

Measuring the benefits and costs of GIS

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The purchase and implementation of a GIS, like that of any other relatively expensive decision-support technology, is not a trivial matter for most organisations, whether they are public or private. Successful implementation of GIS requires a rather substantial commitment in organisational money, staff, and effort. Most organisations will make such a commitment only if the expected payoff justifies it. Justification usually begins with an effort to identify and then assign a price to the benefits and costs of adopting a GIS. It often ends by comparing the benefits with the costs, in what has become known as a benefit–cost (or cost–benefit) analysis. This chapter describes the techniques for measuring the benefits and costs of GIS. The chapter begins by describing the basics of benefit–cost analysis, including a discussion of the traditional and quantifiable costs and benefits in the GIS context. It continues with a detailed discussion of discounting. The chapter concludes with a discussion of the intangible costs and benefits of GIS implementation.

1 BENEFIT–COST BASICS

The terms benefit–cost and cost–benefit are used more or less interchangeably in the literature describing this technique. Using ‘benefit–cost’ has its advantages, however; the most obvious of these is that this word order implies that benefits outweigh costs in justified projects. Moreover, some scholars (e.g. Zerbe and Dively 1994) have argued that the term ‘benefit–cost’ implies a richer analysis than the alternative phrase. ‘Benefit–cost’, therefore, is the phrase used in this chapter.

The end of the twentieth century has brought with it a growing emphasis on economic efficiency within both public and private organisations. ‘Doing more with less’, ‘downsizing’, and ‘rightsizing’ have all become part of everyday language as euphemisms for budget cutting and layoffs (Foster and Plowden 1996; Rhind 1997). In response to calls for increased efficiency, organisations of all types must now provide more reliable and defensible justification for every purchase or new initiative they undertake. Benefit–cost analysis is often the first line of defence

in assuring bosses that organisational GIS initiatives are justifiable; indeed, some organisations require it (Huxhold and Levinsohn 1995).

While private organisations may use benefit–cost analysis, it is most commonly used in the public sector; the private sector may more easily rely on market prices and basic principles of cost recovery to assess the economic validity of implementing a GIS (see Birkin et al, Chapter 51). The thorniest issues related to benefit–cost analysis are those arising from peculiarities in the public sector that make it difficult (and in some cases, impossible) to establish accurate market prices for their products and to externalise many of their costs, as organisations in the private sector can do.

GIS (along with other information technologies) have never been a better buy than they are today. Declining prices have accompanied an explosion in the computing power of GIS and systems that have become remarkably user-friendly in recent years (see Longley et al, Chapter 1). The potential of GIS to increase overall efficiency and productivity in organisations that rely on geographically-referenced data has never been greater. Ironically, the current

economic environment also means that the need to justify the purchase and implementation of GIS also has probably never been greater.

The use of benefit–cost analysis as a justification for adopting GIS is well established in the GIS literature (e.g. Aronoff 1989; Dickinson and Calkins 1988, 1990; Grimshaw 1994; Huxhold 1991; Huxhold and Levinsohn 1995; Smith and Tomlinson 1992). Traditional benefit–cost analysis as an economic exercise begins with an organisation identifying the costs associated with implementing a GIS (e.g. costs of hardware, software, transformation of maps and data into digital format, and adding or training of staff), along with the expected benefits of using the technology (greater efficiency and effectiveness, for example). The next step in the analysis requires that the organisation assign economic value (by price) to both the costs and the benefits, sum each of them, then compare the results arithmetically. If the value of the benefits exceeds the value of the costs, there is justification for making the purchase. Benefit–cost analysis typically covers a multiple-year period. This is particularly true for the organisation attempting to justify the implementation of a GIS, because of the high early costs and (potentially) enduring benefits of the technology.

Benefit–cost analysis has, however, received criticism as a ‘dogmatic approach that knows the price of everything and the value of nothing’ (Zerbe and Dively 1994). Not surprisingly, more sophisticated justifications approach the benefit–cost analysis as an art that recognises the importance of organisational ethics and values as well as the need to consider more interesting and complex questions of economic theory (Zerbe and Dively 1994; and see Campbell, Chapter 44). Huxhold and Levinsohn (1995) recommended an examination of the financial, technical, and institutional feasibility as an alternative to benefit–cost analysis; Grimshaw (1994) suggested a value-added approach to justify a GIS.

1.1 Elements of a benefit–cost analysis

A typical benefit–cost analysis contains several elements. The most rudimentary element is the identification and assignment of a numerical economic value to the benefits and costs associated with an initiative. Costs should include any expense incurred as a result of implementing the project: purchase of any hardware, software, or supplies, the costs of hiring any

additional staff or the training of existing staff, along with the cost of transforming maps and data into digital format (see Bernhardsen, Chapter 41). Costs of these types are classified as ‘tangible’ costs. Tangible costs are readily quantifiable, primarily because they represent costs of products that are bought and sold in the free market. Other products are not so readily quantifiable, creating thorny problems in calculating the benefit–cost ratio.

Along with costs, there are some benefits that the organisation can also classify as tangible. For example, if the organisation expects to be able to reduce its workforce because of the increased efficiencies that the implementation of the technology promises, the numerical value of the salary or wages and benefits of staff members will be both available and quantifiable. Similarly, if the organisation will be able to produce more detailed or more diverse information and information products as a result of implementing a GIS, it may also be able to improve its overall effectiveness. Thus the ‘first cut’ of benefit–cost analysis is the easiest – quantifying the tangible costs and benefits. As one might expect, the analysis usually becomes much more complicated thereafter.

Huxhold (1991) claimed that there are three major categories of benefits of GIS that should be examined: cost reduction; cost avoidance; and increased revenue. Aronoff (1989) identified five categories: increased efficiency; new non-marketable services; new marketable services; better decisions; and intangible benefits. Aronoff’s ideas of increased efficiency and new marketable services broadly correspond to Huxhold’s notions of cost reduction and increased revenue, respectively. It is important to recognise, however, that price reductions made possible by the lower costs associated with GIS implementation may actually stimulate demand for some geographical information products. This can result in increased revenues overall because of increased volumes of sales.

Huxhold defined cost reduction as ‘the decrease in operating expenses of the organisation, primarily caused by a savings in time by operating personnel performing their tasks more efficiently’ (Huxhold 1991). Cost reductions generally accrue because of the improved productivity of staff members responsible for the tasks performed using the GIS.

Cost avoidance is the ‘prevention of rising costs in the future caused by projected increases in

workload' per staff member (Huxhold 1991). This benefit is consistent with, and more or less an extension of, the first benefit – suggesting that, once a GIS becomes part of an organisation's equipment, it may help to optimise the performance of a variety of both current and future tasks. The improvement in performance may make it unnecessary to hire new employees or at least to postpone such appointments by making the best use of existing employees.

Finally, Huxhold suggested that 'a GIS can increase revenues . . . by selling data and maps, increasing property tax collections, and improving the quality of data used to apply for state and federal grants'. The rationalisation of tasks that the GIS makes possible does indeed bode well for the increase in tax collections and the improvement in data quality. However, Dansby (1991) has pointed out that there may be legal impediments to the sale of such products in the public sector, depending on national, state, and local regulations on copyrights and freedom of information (see Rhind, Chapter 56).

New non-marketable services are 'useful products and services that were previously unavailable' and will be used within the organisation (Aronoff 1989). Aronoff pointed out that the organisation could reasonably anticipate some of these benefits of GIS. Other benefits, however, will not typically become apparent until after the GIS is up and running. Therefore, it will normally be difficult to assess accurately the value of non-market services and include it in the benefit–cost analysis to justify adopting a GIS.

As noted, implementation of GIS will make possible the sale of new geographical information products. These new products are the result of the inherent ability of GIS to extract and combine data in a variety of combinations and permutations, essentially enabling its implementers to deliver customised geographical information products on demand. For example, a city government with a comprehensive, large-scale GIS with current, accurate information can quickly produce a map of vacant downtown retail space for an individual wishing to open a bookstore, along with a table identifying the property owners.

Aronoff (1989) also suggested that the adoption of a GIS would produce 'better decisions'. This will occur, he argued, because 'more accurate information and faster and more flexible analysis capabilities can improve the decision-making process itself'. Again,

determining the economic value of 'better decisions' resulting from GIS adoption is problematic. The large body of literature on organisational decision-making takes a more realistic view, essentially conceding that most decisions are made on the basis of incomplete information (see, for example, Cyert and March 1963; Douglas 1986; Downs 1967; Simon 1945/1976). In many cases, organisations deliberately limit their searches for information because of time and/or financial constraints. In other instances, organisations may be unaware of additional relevant information (seeking and using information incur costs). A GIS cannot eliminate these institutional factors (see Campbell, Chapter 44).

1.2 Variations on basic benefit–cost analysis

There are several variations on benefit–cost analysis: one is cost-effectiveness analysis (Layard and Glaister 1994). Cost-effectiveness analysis provides a comparison of the costs of providing a specific outcome, or performing a specific task, using different means. In adding this step to the benefit–cost analysis, the organisation would compare alternative means of performing the same task; for example, the cost of providing information on property ownership both with and without a GIS. Implicitly, adding this step forces the organisation to demonstrate not just that the benefits of its initiative outweigh the costs, but that a specific strategy for performing a specific task is more cost-effective than other strategies (Layard and Glaister 1994).

Another variation is the calculation of the 'payback period' (Huxhold 1991). This is derived by dividing the total cost of implementing a GIS by the estimated annual benefits of using the system. The resulting figure reveals how many years it would take to accumulate enough benefits to pay for the cost of the system (Huxhold 1991). The benefits may include any or all of the benefits described earlier in this chapter. Not surprisingly, this calculation is fraught with the same difficulties apparent in typical benefit–cost analyses.

Grimshaw (1994) endorsed a third variation, the value-added approach. This approach emphasises the new things technology enables the organisation to do and what it adds to the capacity or worth of the organisation, echoing and extending Aronoff's non-marketable services.

1.3 Refinements of benefit–cost analysis

Several other problems arise in performing benefit–cost analysis, some of which apply across the board, others of which are unique to the public sector. There are several refinements of the process to address these difficulties.

1.3.1 Stakeholders

The first of these is the problem of stakeholders (Layard and Glaister 1994; Sen 1994; Zerbe and Dively 1994). Within the context of any organisation's mission, there is a variety of individuals and/or groups who have an interest (or a 'stake') in what the organisation does and the strategies it employs. The most obvious example is that an organisation's customers or clients form a crucial component in its survival (Obermeyer 1990; Weber 1946). The costs and benefits of the actions of an organisation may not be identical for all individuals or groups with a stake in the organisation's actions.

For example, a company whose mission is to produce road maps will include among its stakeholders individuals and groups with varying needs for map detail. The average user who has found the company's maps to be excellent navigation aides is unlikely to be impressed by the company making a decision to provide more detailed maps if that additional detail comes at a higher price. If the company has a competitor which produces a map comparable to the original map at a price lower than the 'new and improved' (and more expensive) version, the company may lose market share and perhaps suffer declining revenues overall as a result of the decision to offer greater detail at a higher price.

The stakeholder problem is even more complex in the public sector where levels of income among end-users vary greatly (Layard and Glaister 1994). For example, a professional nature photographer who can afford to hire a native guide to lead him or her to the lair of an endangered animal (and may also be able to deduct the cost of the guide as a legitimate business expense for tax purposes) has no real need for a detailed, large-scale map of the area. On the other hand, a PhD student trying to study that same animal would probably find such a map to be essential. Thus, trying to anticipate the costs and benefits of all stakeholders can become a complicated, if not impossible, task.

Certainly, a manager cannot afford to ignore the organisation's various stakeholders. In so doing, he

or she risks alienating existing and potential customers and clients. Moreover, the organisation may miss an opportunity to report higher benefits arising from its ability to enhance the satisfaction level of existing stakeholders, or by increasing the actual number of stakeholders reported in its benefit–cost analysis. The flexibility of GIS may make it possible for both private and public organisations to increase their product lines and fill new market niches at relatively small additional costs and, as a result, increase their customer and client bases by appealing to a wider audience.

It is up to the manager to estimate the expected value of these potential benefits and include them in the analysis. For example, the director of a local planning agency can build a case for a GIS by first identifying, then estimating, the value of the GIS to the local government itself following, for example, Huxhold's categories. However, the availability of a large-scale, comprehensive GIS will also benefit local utilities, developers, and private businesses by making accessible high-quality 'official' geographical information products that these groups can then use to inform their own decisions and to help in their day-to-day operations.

Not surprisingly, some local governments have exploited the relationship with their stakeholders by working cooperatively with groups such as local utilities and business leaders to build and implement their GIS. For example, the Cincinnati Area GIS (Cincinnati, Ohio, USA) is a joint venture of the city and county governments, the telephone company, the local power and water companies, and local industry (which includes Proctor & Gamble) (Obermeyer 1995). Working with stakeholders has the added advantage of sharing costs among the participants and improving the level of benefits as a result of the specific functional expertise – and data – that each participant brings to the project.

1.3.2 Time and discounting

A second problem that arises in performing benefit–cost analysis is caused by the effects of time and economic inflation (Field 1994; Layard and Glaister 1994; Little and Mirrless 1994; Smith and Tomlinson 1992; Stiglitz 1994). Even when the rate of inflation is low, over time the cumulative effects of inflation erode the economic value of the costs and benefits of any activity. Moreover, people perceive immediate benefits as having greater value than benefits far off in the future. As Zerbe and Dively (1994) put it, 'a benefit received today is worth more

than one in the future'. Similarly, a cost that occurs far in the future has less significance than a similar cost today (Field 1994). In order to provide a realistic assessment of costs and benefits, organisations must take this into account and adjust their benefit–cost analysis calculations accordingly.

A refinement designed to address this problem is *discounting* (Field 1994; Smith and Tomlinson 1992). The idea behind discounting is to deflate the costs and benefits in order to remove the effects of inflation. Discounting is needed to provide an accurate assessment of the value of implementing a GIS because of the multi-year life expectancy of a GIS and the result that GIS costs and benefits are also spread over multiple years.

Discounting is not a simple matter, particularly with GIS which typically have their largest outlays early in the life of the project then experience declining costs, but whose benefits can last long into the future. Front-end costs include the purchase of hardware and software and either hiring new staff or paying to educate existing staff (see Sugarbaker, Chapter 43). In addition, organisations in some countries can expect high start-up costs arising from the need to convert analogue (paper) maps into digital form. These start-up costs are likely to seem insurmountable for many small and medium-sized organisations. The perception of insurmountable costs may be compounded in local government by the recognition that they will not begin to realise the benefits of a GIS for several years.

Discounting applies to both costs *and* benefits. Its primary purpose is to aggregate a series of costs and/or benefits which occur over the life of a project. The formula for discounting includes three elements: present (or future) value, the length of time appropriate for the project and an appropriate discount rate (Field 1994).

$$\text{Present value} = \frac{\text{Future value}}{(1 + \text{discount rate})^{\text{years}}}$$

As a worked example, consider that we need to calculate the present value of US\$1000 ten years in the future with bank interest rates at 5 per cent. The formula is applied as follows (Field 1994):

$$\text{Present value} = \frac{\$1000}{(1 + .05)^{10}} = \$613.90$$

Multi-year projects are handled as in the following example, a hypothetical GIS implementation. Assume that the costs and benefits for the seven years of the lifetime of the project are as shown in Table 1, and that the discount rate is 6 per cent.

Table 1 The hypothetical costs and benefits of a GIS.

	Year						
	1	2	3	4	5	6	7
Costs	100 000	70 000	50 000	25 000	25 000	25 000	25 000
Benefits	0	25 000	50 000	70 000	70 000	70 000	70 000

Using the figures in Table 1, the present values of costs can be calculated using the following formula (Field 1994):

$$PV_{\text{cost}} = \$100\,000 + \frac{70\,000}{1+.06} + \frac{50\,000}{(1+.06)^2} + \frac{25\,000}{(1+.06)^3} + \frac{25\,000}{(1+.06)^4} + \frac{25\,000}{(1+.06)^5} + \frac{25\,000}{(1+.06)^6}$$

The present values of benefits may be calculated using the following formula (Field 1994):

$$PV_{\text{benefit}} = \$0 + \frac{25\,000}{1+.06} + \frac{50\,000}{(1+.06)^2} + \frac{70\,000}{(1+.06)^3} + \frac{70\,000}{(1+.06)^4} + \frac{70\,000}{(1+.06)^5} + \frac{70\,000}{(1+.06)^6}$$

Choosing an appropriate discount rate is itself not a simple matter. First, there is the issue of real versus nominal interest rates. Nominal interest rates are the actual interest rates available in the market. In order to know the real interest rates, it is necessary to adjust these nominal figures for inflation. For example, if the nominal interest rate is 8 per cent, but the average rate of inflation over the period in question is 3 per cent, then the real interest rate is 5 per cent (Field 1994). In all instances, managers must always consistently use either real costs and real discount rates, or nominal costs and rates (Field 1994).

The plethora of interest rates in use in the world of modern finances complicates the process of discounting. A review of the business/finance section of any reputable newspaper shows a large variety of interest rates from which to choose: rates on normal savings accounts, certificates of deposit, bank loans, and government bonds, to name just a few. There are two views on this issue. The first view suggests that the discount rate should reflect the way people think about time and money. Economists refer to this as the rate of time preference. For example, most people would prefer receiving \$1 today, rather than waiting ten years to receive that same amount. This is a positive rate of time preference. Those who support this view would use the average interest rate on a bank savings account as their discount rate (Field 1994).

The second approach to choosing a discount rate is based on the notion of investment productivity. In

this view, people anticipate that the value of future returns will offset the cost of investment today. In the public sector, this means that expenditures used for long-term projects should yield rates of return to society that are similar to what the same expenditures could have earned in the private sector (Field 1994). Using this reasoning, an organisation should use a discount rate that reflects the rate which banks charge their investment borrowers; these rates are typically higher than savings account rates (Field 1994).

The nature of this debate on discount rates ultimately ensures that it is up to the manager to choose – and justify – an appropriate discount rate unless the organisation as a whole has well-established rules on how to proceed. One resolution is to perform a sensitivity analysis by repeating the discounting of benefits and costs using two or more different interest rates.

It is not difficult to grasp the impediment that discounting imposes on a benefit–cost analysis for GIS. The high start-up costs of GIS will seem even higher than they are in light of the positive rate of time preference. On the other hand, the benefits of GIS will typically seem smaller after discounting. If one carries out the calculations on the hypothetical seven-year GIS implementation example provided above, it will take the entire period for benefits to begin to outweigh costs. A real-life GIS may take even longer to reach the break-even point.

It is, however, important to remember that the benefits of GIS are often enduring. Once an organisation has paid the high front-end costs, particularly those associated with higher staffing costs and digitising, it should reap the benefits of the technology year in and year out unless the operational needs change dramatically (and that may even provide a large benefit from the use of GIS if the new needs can also be met) – but see Bernhardsen (Chapter 41) and Sugarbaker (Chapter 43) for discussions of how GIS investment should be amortised for accounting purposes. Emphasising the enduring nature of the benefits of GIS can be accomplished by carrying out the analysis for as many years as are required to achieve a favourable benefit–cost ratio. In addition, however, the manager should also make it clear that digitising is a one-time-only expense. Finally, the manager should point out that the investment in GIS is likely to endure for generations to come. Whether this is accepted by management may depend on the level of risk involved.

1.3.3 Uncertainty and risk

Time also influences the level of risk and uncertainty among the benefits and costs of an organisation's initiatives. Humans do not possess perfect knowledge about the present, and it is even more unrealistic to expect them to foresee the future with complete accuracy. Zerbe and Dively (1994) identified two types of uncertainty: uncertainty caused by the unpredictability of future events; and uncertainty caused by limitations on the precision of data (see Fisher, Chapter 13). Both types of uncertainty are relevant to GIS benefit–cost analysis, particularly in the past. Throughout much of the time since GIS has become commercialised, there has been a great deal of uncertainty about both the costs and the benefits of using the technology. For example, lack of experience in the early days of commercial marketing of GIS meant that many organisations underestimated the long-term costs of the implementation such as digitisation costs, consultation fees, and training expenses which often far surpassed initial estimates. Today's turn-key GIS products (such as Maptitude and ArcView) enable GIS adopters to know with greater certainty the cost of the basic package. However, there remains a great deal of uncertainty associated with other critical elements of GIS start-up, namely hiring and/or training staff, digitising maps, and gathering and entering data to customise the GIS (see Bernhardsen, Chapter 41).

In evaluating the wisdom of purchasing a GIS, both the benefits and costs of implementation may be difficult to assess because of the uncertainty surrounding them. It is well known and generally accepted that the costs of implementing a GIS extend beyond the purchase of hardware and software. For example, assembling and maintaining data – along with the training of staff – are two areas that require expenditures after the initial purchase of the GIS. The exact dollar amount of these additional costs is usually difficult to know ahead of time. However, as Smith and Tomlinson (1992) optimistically noted, 'the costs [associated with implementing a GIS] are loaded heavily in the early period whereas the benefits increase . . . and then remain constant'. This assumes a stable organisation and external environment. The wise manager will prepare for unexpected contingencies throughout the life of the system.

These uncertainties surrounding the calculation of benefits and costs of implementing a GIS have been the subject of discussion by several authors (e.g. Aronoff 1989; Huxhold 1991). There are several approaches to

handling uncertainty in benefit–cost analyses. The first is to ignore it, which is appropriate if the uncertainty is likely to be minor or where the analysis is intended only to be a rough estimate. It may also be possible to reduce uncertainty by gathering additional information and the organisation should make every reasonable effort so to do. The project manager should also talk with other, similar organisations which have implemented GIS in order to add to their knowledge base. Finally, the organisation can recognise uncertainty and include it in the benefit–cost analysis explicitly (Zerbe and Dively 1994).

1.3.4 Selling data

The sale of geographical information products is often suggested as a benefit to be included in the benefit–cost analysis. Properly managed, these benefits can indeed be significant. For example Rhind (1997) reported that Great Britain's Ordnance Survey generates US \$100 million in annual revenues through the sale of geographical information products. Ownership of the copyright to datasets is a prerequisite to having the right to make such sales (Rhind, Chapter 56). In most countries, the national government holds the copyright to all the datasets they develop; the US Federal Government is an exception to this rule (although US cities and states may copyright data).

Difficulties in establishing prices for geographical information products can complicate the assessment of likely benefits, but an organisation can compare its geographical information products with similar products offered for sale by the private sector in order to establish a basic price list. Once products are officially offered for sale, the organisation can adjust the price to try to achieve its desired sales and revenue goals. The sale of data and other geographical information products may expose an organisation to liability risks arising from negative outcomes associated with unintended uses or deliberate abuse of the products (see Onsrud, Chapter 46). The wise manager will consult with the organisation's legal department to resolve these issues in advance of making any commitments.

In short, organisations contemplating the sale of data as a benefit of their GIS should be aware of the pitfalls as well as the benefits. The potential rewards certainly warrant the sale of geographical information products if the organisation is permitted to do so. Rhind (Chapter 56) and Smith and Rhind (Chapter 47) discuss policy aspects regarding the sale of data in more detail.

1.3.5 Externalities and spillovers

Externalities and spillover effects are mirror-image problems that may arise in developing benefit–cost analyses. Externalities arise when a company shifts its costs outside the organisation, usually by ignoring a problem (Papageorgiou 1978). Externalities are particularly troublesome for public institutions which are limited in their ability to externalise. Yet frequently these organisations are involved in cleaning up problems created when private organisations externalise their costs. For example, in the USA the Federal Government has assumed responsibility for cleaning up toxic waste dumps created by the private industry. It is true that the government could ignore the problem but this strategy could lead to problems cropping up elsewhere, for instance in the overall health of people living near the sites. These are ramifications that private companies can – and often do – ignore.

Spillover effects, or positive externalities, are the benefits that an organisation enjoys because the activities of another organisation extend beyond its jurisdictional boundary (Faulhaber 1975). Private companies often enjoy the spillover effects created by public expenditure (e.g. transportation networks, sewer, and water projects), just as some public agencies may benefit from the activities of private companies or other jurisdictions. For example, a GIS firm that includes government census data with its software is able to add value to its product and thus receives tangible economic (spillover) benefits from the data gathering and dissemination activities of the government.

Handling externalities and spillover benefits in the benefit–cost analysis is a matter that merits attention. In the case of governments which are performing a benefit–cost analysis as a prelude to their implementation of a GIS, Smith and Tomlinson (1992) recommended incorporating 'all benefits . . . in the analysis whether or not they accrue to the potential GIS purchaser or the departments that will use the information products'. Among the non-government groups that may realistically expect to benefit from the implementation of a government GIS are taxpayers, private companies, and special service districts.

How does an organisation handle these externalities and spillovers? First, it is necessary to identify them. Perhaps the most significant externality of a GIS is the potential loss of privacy associated with the ability of GIS to disaggregate data (see Curry, Chapter 55). Large public datasets based on national censuses are

most likely to raise privacy concerns; however, some private firms have collected large databases that may also threaten the privacy of individuals. It is extremely difficult to place a value on this potential loss of privacy to an individual. Is it \$1 per person? £10? More? In this instance, managers are left to make their own assessment.

Spillover effects of a GIS, as Smith and Tomlinson (1992) noted, may accrue to taxpayers and others as they reap the benefits of readily accessible maps, data, and other geographical information products made possible because of the implementation of a GIS. Spillovers, while still problematic, are somewhat easier – and obviously more pleasant – to handle than disbenefits engendered by the export of problems by others. For example, the county assessor might anticipate shorter transaction times for fulfilling requests for basic information, such as a property registration map. In order to assess the value of these time-savings to customers and clients, one should multiply the average number of annual transactions by the economic value of the anticipated time-savings per transaction, which in turn is based on the average hourly wage figure for those involved. Given the range of beneficiaries of spillover effects, there is great value in paying careful attention to assigning benefits to spillovers. Governments in particular, since they have a broad (and in some cases nearly universal) set of stakeholders, can bolster their anticipated benefits by considering spillovers. Whether this is a relevant consideration varies according to government policy (see Rhind, Chapter 56).

1.3.6 Intangible benefits and costs

Many of the benefits and costs that contribute to the development of a benefit–cost analysis are intangible. For example, how can one place a numerical economic value on increased reliability or diminished institutional confusion? Smith and Tomlinson (1992) defined intangibles as ‘. . . not as much a separate category of benefits as they are a class of benefits that is more difficult to quantify’. The benefits might include such things as better internal communication in the organisation, improved morale, and a better public image. Obviously, placing a specific dollar (or Deutschmark or franc or pound) value on these intangible benefits is not possible. It is, however, still necessary to give an estimate. Organisations may begin by describing these potential benefits and costs in text accompanying the benefit–cost analysis.

Assigning an economic value to intangible benefits is part of the art of the benefit–cost analysis. Assigning such value may be accomplished by using

surrogates. For example, improved morale may result in reduced staff turnover, which in turn results in lower costs for personnel searches and training. These items are easier to value than is morale.

Organisations may experience negative changes as they implement GIS (Grimshaw 1994; Huxhold and Levinsohn 1995), resulting in additional intangible benefits and costs. For example, an organisation may find that, as it introduces GIS, those who are most knowledgeable become more important to the organisation; conversely, those who are slow to adapt to the technology may find themselves losing ground and, eventually, their jobs. Some tasks may become deskilled, leading to staff unhappiness. The overall result may be institutional confusion which may in turn temporarily cause a drop in productivity. While a manager might find it impossible to place a precise economic value on institutional disarray, assigning an economic value to time lost to the disruption of the social order of the organisation is easier to do.

Conversely, organisations may find that their foray into the world of GIS may give them increased visibility and an enhanced reputation. For example, the US Department of Housing and Urban Development is attempting to solidify its client base by collaborating with the Caliper Corporation to develop and sell its Consolidated Planning Software GIS program. Similarly, the US Geological Survey noted the value to society of improved decisions made possible by its many mapping products (Bernknopf et al 1993). In the light of the zeal of the calls for downsizing the public sector, solidifying this relationship makes sound organisational sense, given the importance of the relationship between organisations and their client groups (Obermeyer 1990; Weber 1946).

Again, in assigning an economic value to these intangible benefits, organisations need to take a wide perspective. For example, public organisations that make available low-cost or even free geographical information products to citizens might place a value on the goodwill they generate through these actions by calculating the aggregate cost savings that their customers or clients received by using the organisation’s products rather than more expensive commercial alternatives. This is fraught with some dangers and must only be carried out with the advice of professional accountants – for instance, such action may actually damage the local private sector, creating externalities of another kind.

Assigning values to intangible benefits and costs can thus be difficult. In the case of benefits, it is extremely important to do so in order to accumulate benefits to offset costs as part of the analysis. In the case of costs, it is necessary to do so in order to achieve fair and honest results. As noted, this part of the analysis is as much art as it is science. Nevertheless, through careful thought, an organisation can usually assign plausible and defensible values to these intangibles, as suggested by Table 2.

Table 2 Summary of the costs and benefits potentially gained through use of a GIS.

Category	Costs	Benefits
Economic (tangible)	Hardware Software Training New staff Additional space	Cost reduction Cost avoidance Increased revenues New market services
Institutional (intangible)	Internal personnel shifts Layoffs	Improved client relationships Better decisions Improved morale

2 CONCLUSION

Benefit–cost analysis is the preferred method to justify the implementation of a GIS, particularly in public organisations. The GIS must be assessed in comparison with existing practices and technology already used in the organisation. In addition, the organisation must consider other alternative means of performing the same tasks. Making these comparisons requires the organisation to perform a separate benefit–cost analysis for each alternative under consideration. The alternative with the highest ratio of benefits to costs is the most efficient one although other factors like cash flow may influence which option is finally chosen.

All of the above should have made it clear that benefit–cost analysis plays an important role in providing an economic rationale for an organisation's decision to adopt a GIS. Performing such analyses is not always easy but it is necessary for some organisations and it is advisable for all others. Taking the time and effort to perform a thoughtful, careful benefit–cost analysis is a first

step in building a secure foundation for a successful GIS implementation.

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