BEST-GIS

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Guidelines for Best Practice in User Interface for GIS

Section 9
"Cost-Benefit Analysis of GIS projects"

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9. Cost-Benefit Analysis of GIS projects

9.1 Introduction

Understanding and estimating the costs and benefits of a GIS project is an important part of the strategic planning and decision making process. Determining the economics of a GIS project is difficult. Cost valuation issues focus on fair determination of staff (training), equipment (hardware and software), and other costs (services, data), particularly when comparing alternative implementation scenarios. Benefit evaluation incorporates a clear division of direct, indirect, and external benefits. The user interface of the GIS application affects many of these key elements of the project, especially when we take the time to measure how long (or using how much effort) to get the job done. By better understanding the work flow of the users within their organisational environment, we can better place values on both costs and benefits.

This section can only give an overview and expert advice. The subject ”cost-benefit of GIS projects” could be described in complete books based on different theories (e.g. Born 1992).

Cost-benefit analysis (CBA) is a method to reduce uncertainty during decision making and planning by replacing opinions, believes and emotion, by a framework for identification and determination of the benefits and cost, respectively of each alternative GIS.

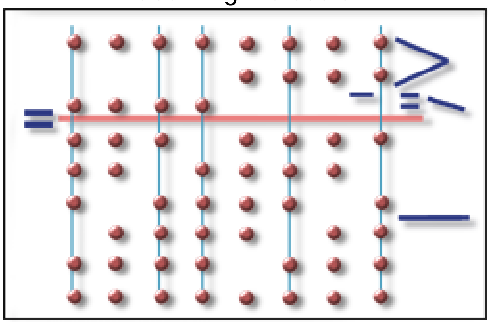
The results of CBA provide a basis for comparing GIS options. Public sector decisions are thought to be more complex because both policy and financial impacts must be considered. Private enterprises need to be concerned only with the accountant's 'bottom line'. In fact, though, both private and public sector decisions are better when they consider all aspects of a given alternative, whether those aspects have a line in the balance sheet or not.

What we face is the difference between theoretical eloquence and real-world practicality. The goal is to find a practical way to accomplish the task at hand - that is, performing the CBA - while not opposing the basic theory of cost-benefit analysis.

9.1.1 Objectives

The objective of Cost / benefit analysis is the assessment of the advantages of a specific GIS application over competitive solutions and traditional work procedures (i.e. not utilising a GIS). It is important to assess the total value of the GIS application to the user and customer. Requirements of user groups who perform different tasks with the GIS applications or are subject to different constraints may result in different cost / benefit situations for these groups.

Counting the costs



The abacus is a calculator whose earliest known use is circa 500 B.C. by the Chinese civilisation.
Addition, subtraction, division and multiplication can be performed on a standard abacus.

Cost / benefit analysis should include the following:

- a precise estimate of the total cost of use and ownership of a GIS application (including overhead) during the life cycle of the GIS application.
- estimates of the subjective assessment of the GIS user interfaces by real users (often dissociated from the objective cost), which are comparable across different GIS applications
- quantitative estimates of the time required to carry out key tasks. This time naturally translates into cost.
- estimates of convenience, workload, and positive acceptance by users
- elaboration of the added value and benefit offered by the GIS application

- consideration of all realistic alternatives and competitive solutions.

A new GIS application is always assumed to deliver a positive benefit for the customer (used in a general sense). This benefit must be greater when using the new GIS application than without it, taking all factors into account. The objective of the assessment of the cost / benefit ratio offered by a new product is to estimate the total cost as precisely as possible. A minimum requirement is to make explicit the ***hidden costs***, which can make an application too costly and therefore unattractive to the customer. The proposed procedure is based on the estimation of the quantifiable costs and upon using reasonable approximations for those factors which are harder to quantify.

When proceeding through the steps described below, it is important to use objective data for user costs, implying that a rational decision according to these factors is made by the customer. Taking all aspects into account in a precise and objective manner is often difficult, because there are factors which are measurable (e.g. purchase price, customisation cost, operating and maintenance costs, system performance) - although not always easily - and others which are difficult to measure in a precise manner (e.g. whether users are satisfied with using the GIS user interface and how they assess the quality of use). Note that the cost factors are partly dependent on individual preferences and values, and also differ systematically between groups: The subjective experience of ease-of-use and satisfaction are highly individualistic. Thus, the various cost factors must be weighed according to the customer's preferences and environment.

We propose estimating the total monetary costs first, and then to relate them to the subjective estimate of the benefit offered by the GIS application.

9.2 Time aspects

An aspect of CBA is that the results must be looked at over time. In the first year or years the costs tend to outweigh the benefits. The up-front outlays in planning, system setup, data automation, application development, staffing, and training do not produce immediate benefits. Typically, benefits begin to accrue after the second year, and then can surpass the yearly costs on a continual basis.

Thus, it is important to look at costs and benefits over time -- but not too long. There are too many uncertainties if the planning horizon is extended too far into the future. Hardware and software advances are expected to occur, but the impacts of those advances on the costs and benefits are just too uncertain. Experience shows that a six-year planning horizon is reasonable.

Over this six-year planning horizon there is a very typical pattern of costs and benefits. In the first years costs are high, and benefits are low. In the latter years benefits often greatly surpass costs. Thus, it is necessary to look at the cumulative effect of the costs and benefits over time. This is easily done once the cost and benefit numbers for each year are known. The cumulative numbers for the second year are the sum of the numbers for the first and second years, and so on until the sixth year, in which the numbers reflect the total costs and benefits for all six years.

Experience has shown that a well-planned, carefully implemented GIS can achieve a long-term, fully discounted, cumulative return about 2.5:1 over the foreseeable planning horizon. This means that every dollar invested in hardware and software, data automation, system start up, application development, and the ongoing costs of operations can yield about $2.50 in benefits due to efficiency, avoided costs, etc.

9.3 Counting the costs

9.3.1 Estimating the 'total cost of ownership' of a GIS application

The objective is to understand the costs incurred for the user when adopting a GIS. The resulting estimate takes all monetary costs into account, based on objective estimates. These costs can be calculated for relevant competing GIS applications:

- Define user groups and usage scenarios (as described in section 4).
- Select the GIS alternative which offers the best value to the customer.

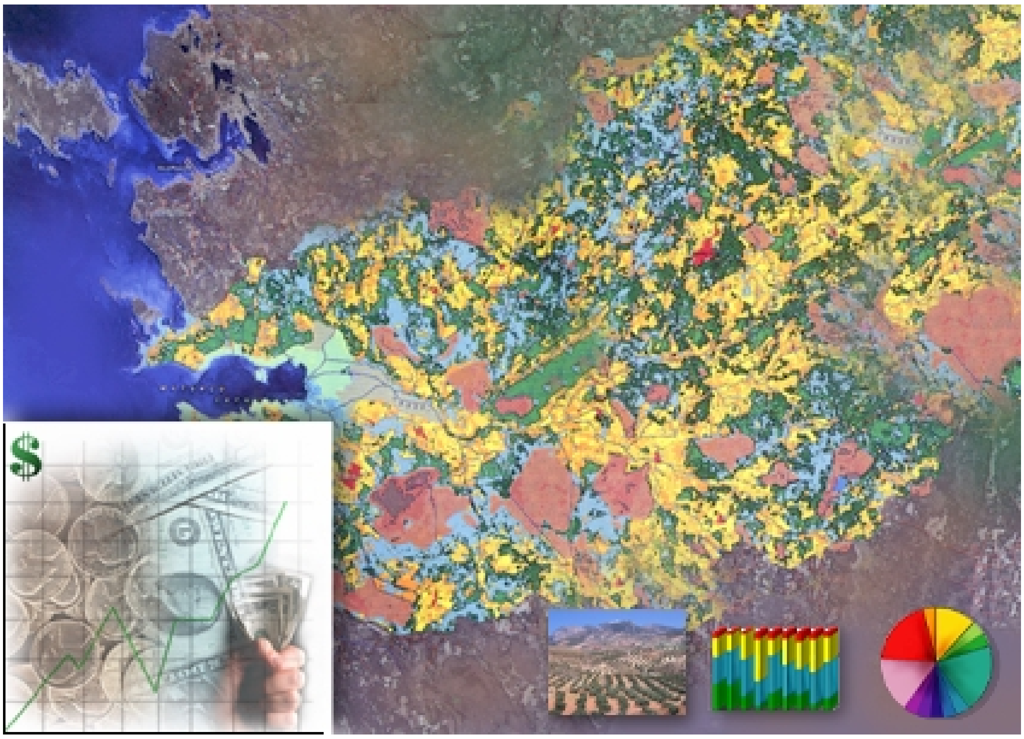
For each usage scenario:

- Identify the components that the GIS project or GIS purchase consists off. The components are explained in the next section.
- Understand the relevant cost and benefit factors. These are all factors which may influence the decision of the customer during the lifetime of a GIS application (e.g. purchase and customisation costs, integration of legacy systems, introduction cost, maintenance, cost of migration to new technology).
- Make up the balance sheets for each GIS alternative. This should include relevant cost items and other relevant factors (cost estimates for purchase, customisation, user training, operating and maintenance, and also estimates of the time spent for learning how to use the GIS application and for using it, and of the cost of this time). As a result, the sum of all costs, which occur during the lifetime of the GIS application (i.e. the total cost of ownership) is calculated. There may be different results for different usage scenarios.

The next sections describe calculation of costs and benefits in more detail.

9.3.2 Cost calculation

The cost estimation is a vital link in the success or failure of the GIS project/purchase. However, **the price of a GIS (hardware and software) is <u>not</u> the most important cost factor**. Issues such as usability, learning and training cost, support, (future) vision of the vendor as well as data compatibility all affect the decision for a particular GIS.



The price of a GIS (hardware and software) is not the most important cost factor.

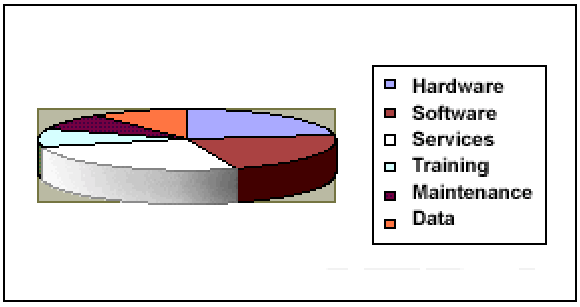
A GIS purchase that only consists of software and hardware <u>can</u> be calculated. GIS in general is not (yet) a commodity item for the consumer market. If that was the case (like with text processors), the price calculation would be easy: It would consist of the (one off) purchase of hardware and software. All additional work would be at the consumer's expenses.

However, in almost all cases a GIS is not purchased standalone. It is customised with respect to a certain project, tasks and work flow to be performed. Such a GIS project can vary from very simple "data viewing project" (500 – 4000 ECU per seat or workplace) up to very complex "data capturing, management and analysis projects" that cost more than 1,000 KECU.

The user-centred design approached advocated in these guidelines can help to better define the work flow necessary for the users "getting their work done" with minimal interference from the GIS technology.

Roughly one can divide the costs of a GIS into the following components:

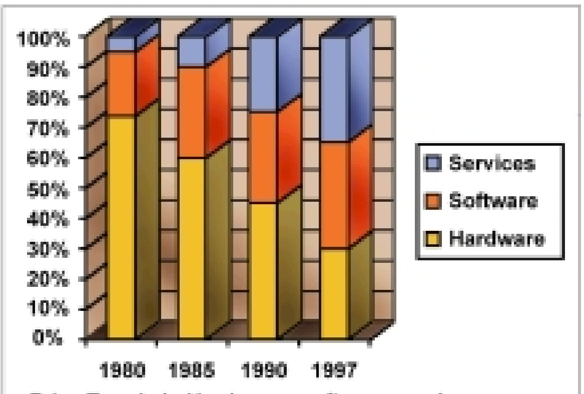
- Hardware
- Software (base software, base GIS and additional GIS modules)
- Maintenance
- Services (resources to fulfil the GIS project objectives, e.g. customisation)
- Training
- Data (if obtained from elsewhere)



The last item, data, is questionable as a separate category. It could also be considered as services (if data is captured with the GIS project), but more and more GIS projects obtain data from outside, rather then building data within the organisation.

Quite often training, consultancy, customisation, maintenance, data, etc. are grouped into ***Services*** except ***Hardware*** and ***Software***.

Like the trend of price reduction in the Information Technology (IT) market, the same ongoing trend can be observed in the GIS market. Some ten years ago GIS seats (or workplaces) were installed that cost more than 100 KECU. The initial investment was the highest share of the overall sale. The cost for the GIS operators/users were less than the cost for the system itself. Currently a GIS seat varies from 10 – 30 KECU per seat for the superusers market (i.e. users who set up and maintain GIS).

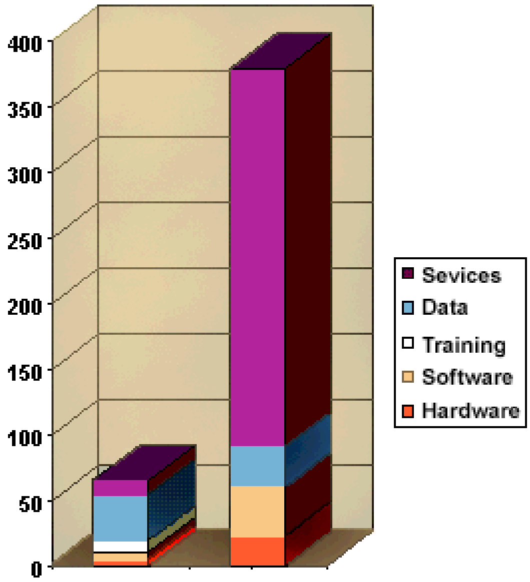


Price Trends in Hardware , software services (Rough estimate)

Today, the viewers market (i.e. users who only view geographic information) will typically have seats from 1,5 – 5 KECU depending on the system and the desired viewing capabilities. When using Internet solutions, the price per seat for the client might even be lower than the indicated figure. The GIS viewer market does not have such a long history as the doers market. The price for a viewer seat has dropped a little, but not to the extent of the superusers' seats.

9.3.3 Variation of costs

The cost of a GIS installation and customisation for whatever purpose varies very much per application area and the job or project that the GIS is needed for. Let's take two examples:



Variation of cost in two GIS applications

1. An enterprise buys a GIS for GeoMarketing. GeoMarketing is a GIS application for planning a new site (based on the optimal location), where to place billboard in a city, customer penetration etc. The price of a GeoMarketing system is around 50 KECU. The software is relatively cheap (viewer seat), but the data consumes more than 70% of the total price.
2. A department of a local authority buys a GIS to build their utilities network digitally. The department estimates 3 man year work. The software for three doer's seats, will cost around 60 KECU. Data is not a cost, since it will be build by the department, using the GIS.

The two examples clearly show that there is a large variation of price per seat due to the prices for the hardware, software, data, and services needed for a project.

Mostly it is the work of a GIS expert (GIS consultant) to analyse the user's and customer's requirements in order to estimate the total cost of a GIS project, including the sub-division of the mentioned components.

GIS consultants have the expertise to make cost estimations for a project and a GIS purchase. Mostly this is an effort of at least a few days up to a few months in order to specify all the project ingredients. These consultants will not disclose that information, it is part of their (and their company's) business. The consultant can be held responsible when his advice proves to be wrong, i.e. when he makes an inaccurate cost estimation, his reputation is damaged.

Because of the large variation of GIS applications recommendations can only be given in terms of examples. Consider for example tenders that are published in the Official Journal of the European Commission: Almost every public tender that involves GIS has been written by an expert. This applies both for the functionality that is demanded and the rough price for the project or system.

9.4 Counting Benefits

There are no fixed categories of benefits. This makes counting benefits much more difficult than counting costs. Past categories that have been successfully used include primary and secondary; tangible and intangible; internal and external; and tactical and strategic. The latter differentiates between lower costs of producing the same outputs and producing new outputs. That can be a valuable differentiation when evaluating the risk associated with establishing the GIS.

In a large government-wide project, benefits were grouped into four categories: direct, agency, government, and external. Direct benefits were those accruing as a result of using GIS rather than manual means for storing and producing information. Agency benefits reflected the increased productivity and improved quality of work credited to the better and more timely information produced by the GIS. Government benefits were similar to agency benefits, but considered how better information generated by one agency benefited other agencies. Lastly, external benefits focused on both qualitative and quantitative benefits that accrue outside the structure of government. A valid equivalent for the private sector would be direct, departmental, company-wide, and external.

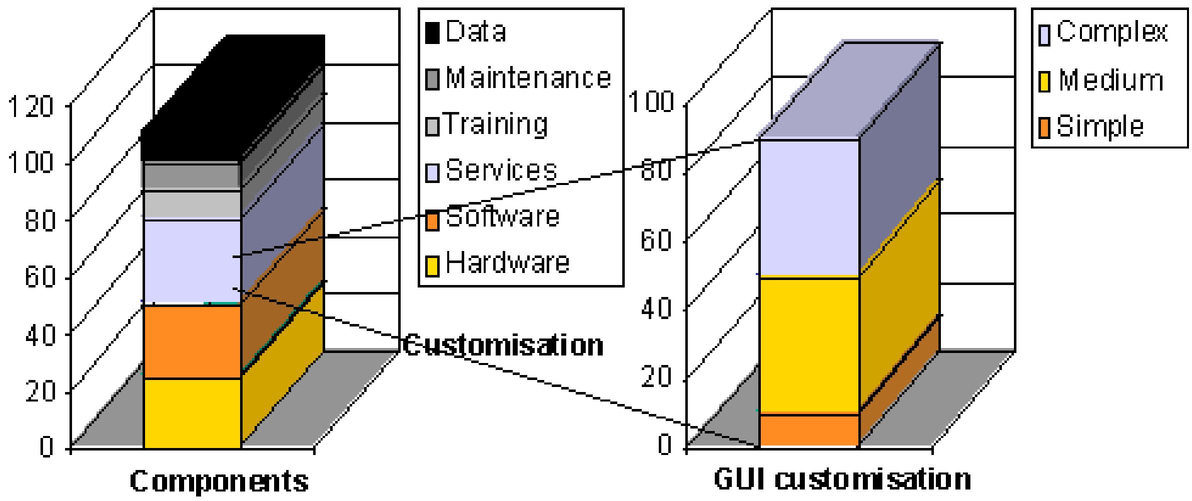
- Higher productivity (of the end-user's final product). For instance compared to using old methods (hand drawn maps) productivity increases with a factor 4 to 6.
- Resource reduction. By using a GIS, the number of people working in the department can be reduced. Although care should be taken with the statement. Many people have thought the GIS and automated mapping would cost jobs. The opposite proves to be true. Mostly the same number of people were employed, only the production went up.
- Quicker response. In some applications, such as traffic management using a GIS, the time factor is important.
- Easier (cheaper) maintenance. Often the real payoff for a GIS lies in the maintenance of data. The initial data capturing is the big hurdle to overcome (technically and price-wise). For instance the initial capturing may cost 400 KECU and the yearly maintenance cost 50 KECU.

The issues above (and more than those mentioned) should be expressed by the end user in terms of cost savings. I.e. *What is the value of the ability to produce 20 maps per month, instead of 2 maps?* This also lies a solid foundation for a cost calculation using the reverse method: What type of cost savings do I want to make (split into various components), so how much may the complete system (SW, HW, Services, etc.) cost?

9.5 GUI customisation

Ideally, optimal GUI customisation should be finished before using the GIS application instead of adapting and changing layout and functionality when the GIS is in use. Users tend to get accustomed to the workflows supported by the system and do not want to adapt to changes. Unless optimal customisation is a very expensive operation, it will normally pay off as an increase in productivity.

GUI customisation is a part of the services which form a substantial part of the overall GIS sale. The task (and thus involved cost) of GUI customisation should be split in three categories:



1. **Simple** customisation that the GIS offers. For instance rearranging menus so that only the valid options for the particular applications are presented to the end-user. The customisation effort mostly varies from a few days to two weeks. The costs are low, simple customisation should <u>always</u> be done to increase the productivity of the GIS.

2. **Intermediate** customisation could involve sequencing GIS commands to reflect the user's workflow, automatically passing data from one command to the other, (standard) connection to other systems, databases, etc. These customisations vary from weeks to months and require a good business plan: *Is it worth 40,000 ECU to optimise the workflow? Thinking 6 years into the future, the answer may very well be yes.*
3. **Complex** customisation requires an intensive study and analysis of non-standard tasks and problems that should be solved with the GIS. New commands, combination of GIS commands, automatic uploading and controlling of real time databases are examples. When complex GUI customisation is performed it is actually no longer part of the GUI customisation, but forms part of the ”Services”**.**

9.6 Recommendations

Above, many issues were presented that should be considered as best practice when making a cost-benefit analysis. Below are some main recommendations for the users:

- Definition of the components that build up the costs. Hardware, Software, Service, Training, Data. Be aware that nowadays, often the highest costs of a GIS project are the services and no longer the hardware and software. Also compare data buying against data capturing. This means shifting the budget from ”Service” to ”Data”. Often this is more economical, especially when enough data is available.
- Modularise the components. As much as possible, functions should be split into components in end-users terms. Hopefully this can then translated into GIS functional components. An example is the case where the end-user requirements are to automatically receive and store satellite images. The corresponding GIS (or IT) components might then be translated into network requirements (capacity, type) and database requirements necessary to support these functional requirements.
- Maturity. Cost calculations of large GIS projects should be made together with an expert who has the expertise to analyse the problems and user needs resulting in a more precise description of the System. Organisations with more maturity in IT planning and design will also find it easier to make cost and effort calculations for system customisation.
- Plan customisation. Most GIS end-users will take a GIS as-is and after working with the system for a while, they plan customisation to optimise the work flow. This is contrary to our goal of proactive design. Planning the customisation before use of a GIS saves costs later in the project.

9.7 More Issues to consider when calculating cost

9.7.1 Budget constraints

The end-users of the GIS are generally not the people who determine or control the budget for the GIS purchase. The classical case is that the IT department demands a system that would require twice the budget than is made available by management. Simply increasing the budget is not an acceptable solution in most organisations.. Dropping functionality could be an option. Ideally, each functional option should be described in cost saving. The old adage ”you get what you pay for” is relevant here. The costs can be quite high, but also the benefits if planning and implementation are properly executed.

9.7.2 Time constraints

If a project has to be finished in one year, with 12 man years of work, the cost for software and hardware will be quite high, because 12 GIS seats will be necessary. If the project could be done in three years, the cost of services will remain the same, but the hardware/software will drop substantially, only 4 GIS seats are needed. Time constraints should not be confused with time aspects. Time constraints are the factors that cause a different division of the (standard GIS) components, time aspects are the considerations that a GIS should not be seen as a one-off purchase.

9.7.3 Quality

Obviously high quality operations require more cost in services than medium or lower quality. For instance if a street network has to be captured with an accuracy of 1 meter, it requires much more resources (including quality control) than the case where an accuracy of 5 meters is sufficient. It could even be such that the method of capturing high quality data is different than low quality, which may again, double the costs.

9.7.4 What is the user's goal?

GIS is not a miracle machine that solves all the customer's problems. It should be considered as a tool that forms part of a project of which the service cost is bigger than the system itself. A few objectives could be:

- Cost savings. Install a GIS in order to save cost that would be spent without a GIS.
- Better response times. Install a GIS because the traditional workflow is too slow.
- Higher quality. Install a GIS because the traditional work procedures produce inaccurate results
- Other

The key question always to keep in mind is "what is the user's goal?" It has been demonstrated in many failed IT projects that a seemingly wonderful system does not solve the desired problem because it was poorly focused and aimed at the outset. User-centred design and development concepts can help to get at the user's true work flow, and then can help design software which augments that workflow or even redesigns (reengineers) and radically improves the workflow.

9.8 Conclusion

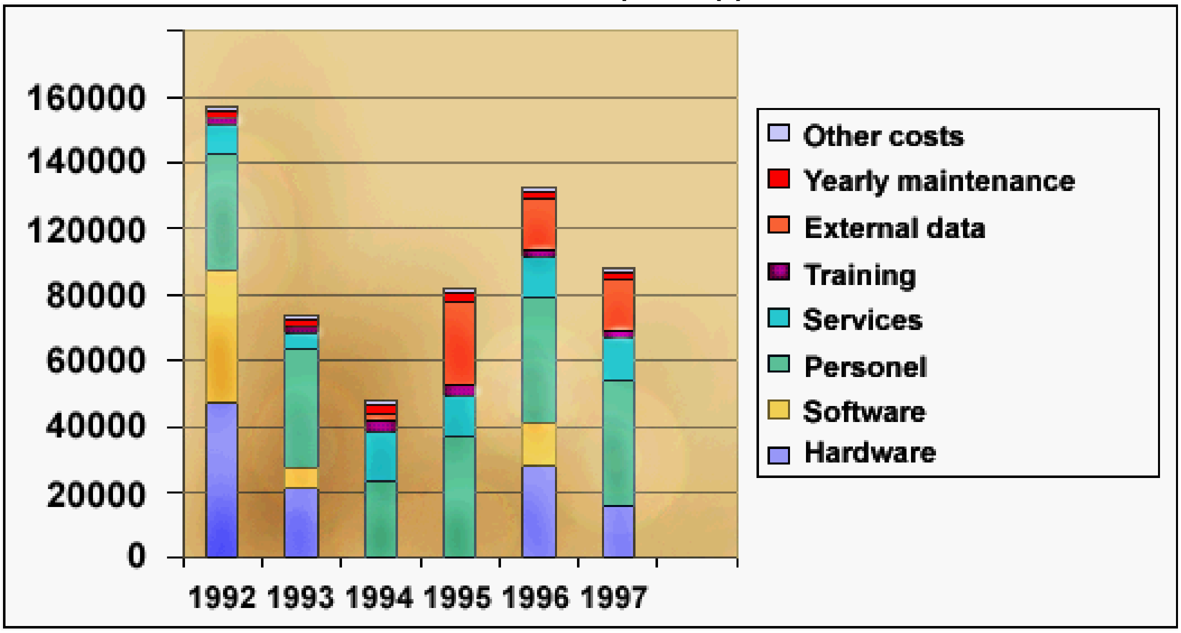
Cost-benefit analysis is not an easy undertaking. The guidelines suggested here offer a structured approach to counting the costs and benefits associated with each potential output of the GIS. The resulting benefit/cost ratios are used along with other key information to complete a strategic plan for GIS development. A good strategic plan will indicate when purchases should be made and when each justifiable output can be undertaken.

If desired, a number of strategies could be produced, for instance, to compare the long-term results of a high front-end investment versus a more steady rate of implementation at a longer-term. When a clear picture of the costs and benefits of a GIS is presented it can be compared to other competing alternatives to identify the best use of resources.

9.9 Examples

Three fictitious examples of GIS purchases are given. Case 1 was rated as a bad expenditure, case 2 as medium, and case 3 as a good estimate. In order to keep the information confidential, no names of organisations that were involved are mentioned.

Case 1: Municipal GIS(1)



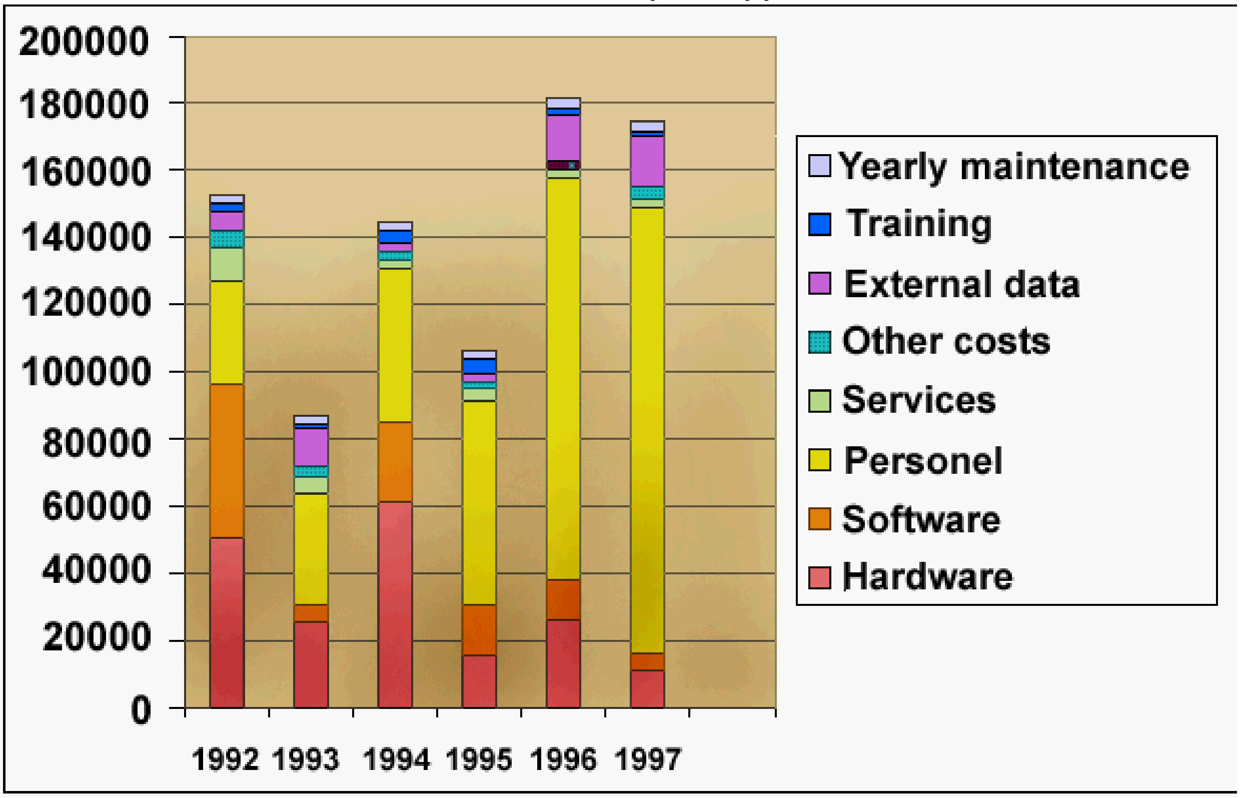
COSTS (KECU)

	1992	1993	1994	1995	1996	1997	1998
Price for the hardware	47	21	0	0	28	16	112
Price for software	40	6	0	0	13	0	59
Price for (yearly) maintenance	2	2	2	2	2	2	12
Costs for services	8	5	15	12	13	13	66
Training	2	2	3	4	1	2	14
External data	0	0	3	26	16	16	61
Personnel	35	36	23	37	38	39	208
Other costs	1	1	2	2	2	1	9
Total	135	73	48	83	113	89	541

ESTIMATED BENEFITS (KECU)

	1992	1993	1994	1995	1996	1997	Total
Services	0	0	0	0	0	0	0
Products (maps, applications)	0	0	0	0	0	22	22
New internal services performed	0	12	23	27	34	22	118
Research projects	0	24	24	0	0	33	81
Total	0	36	47	27	34	77	221

Case 2: Municipal GIS(2)



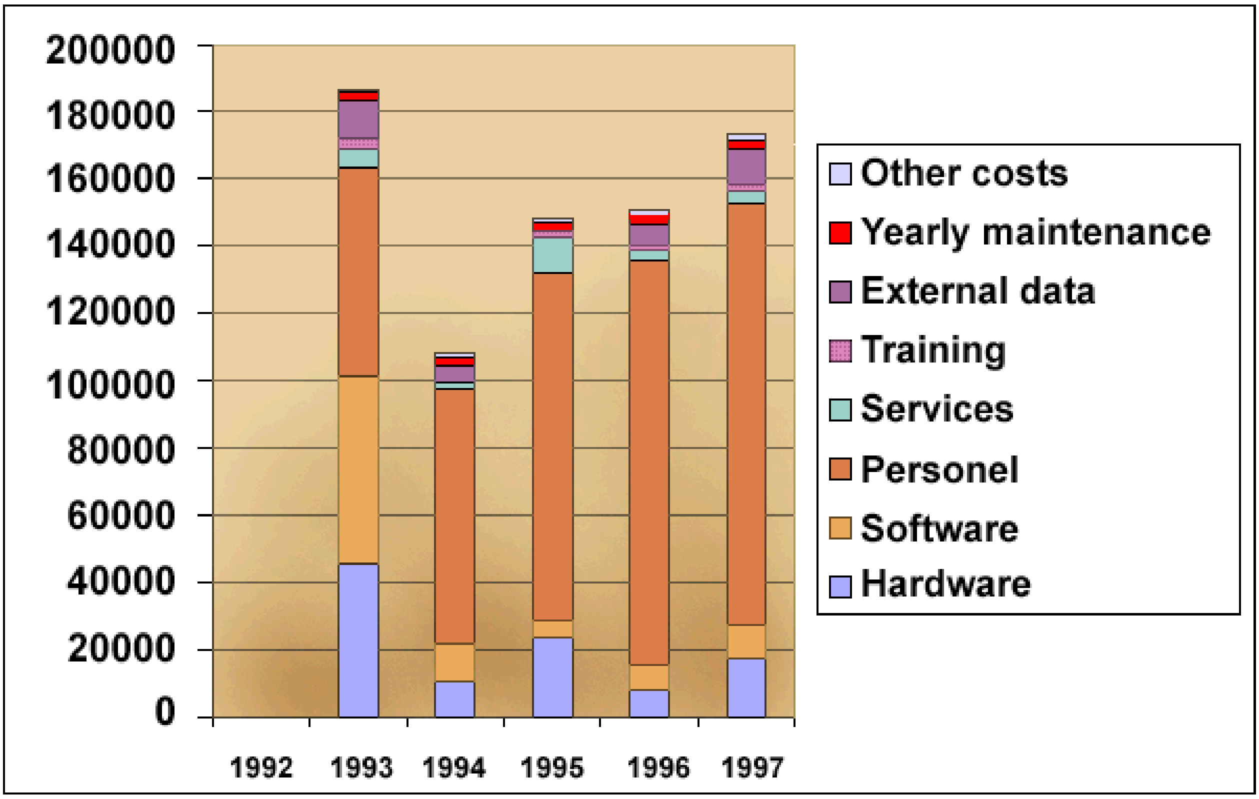
COSTS (KECU)

	1992	1993	1994	1995	1996	1997	Total
Price for the hardware	51	25	61	15	26	11	189
Price for software	46	5	24	15	12	5	107
Price for (yearly) maintenance	26	3	3	3	3	3	41
Costs for services	10	5	3	4	2	2	26
Training	26	2	4	4	2	2	40
External data	5	11	2	3	14	15	50
Personnel	31	32	45	60	120	133	421
Other costs	5	3	3	2	3	4	20
Total	200	86	145	106	182	175	894

ESTIMATED BENEFITS (KECU)

	1992	1993	1994	1995	1996	1997	Total
Services	0	0	0	60	65	14	139
Products (maps, applications)	0	0	10	0	0	82	92
New internal services performed	0	21	46	60	81	20	228
Research projects	0	70	85	85	25	125	390
Total	0	91	141	205	171	241	849

Case 3: GIS Laboratory at University



COSTS (KECU)

	1992	1993	1994	1995	1996	1997	Total
Price for the hardware	0	46	11	23	8	17	105
Price for software	0	56	11	5	8	10	90
Price for (yearly) maintenance	0	2	3	3	3	3	14
Costs for services	0	5	2	11	3	4	25
Training	0	3	0	2	2	2	9
External data	0	11	5	0	6	11	33
Personnel	0	62	76	103	120	125	486
Other costs	0	1	1	1	2	2	7
Total	0	186	109	148	152	174	698

ESTIMATED BENEFIT (KECU)

	1992	1993	1994	1995	1996	1997	Total
Services	0	22	40	23	23	19	127
Products (maps, applications)	0	0	0	0	45	31	76
New internal services performed	0	21	22	16	16	25	100
Research projects	0	28	47	54	46	32	207
Total	0	71	109	93	130	107	510

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Born, J. (1992). Can the Installation of GIS be decided by cost/benefit analysis? In Proceedings of the Geographic Information Systems and the European Challenge. A solution for common problems across Europe. October 7-9, 1992 - Montreux, Switzerland.