a voice for the GIS community in their respective regions and/or internationally. These organizations (or associations) provide a range of services or activities, such as issue publications, reports and newsletters, provide GIS certification, conferences, consultancy, advice to government, support and training, and networking opportunities. They may also help the profession to maintain and improve standards. Professional GIS organizations exist in many countries worldwide, and joining one can be advantageous from career, influence and participation viewpoints. A sample of such organizations is listed in Box 4.15.

BOX 4.15
Professional GIS organizations

- American Society for Photogrammetry and Remote Sensing (ASPRS) – United States of America
- Asociación Española de Sistemas de Información Geográfica – Spain
- Association for Geographic Information – United Kingdom
- Association for GIS Professionals – United States of America
- Association of American Geographers (AAG) – United States of America
- Canadian Institute of Geomatics – Canada
- Conseil National de l'Information Geographique – France
- European Umbrella Organization for Geographic Information – European Union
- Geospatial Information and Technology Association (GITA) – United States of America
- Grupo SIG–FAM – Sistemas de Información Geográfica – Chile
- International Association of Chinese Professionals in Geographic Information Sciences – China
- International Society for Photogrammetry and Remote Sensing – United States of America
- Management Association for Private Photogrammetric Surveyors (MAPPS) – United States of America
- Open Geospatial Consortium – International
- Open Source Geospatial Foundation – International
- Organización de los Proyectos de Sistemas de Información Geográfica Territoriales – Cuba
- Pakistan Society of GIS – Pakistan
- Society of South African Geographers – South Africa
- Syndicat Professionnel de la Geomatique – France
- The Korean Geographical Society – South Korea
- Tokyo Geographical Society – Japan
- Urban and Regional Information Systems Association (URISA) – United States of America