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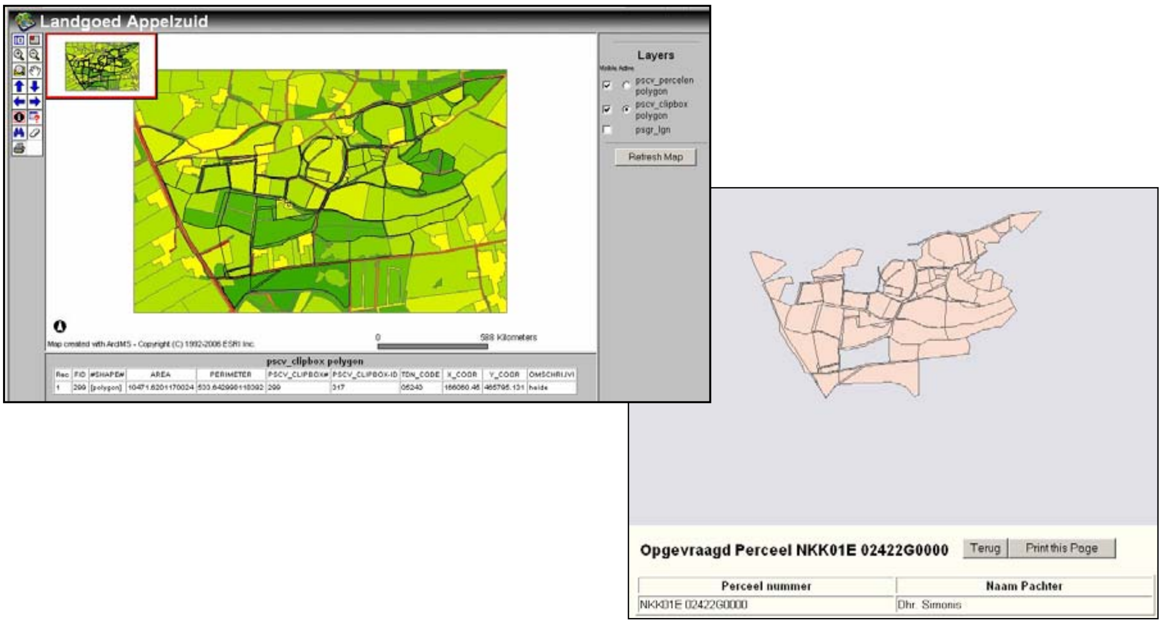
Assessment of geo-information requirements

A case study with stakeholders of Appel-Zuid, a private land property

Annemarieke de Bruin



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A case study with stakeholders of Appel-Zuid, a private land property

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Acknowledgements

This research started from an interest growing for already seven years on how people deal with existing (specialist) technologies. After a study focussed on anthropology, economics, erosion and farmers, the technical courses of the GI-science department were a relief. Not the social research stood central where multiple ambiguous human interpretations result in lengthy discussions, but the ability to work with GI-technology. The results of the work were immediately visible; effects of changes could be seen on a very short term, and interpretation of results felt neutral. However, after one year of courses I was interested in how other people and organizations interacted with this technology.

In class, we experienced that using GI-technology is faster, more efficient and money saving. With GIS, you can do so many things: see the neighbour in the backyard from an aerial photograph, find your way in the most remote areas, and estimate the yield of a crop: why is not everyone in the Netherlands using it? Is it the people who are slow learners, should GI-technology be more advertised that more people know of it or is it a technology for specialists only? In this research, I had the opportunity to discuss this with two stakeholders of two different organizations. Their views on GI-technology came forward during the assessment of their geo-information requirements. It was very interesting to see the effects on their views on my view on GI-technology when they got to know more about what this technology actually entails and what the limitations of the technology are. I understood what contributed to this gap between requirements and technology.

I would like to express my gratitude towards Sytze de Bruin for the opportunity to change the objective of a thesis to this more people oriented research. Thank you for redirecting me every time during the fieldwork to the point that a prototype is a tool and not a goal, and thanks for your constructive criticism from which I never hope to forget the ‘zandloper’-model of writing.

For the case study, I would like to thank both stakeholders, Leidje Verkerk of Bosgroep Midden Nederland and Auke F. van Marle of the administrator’s office Witte. It depended on your time and openness that this research turned out to be so interesting. The interviews were possible to be semi-structured because both of you took the time to discuss with me your views and requirements.

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Summary

In the 1980's and 1990's GIS matured as a technology (Clarke, 1999). Geo-information technology made large impacts on our society. Many organizations benefit from this technology but the widespread adoption of GI-technology will however, disadvantage small, local organizations that have limited access to this technology relative to other stakeholders, as well as limited resources for making use of this technology in legislative, financial, or other settings (Fox et al, 2005). Governmental subsidies for example can be influenced by the precision of analogue versus digital data. Organizations dealing with spatial issues have incorporated GI-technology into their organization but these GI-systems often fail to deliver the expected benefits.

In the socio-technical view an information system of an organization should not be viewed as only hard- and software but should include people. However, people often have high level, vague, and generally unhelpful requirements (Coley Consulting, 2006). The working hypothesis is that the assessment of geo-information requirements helps to bridge the gap between the technology and the requirements of stakeholders and consequently will increase the successfulness of the implementation of GI technology in organizations. In this research, an assessment was done of the geo-information requirements of two organizational stakeholders involved in the management of a private land property called Appel-Zuid. The study area is situated in between Nijkerk and Putten in the Province of Gelderland. In this property, three parties manage the nature areas. The administrator's office Witte, an organization called Bosgroep Midden Nederland and the government.

The method used to assess the geo-information requirements of the stakeholders was developed based on two assumptions. Firstly, participation of stakeholders will improve the usability of a possible outcome. Secondly, it is structured around the hypothesis that there exists a development of requirements. An iterative and dynamic cycle was developed in which the second loop of the process is based on the outcomes of the first. The phases in the cycle are identification, feasibility, implementation and evaluation. Prototyping was used to help potential users determine their requirements (Reeve and Petch, 1999).

This assessment resulted in different and more precisely defined geo-information requirements of the stakeholders compared to the ones they had at the start of this assessment. The stakeholders were supported to formulate their requirements more precisely by seeing the possibilities and possible limitations of GI-technology for their requirements. Through the looping of semi-structured interviews and prototyping, it was possible to clarify and sharpen the formulation of technical details.

The methodology turned out to be useful. The discourses of the stakeholders and of the researcher were bridged due to the maximum level of participation used and prototyping increased the familiarity of the stakeholders with the possible technical solutions to the requirements. Will these

formulated requirements result in a change of the Geographic Information Management (GIM) of these stakeholders? The nature manager is part of an organization with access to geo-data and GIS tools. This organization has enough resources to introduce the use of digital geo data and information and to use GI-technology. The administrator's office is a small and local organization with limited resources in comparison with other organizations in its context. It is not be able to and will not use GI-technology within its GIM.

With assessing geo-information requirements, the overall GI-technology is addressed from a socio-technical point of view. People are included in the process, making it a technology that people can handle and that has exit rights. It is possible not to use GI-technology after an assessment of geo-information requirements. It can therefore be concluded that through the assessment the gap between GI-technology and the requirements of people is bridged.

The developments in the field of GI-technology will continue just as in the 1980's and 1990's when GIS matured into a GI-technology. Also, the contexts of organizations will change in the future. Organization would then benefit from doing an assessment of the geo-information requirements of the organizational stakeholders before implementing any changes into their GIM. In this way, the information management can be adapted to the needs of the stakeholders in such a way that they would not even realize that GI-technology was there.

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Chapter 1 Introduction

1.1 Background

“GIS operations could become so transparent to the public that we would not even realize that GIS was there.” Clarke, 1999.

Geographic information system operations could become a technology comparable to the mobile phone. Without people knowing what happens in the tool they use, their goal is fulfilled and they assume they will get it whether it is a map or a phone contact with others anywhere at anytime. In the 1960’s a process has started where a geographic information tool matures into a geographic information technology.

Coming from the analogue field of cartography dating back centuries, in the last century digital mapping became possible. More analytical tools were developed such as software for the overlay of different maps and with the introduction of the PC in the 1980’s hardware was developed that could cope with large geographic information packages. In the 1980’s and 1990’s GIS matured as a technology (Clarke, 1999). The difference of GIS being a tool or a technology lies in the fact that a tool can be used and not used, a person can choose because there are alternatives and exit rights. Technologies on the contrary, although built from the ground up, have no exit rights. The impacts spread to other component systems (Lemke, 2000) and are soon integrated into society. The technology becomes transparent for people using it, but the gap between those using the technology and those who do not increases. Geo-information technology already made large impacts on our society. It transformed the discourse about land, the meaning of geographic knowledge, the work practices of mapping and legal professionals, and the very meaning of space itself (Fox et al, 2005).

Many organizations benefit from this technology throughout Dutch society and this process is continuing. Governmental institutions at national as well as local level (e.g. Dutch agricultural ministry and a city as Arnhem), nature management organizations (e.g. Natuur Monumenten), water boards (e.g. Waterschap Rijn and IJsel), infrastructure developers (e.g. ARCADIS), and many other organizations that deal with spatial issues have a GIS within their information systems.

The wide-spread adoption of GI-technology will however, disadvantage small, local organizations that have limited access to this technology relative to other stakeholders, as well as limited resources for making use of this technology in legislative, financial, or other settings (Fox et al, 2005). This article describes the effects of GI-technology on indigenous communities in different countries but can be used for organizations that work at local level, have a very specific geo-information need and have limited resources to access geographic data and tools. Because more and more organizations use digital geographic information, organizations that cannot follow this development will loose access to the market. Or, for example, governmental subsidies can be influenced by the precision of analogue versus digital data and farmers can loose the right to subsidy because of it.

The side effects on society can also be found at organizational level. In organizations that adopted a GIS also the technology was introduce and impacts were difficult to predict and manage (Doherty and King, 2005) and this was indicated as the primary cause of GIS failure. Geographic information systems often fail to deliver the expected benefits (Reeve and Petch, 1999, Luna-Reyes et al, 2005). How can this happen with a technology that can do so much for organizations dealing with spatial issues?

When GIS is introduced as an additional tool into an organization, what actually happens is that stakeholders deal with a technology that has no exit rights. The GIS is a part of a technology and when introduced its effects will spread to other component systems creating unforeseen impacts. The organization then has to fit the technology (Drury and Farhoomand, 1999). Based on the GIS-tool, the GI-technology in this case will not address people, the users of the geo-information. Only in the socio-technical view on GI-technology is it recognized that although the technical aspects may be successfully developed and seem to fulfil every geo-information requirement of organizations, its adoption will ultimately depend on how well implementation strategies address organisational barriers (Cullis, 1994). In this view, the information system is not only hard- and software but people are addressed as well (Reeve and Petch, 1999).

However, when people are addressed they could have no precise idea on what their requirements are. Many projects have high level, vague, and generally unhelpful requirements (Coley Consulting, 2006). As a result, the system developers, lacking proper input from the users, build what they believe is needed, without having any real knowledge of the organization. Inevitably, when the system is delivered users say it does not do what they need it to. To avoid this, users must know what it is they want, and be able to specify it precisely (Coley Consulting, 2006) how difficult that may be. The point is that the technology with all its possibilities is available and the people who want to make use of it are there as well, but the communication between both is lacking. When an organization decides it wants to make use of the GI-technology, people's geo-information requirements will have to be assessed and the impacts of technology discussed in such a way that there are still exit rights.

In this thesis, the working hypothesis is that the assessment of geo-information requirements helps to bridge the gap between the technology and the requirements of stakeholders and consequently will increase the successfulness of the implementation of GI technology in organizations. During the process of formulating the requirements, users become aware of the possibilities and the limitations of technology. They will be helped in the formulation of their requirements. The users play an active role, they participate in the process, and they shape a possible but not inevitable change in the information system. The overall research question of this research is:

Can the assessment of geo-information requirements bridge the gap between GI-technology and geo-information requirements?

This is answered by doing an assessment of the geo-information requirements of two organizational stakeholders involved in the management of a private land property called Appel-Zuid.

1.2 Context

The study area is a private property called ‘Appel-Zuid’, which is situated in between Nijkerk and Putten in the Province of Gelderland as can be seen in Figure 1.1. This area was selected as representative area for other private properties managed by the administrator’s office and Bosgroep Midden Nederland. Geo-information requirements for this area would be similar to those in the other properties. The area is approximately 250 hectares. The main land use is agriculture and a smaller portion of the area is nature, which consists of forest and heather areas. The heather areas have been sod-cutted some thirty years ago and are in need of new management because the grass and wood deposit are slowly decreasing the areas of heather.

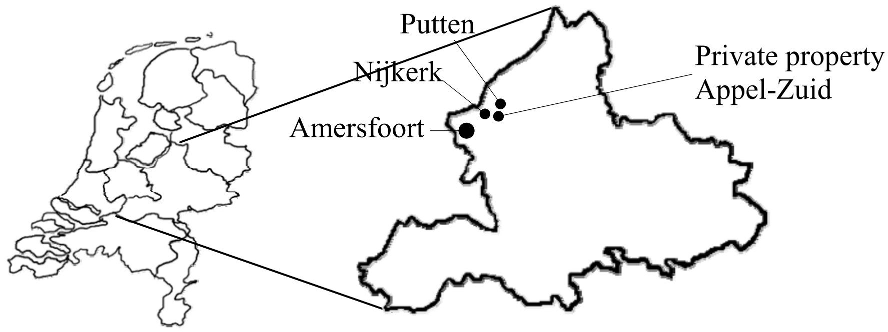


Figure 1.1 The location of the private land property Appel-Zuid in the province of Gelderland in the Netherlands *(In the references the source of the maps can be found)*

In this property, three parties manage the nature areas. The administrator’s office Witte manages the property in terms of legal issues, financial means and controls the land use according to the regulations set by the owner of the property. In this report the administrator’s office will be referred to as the ´administrator’. The actual planning and coordination of the nature management is done by an organization called Bosgroep Midden Nederland, which will be referred to in this report as ´nature manager´. The third party is the government that stimulates specific management activities through the possibility of applying for a subsidy. All three entities exchange geo-information about the property with the other two stakeholders as shown in Figure 1.2.

The administrator communicates with other administrative stakeholders such as the owner of the property, the ‘Grond Kamer’ that registers all land transfers in the Netherlands, other administration offices and with the government. The nature manager communicates with field management stakeholders such as the butterfly habitat organization, contractors who execute the management and soil analysts in order to plan and coordinate the management. These are mainly one-way flows of information. Both stakeholders communicate with the government and with each other about the subsidy applications. The three main stakeholders, government, administrator and nature manager will now be introduced in more detail.

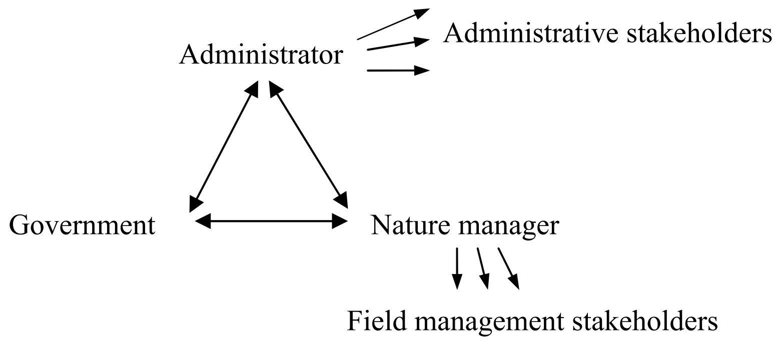


Figure 1.2 The information flows between stakeholders of the private property Appel-Zuid

By law, every use of land has to be known by the government. The users of agricultural areas have to record their land use every year (LNV-loket, 2006). Based on these data the users of these areas can apply for governmental subsidies. In the same way, the owners of nature areas record the land use and when management is planned in these areas subsidies can be requested, because the government will support certain management. For example, when heather areas need to be sod-cutted, a nature management organization can apply for a subsidy to finance the management activities for the coming years. Such an application is based on the subsidy regulations and the geographical information needed for such an application is the description of the land use, the future management, the codes to which the land use and subsidies belong and a map in which is indicated where all these are or will take place (Overheid, 2005). This map has a scale of 1:10.000 and the land use information can be indicated with colours. Although the government is an important stakeholder in the context of Appel-Zuid it is not a part of this assessment as its geo-information requirements are already known through documentation and these will not change in the near future.

Private land properties are often managed by an administrator office, which is contracted by the owner of a land property. This administrator is in charge of the transactions of land: it records all land use and contracts third parties when specific management has to be done in nature areas or along roadsides. It communicates on behalf of the owner with others about the land property and informs the owner about changes in the property. The office also handles the applications for subsidies.

Bosgroep Midden Nederland is part of an organization that has as goal to support owners of forest and nature areas in the management of these areas (Bosgroepen Nederland, 2006). This specific organization plans and executes nature management in the province of Gelderland. The administrator's office contracted the management of heather areas within some specific land properties out to Bosgroep Midden Nederland. This organization coordinates the people involved in the execution of nature management and applies for subsidies for the areas that are their responsibility.

This year it is possible to apply digitally for a subsidy (DLG, 2005 and DLG, 2006). The government has already changed years ago from the use of analogue maps to a digital GIS. Still the stakeholders receive analogue maps, but these are now print outs from a digital file that contains more data layers, and colours then before. The stakeholders are however confronted with their disability to apply digitally because the administrator and the nature manager work with analogue maps of the area. Both stakeholders had a request to start making use of digital geo-information. However, they did not know how to start this process.

1.3 Chapter overview

The context of this research has been presented in this chapter. In chapter 2, more concepts and principles are described and defined. In chapter 3, the methodology is described that was used for this research: the iterative looping uses both interviews and prototyping. In chapter 4, the results of the assessment with the stakeholders are described. The results are discussed in chapter 5, where the case study is related to the concepts and definitions as presented in this chapter and chapter 2 and the methodology is evaluated. Finally, the conclusions are given in chapter 6 as well as recommendations for future research.

Chapter 2 Definitions and concepts

This research is based on certain definitions and concepts that are part of the assessment of geo-information requirements. In section 2.1 geographic information, GIS and requirements are defined. In section 2.2, more will be explained about the principles on which an assessment is based and concepts used within the assessment are worked out in more detail.

2.1 Geographic information requirement

To be able to define a geographic information requirement it is useful to first define the three components: information, geographic information, its communication and management, and a requirement. Doing so, illustrates the impact of geo-information technology on for example views on the world and the concept of visualization.

2.1.1 Information

Often the words information and data are used interchangeable but they are not synonyms. What makes it confusing; the information for one person can be data for somebody else, depending on whether a person understands the data (or its context). Data can only become information when someone organizes, filters, and presents the data within a context (Bates, 2005). Data becomes information due to the relevancy, or added meaning, for that person. Information is data serving a purpose, or data that have been given some degree of interpretation (Longley et al, 2005). For example, the numbers of the year 2006 in a different context could represent the number of inhabitants of an area. On their own, the numbers 2006 have no meaning and it depends on the context what meaning the numbers will have. Further information about this distinction can be found in an article written by Bates (2005).

2.1.2 Geographic information

Geographic information, or geo-information, can now be defined as information of or relating to the earth and is based on data of geographic features (ESRI, 2006). This geographic data are a composite of spatial data and attribute data. Spatial data is defined as data about the locations and shapes of geographic features and the relationships between them, usually stored as coordinates and topology. When non-spatial data are to be spatially distributed, a link has to be made with a location on the earth’s surface. This is called geocoding when done in a digital record using the coordinates of a point location (Clarke, 1999). Then attribute data, tabular and/or textual data describing the geometry and thematics of geographic features can be displayed. The geometry describes the measures and properties of these geographic features and is used to represent the spatial component. The thematic characteristics describe the features as a single topic or theme, such as population density or geology (ESRI, 2006).

Two fundamental views on the world describe the representation of these geographical features; the discrete object view and the continuous field view (Longley et al, 2005). The discrete object model views the world as being composed of well-defined spatial entities (De Bruin, 2000). Objects are homogeneous within their boundaries, at least with respect to some properties. The structuring of the geographic data is then based on different spatial objects: the point, line and area objects. Points can be used to indicate spatial occurrences or events. Lines are often used to represent linear entities such as roads, pipelines, and cables, which frequently build together into networks. Natural objects, such as agricultural fields are often represented by area objects (Longley et al, 2005).

In another view, the continuous field model, the geographical space is a continuum where data are presented in spatial fields as a continuous range of values (De Bruin, 2000). The geographical world is then described by a number of variables, each measurable at any point of the earth's surface, and changing in value across the surface (Longley et al, 2005). Examples are the elevation in a landscape or the percentage of grass within a heather area.

These different geographic features can be represented in raster and vector format. The raster format is a spatial data model that represents space by an array of equally sized cells arranged in rows and columns (Clarke, 1999; ESRI, 2006). Each cell contains an attribute value and –implicitly– location coordinates as raster coordinates are contained in the ordering of the matrix. Groups of cells that share the same value can represent discrete objects. The vector format is a coordinate-based data model that represents geographic features, whether discrete or continuous, as points, lines, and polygons. Each point feature is represented as a single coordinate pair, while line and polygon features are represented as ordered lists of vertices. A vector structure stores the explicit coordinates of each feature (ESRI, 2006).

2.1.3 Communicating geo-information

To be able to add meaning to these data the representation of geographical data in a context is needed. Two types of processes exist to extract geographic information from data: the interpretive and expressive use of data (Lo and Yeung, 2002). In the interpretive use, the user is a "reader" who tries to extract the meaning of the data from a visualized set of data, for example a map. Conventionally, printed maps served a triple function simultaneously as a data store, data carrier (i.e., medium of data transmission) and a mechanism for information presentation (Lo and Yeung, 2002). An average map user has no control over the information contained in maps; he or she is simply a consumer of the information. The mode of communication is therefore largely a one-way flow of information.

Computer databases however, have become the data store, and the computer network has become the primary data carrier (Lo and Yeung, 2002). Digital maps in the form of screen display (soft copies) have gradually replaced printed maps (hard copies) as the predominant method of viewing geographical data. The presentation of information is now the primary function of these digital maps. This development made it possible that users are an "author". In the expressive use, the user tries to convey the meaning of the data through visualizing the data himself. The map serves as the spatial index for accessing the geographic database (Lo and Yeung, 2002). It provides the mechanism for the visualization of the results of spatial analysis and allows the users to communicate geographically with one another.

From the above can be concluded that the concept of visualization is much broader than the idea that visualization simply means "making visible" (MacEachren, 1995). The concept of visualization as implied in scientific visualisation embraces three elements: computation, cartographic cognition and graphics design (Buttenfield and Mackaness, 1991). The expressive use of data is based on computation, which denotes visualization as a method of computing, a set of hardware and software tools, as well as the mechanisms that facilitate human-computer interaction. Human-computer interaction provides a working environment that optimizes the communication and presentation of geographic information. Through means of a user interface, an application program that is designed to facilitate the communication between the user and the computer (Lo and Yeung, 2002), the user can create and view digital maps.

In both the interpretive and expressive use cartographic cognition plays an important role. This is the human ability to develop mental representations, identify patterns, and create orders in data analysis. Both analogue and digital maps are based on this. Graphics design, the third element of visualization, relates to the construction of visual displays using the principles of graphics communication and therefore is also present in both the interpretive and expressive use.

2.1.4 Geographic information management

In organizations that use geographic data and information, both are managed in a certain way. As said before, the spatial data storage is the computer database, the network the data carrier and the digital screen display the representation of data and information. According to Clarke (1999), this is a simple description of a Geographic Information System or a GIS. However, there are many more definitions on what a GIS is. A more precise definition comes from Burrough and McDonnell (1998). They say it is a set of computer tools for collecting, retrieving at will, transforming and displaying spatial data from the real for a particular set of purposes. GIS in this definition is a toolbox for geographical analysis. The focus on information is however, not mentioned.

In the definition of Dueker (1979) information does play a role. "A GIS is a special case of information systems where the database consists of observations on spatially distributed features, activities or events, which are definable in space as points, lines, or areas. A geographic information system manipulates data about these points, lines and areas to retrieve data for ad hoc queries and analyses." The information system in this definition shows that GIS has as goal to solve problems, do queries, answer a question, or try a possible solution. The data are manipulated digitally in order to extract information; the available data are used in an expressive process. The spatial activities mentioned in this definition present the human activities that create geographical patterns and distributions, for example population maps. The events add the dimension of time to the GIS. Also changing geographic events can be displayed in addition to geographic features that exist over time.

From this definition, it is possible to go towards geo-information management. GIS is clearly a digital based system, but geographical information and data is not necessarily digital. Many organizations do not (yet) have digital data but manage their analogue geo-data and information as well in order to solve problems, do queries, answer a question, or try a possible solution. A GIS is defined as such that it cannot include the analogue data and information and people. People, however, should be included as they handle the data and information. Therefore, a Geographic Information Management (GIM) will be introduced to include these. A GIM is defined as a framework for gathering and organizing spatial data and related information. Such a framework then consists of different data and information flows (Herweg and Steiner, 2000), that let the correct data get to the correct users that in consequence can extract information, redistribute this information or redirect the data whether in digital or analogue format.

2.1.5 Geo-information requirements

What is assumed in this framework is that there is a goal, an objective to be achieved that needs geo-data and information. When there is no purpose to the use of either data or information, there is no flow. These goals or objectives can range from efficient data management to retrieval and provision of information about location, distribution, and pattern, land use planning, animation of spatial processes, spatial simulation and predictive modelling (Lo and Yeung, 2002). To achieve the objective, in other words, a condition or capability is needed by a user, in this case geo-data and information. Such a condition or capability is defined as a requirement (CMMI, 2006) and is directly related to the concept of usability. To fulfil a certain goal, certain useful data and information, and usable and understandable tools are needed. These are all requirements and are defined by the users.

The ISO, 1998 defined usability as the extent to which a user can achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. The usability of data and information is influenced by the accessibility to both, and whether they are searchable, reliable, valid and up to date for the goal in question (Hunter et al, 2003; Herweg and Steiner, 2000). It depends on the trustworthiness that again depends on the data processing and context. From a data point of view, the intended use of spatial data usually remains unknown for the producer of these data therefore usability of data is defined by the user.

On a more general level, that of the GIM, usability refers to the same issues but then not one goal has to be fulfilled, but a framework of goals. The usability of a GIM can be specified in terms of how well potential users can perform and master tasks in the framework (Haklay and Tobón, 2003). The needs, capabilities and preferences of the users in order to fulfil a goal within the organization should influence a GIM. It is therefore necessary, in other words, to understand how people do their work. The GIM can then support the users in accomplishing their tasks effectively, efficiently, safely, enjoyably and satisfactorily (Haklay and Tobón, 2003).

2.2 Assessment of geo-information requirements

2.2.1 Requirement development

Organizations with a GIM, work within a context of other organizations, governmental institutions, economic markets and many other entities. They deal with many stakeholders outside of the organization as well as inside. Over time, this context of stakeholders will change due to factors outside the influence of the organization, such as national politics or different regulations in the field of work and will change because of the work of the organization itself. Due to this changing context, new issues can arise within the management of geo-information of an organization. The information requirements of organizations and stakeholders are context specific, when the context changes, the requirements change as well.

As requirements develop over time, the GIM can be influenced accordingly. Therefore, it is useful to assess the information requirements every now and then. Such an assessment is a determination of performance and functional characteristics based on analyses of user needs, expectations, and constraints (CMMI, 2006). Whether these changed requirements result in an actual change of the GIM depends on the limitations of the current GIM and the influence of the contextual changes on the objectives of the users of the GIM. When the information requirements in an organization are assessed at one moment, they have to be evaluated later on to see whether the GIM that is based on the first assessment is still valid for the situation of the context as it is today.

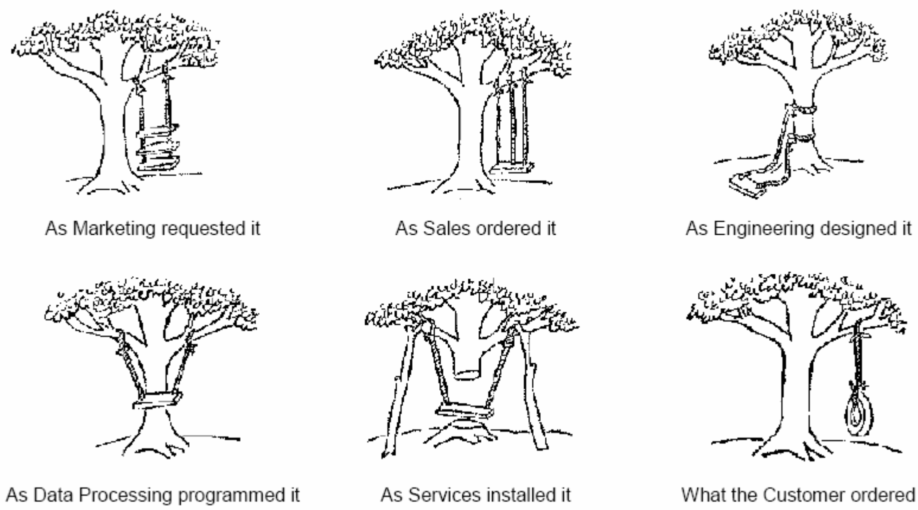


Figure 2.1 Multiple interpretations of one requirement to illustrate the importance of active participation of multiple stakeholders *(The source can be found in the references)*

2.2.2 Participation of stakeholders

In such an assessment, it is necessary to start with an observation of the contextual changes. Sometimes the context is too flexible for an organization to respond to and it needs to block out certain influences from outside. What is important is the participation of different stakeholders from within the organization. This participation by multiple stakeholders puts more information and more interpretations into play, which creates more opportunity for adaptation of an information system to the changing requirements context (Ashmos et al, 2000). These stakeholders can then explain the complex set of decision-making and information-exchange relationships present in the actual context. In this way various perceptions, attitudes, opinions and objectives of different stakeholders are comprised (Herweg and Steiner, 2002). Figure 2.1 shows the possible effects of a design without participation of different organizational stakeholders. The local use of information flows and local ways of sharing information about change can then be used within the assessment to save time, resources and insights (Guijt, 1999; Longley et al, 2005).

Senge, 1990, describes four levels of participation. In the first level of minimum participation, decisions about the necessary changes in the GIS are taken on the highest managerial level. Other stakeholders have only the choice to accept the top-down plan or to leave the organization. Possible consequences of such an implementation in a top-down way are frustration and refusal of co-operation and therefore a useless output. However, in the fourth level where participation is the most, the managerial level recognizes that it cannot possibly have all the answers and consults other organizational stakeholders about the possible change in the GIM. This creates commitment of all stakeholders to the change when implemented. Such a process takes time and requires real commitment at the managerial level to correct initial decisions.

The managerial level Senge talks about in his four levels of participation can be substituted for technical specialist, or GIS-specialist, the one who assesses the geo-information requirements. He can do this assessment alone without involvement of organizational stakeholders or he can consult multiple stakeholders about their requirements and together with his technical input, they can come up with a suitable solution for the GIM that is then supported by all stakeholders involved.

2.2.3 Prototyping

The technical input of a GIS-specialist during an assessment can be through means of prototyping. The established idea of prototyping is to spend a limited amount of time and money on producing something in the small before producing something in the large. This reduces uncertainties and minimises overall costs of the final output (Reeve and Petch, 1999 and Longley et al, 2005). Traditionally prototyping provides an opportunity to explore alternatives after requirements have been defined. However, prototyping can also support the development of these requirements in the first place. The definition of prototyping then becomes the construction of a working model provided to help potential users to determine their requirements (Reeve and Petch, 1999). This will increase the familiarity with the possible technical solutions. It is a mechanism by which participation is ensured and through which the user's view if the system can be expressed.

To help the geo-specialist make decisions as to what should be displayed in the prototype the methodology of MoSCoW was developed. This prioritization technique focuses on the functionalities of the prototype (MoSCoW, 2005). Some components will be vital, and the prototype "Must have" these. Other components are necessary but not vital, the prototype "Should have" them. Another part is only interesting but will never be possible to be included within this period, it "Could have" had these and lastly the part that will never be in as it is impossible to be fulfilled; the prototype "Won't have" these. In the following chapters, an assessment is described that was done with the stakeholders who are involved in the management of a private land property called Appel-Zuid.

2.2.4 Costs and benefits

A requirements defect, i.e. not getting the customer's needs right, can cost from 5 to 200 times more to fix than it would have done at the time requirements were being specified (Reeve and Petch, 1999). For an organization it is therefore of high importance to be clear about its geo-information requirements and to take time to go through a process understanding what changes have come up within the requirements. A possible result can be that the benefits of a changed GIM will not outweigh the costs of implementing. In this balance, also the organizational impacts have to be addressed, as these can be costly as well. What is interesting is that organizations will find the perceived economic justification of a technology more important than its real economic rationalization (Drury and Farhoomand, 1999). Although most GIS cost-benefit analyses prove a good case for proceeding with GIS, the amount of the initial expenditures and the distance of the payback point can present problems. An organization must consider the cost-benefit period, not just net cost-benefit or payback point (Somers, 1998).

Chapter 3 Methodology

In this chapter, the research methodology is presented. The methodology consisted of three parts. In section 3.1, the first part where the current situation was reviewed is described. The second part was the looping with its four phases and is worked out in section 3.2. The last part of the methodology, the review, is described in section 3.3.

3.1 The current situation

To get to know the current geo-information management of both stakeholders an interview was held covering a stakeholder analysis based on PSA, Participatory System Analysis (Herweg and Steiner, 2002). An inventory was made of geo-information and data that was exchanged between these stakeholders and internally, within the organizations of the administrator and nature manager. In addition, the shortcomings of the current situation and the expected benefits of a more digitally based GIM were asked. This interview can be found in Appendix A1, in Dutch.

3.2 The looping

During this assessment, the following questions were answered:

- What kind of information is needed by the different stakeholders (purposes of geo-information management, information questions)?
- Which form of presentation of data is useful to provide the stakeholders with the information (attribute data, thematics and geometry, data format)?
- What is the best way to communicate and disseminate the information (interpretive or expressive use, user interface, colours, maps or tables)?
- What kind of information can the stakeholders provide (background information, specific datasets, data etc.)?

The method used to assess the geo-information requirements of the stakeholders was developed based on two assumptions. Firstly, participation of stakeholders will improve the usability of a possible outcome. Secondly, it is structured around the hypothesis that there exists a development of requirements, a growth in the formulation of stakeholders needs. The confrontation with the potential limitations of technology and the realistic view on stakeholders' personal needs results in a better understanding of what they want and of what they could obtain. Therefore, an iterative and dynamic cycle was developed in which the second loop of the process is based on the outcomes of the first. The phases in the cycle are based on those used in project cycle management (MDF, 2003).

These four stages are identification, feasibility, implementation and evaluation are shown in Figure 3.1.

3.2.1 The cycle

In the identification phase, a semi-structured interview was held with the two stakeholders about their geo-information requirements following the four assessment questions. The interview, in Dutch, can be found in Appendix A2.

The feasibility phase of the cycle came next. Here, the contextual information requirements were translated into technical functionalities that could assist the answering of the requirements. In the interview, the stakeholders had been asked to prioritize their requirements. The functionalities needed to support the information retrieval were selected by the researcher and prioritized according to the method MoSCoW (MoSCoW, 2005).

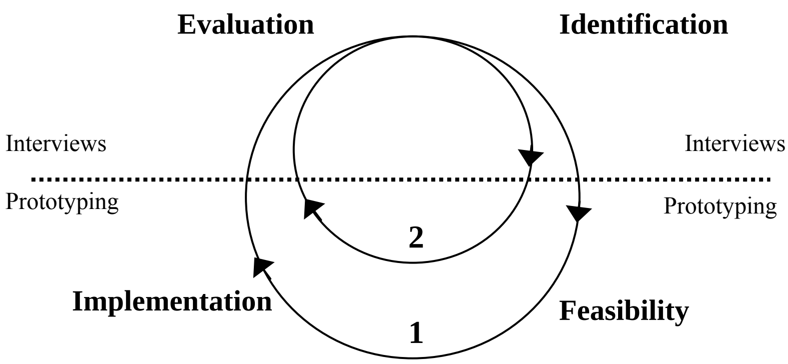


Figure 3.1 The looping procedure adopted in this research

Within the phase of implementation, a prototype was created based on the functionalities resulting from the MoSCoW. Software and programming languages were compared on the functionalities they could offer, the time needed to get to know the software, and whether technical support was available. More information on the prototype can be found in section 3.2.2.

Then the final phase in the cycle is the evaluation. After the prototype was made, it was shown and explained to the stakeholders. The information that could be retrieved from the prototype to answer their requirements was shown. In a semi-structured interview, they could comment and give feedback to the extraction of information and the functionalities of the prototype.

After the evaluation, the interview went on with addressing the possibility of new requirements or different requirements of the stakeholders, and by this starting the second cycle. Similar to the identification phase, these new or rephrased requirements were again followed by the four assessment questions. This interview can be found in Appendix A3. After the identification again a feasibility study was done, a second prototype was made and then evaluated in an open discussion.

3.2.2 The prototype

For the first prototype, datasets were selected on their availability, data on the area Appel-Zuid and at least one topographic and one cadastral dataset were needed. This resulted in three datasets that were used: the topographic dataset, ‘top10vector’ in vector format of the cadastral service of the Netherlands, the topographic dataset ‘LGN4’ in raster format with a cell size of 25 by 25 meters of Alterra, and the cadastral boundaries from almost all parcels belonging to Appel-Zuid in vector format from the cadastral service as well. Using ArisFlow, the topographic datasets were clipped to a box of coordinates of the Rijksdriehoeksstelsel in which Appel-Zuid was located. The three data layers were used to make a representation in ArcMap. Then this map was used as input for ArcIMS in which the html output was chosen. IIS was used as server. The data files were put on a server and the web-application ‘Landgoed AppelZuid’ was available (http://imsgrs.wur.nl/website/Landgoed_Appelzuid). The map made in ArcMap software was also used as prototype when connection to the website failed and to show the integration of different layers.

For the second prototype, the cadastral data were used again and in addition, a database of Microsoft Access was created. With the programming languages ASP and Active X a web-application was built (http://imsgrs.wur.nl/test_appelzuid). Both ArcMap and ArcView were used to explore the drawing functionalities and ArcMap was used to show the updated version of the first prototype. As another data source, a structured interview was held with F. van Belle, an ecologist of a Dutch nature organization called Natuur Monumenten to get a preview of an organization using GIS to manage nature areas.

3.3 The review

In this assessment the expected benefits, the methodology and the willingness of the stakeholders to invest were evaluated through a questionnaire with statements. This questionnaire can be found in Appendix A4, in Dutch. After the two stakeholders filled in the form, the outcomes were discussed and an answer was found to the question whether costs and benefits of using digital geo-data and –information would result in a nearby change of the GIM for the organizations of the nature manager and the administrator. In this discussion, also the current situation of the GIM came forward when changes had already taken place in the organization during this assessment.

In addition, an assessment was made of the costs involved in the implementation of a digital geo-information management. This assessment was based on literature and on websites of software vendors such as ESRI.

Chapter 4 Results

In this chapter, the results from the methodology are presented. In section 4.1, the current GIM as it was at the beginning of the assessment is described. Section 4.2 presents the results of the iterative looping consisting of four phases: identification, feasibility, implementation and evaluation. The review in section 4.3 presents the results of a questionnaire and a discussion about the stakeholders' opinions on the expected benefits, their willingness to invest in changing the GIM.

4.1 The current situation

The first assessment, to identify the current GIM, presented the following situation of geo-information flows. The datasets that are exchanged between the stakeholders are shown in Table 4.1 and will be explained further in the following text. All geo-information flows from the nature manager and the administrator to other stakeholders are either analogue maps or verbal communications.

Table 4.1 The geo-information flows between the different stakeholders. Internal use is presented by the cell with the same start and end stakeholder of the flow.

From \ To	Government	Nature manager	Administrator	Other stakeholders
Government	• Aerial photographs • Topographic datasets • Cadastral dataset	• Subsidy application map	• Subsidy application map	n.a.
Nature manager	• Topographic datasets • Subsidy areas	• Thematic map of 2000	• Verbal communications	• Wooden sticks
Administrator	• Topographic datasets • Subsidy areas	• Verbal communications	• Topographic datasets	• Land transactions
Other stakeholders	n.a.	• Butterfly habitat map • Soil analysis	n.a	n.a.

Both stakeholders use the topographic map of the Netherlands as displayed in the ANWB atlas (2005). Also the map that accompanies the subsidy request as shown in Appendix B is used in these flows. The topographic map is used to indicate the location of the property and is used as background for new subsidy applications. After the government has granted a subsidy application, the map in Appendix C is sent back every year to both stakeholders for verification of the subsidy area. Several layers are displayed in this map: an aerial photograph, the topographic and cadastral boundaries and the layer of the subsidy codes. It is a printout of a digital map made by LNV, the Dutch ministry of agricultural.

In addition to these two maps, the nature manager uses a thematic map of the property made in 2000. This map has a thematic classification that is based on red-list and endangered species and indicates areas where management is needed. A specialist GIS company made it. The nature manager uses this map to plan the management. When a plan is to be executed, wooden sticks are sometimes placed around areas where machinery should not come, due to biotopes of butterflies or special species of heather.

The administrator makes subsidy applications and other maps manually by extracting correct data through copying, enlarging the topographic maps on a copy machine, classifying the map with colour pencils and written numbers. One such map is present in Appendix C, although copied in black and white Appel-Zuid is highlighted. The numbers are visible that indicate a classification of landscape elements.

According to the stakeholders, these information flows have shortcomings. Data that are used are outdated and too unspecific. The nature manager considers the updating of the thematic map of 2000 too time consuming. The administrator describes the extraction of information for subsidy applications from the topographic map as a boring process that is inaccurate. For example, to get the correct scale of the map for the subsidy applications 1:10000 is obtained with the copy machine with the errors on the side of the image. In addition, it takes too much time to find the correct and useful data and the end result is only usable for a single application. Paper is also very prone to mistakes and an output easily disrupted by a small adjustment. Consequently, the process of data retrieval is often repeated.

4.2 The looping

<u>4.2.1 Cycle 1</u>

Identification - Nature manager

As response to the identification phase of the looping, the nature manager answered the following to the four assessment questions. Firstly, the nature manager indicated that the purpose of the digital geo-information management is to learn from past heather management and monitor future management in order to optimize the frequency and the activities itself.

Secondly, the thematic information requirements are shown in Figure 4.1. To learn from past management the nature manager needs data on where management has taken place and new management has to be recorded. To plan future management, more information is needed about the physical characteristics of the heather areas. This means that from the land use of the area, nature should be worked out in forest, heather and wood deposit. Heather areas should be sub-classified into the percentage of grass and the type of specie. This data in combination with the management dates and areas makes the extraction of information for the monitoring of the management possible. The information about the nature areas should be visualized in raster format because management is also planned and executed in squares. More information about the geometry of the thematic classes can be found in Table 4.2.

The answer to the third question was that the data should be digitally available for the nature manager to make plans and for the use of the data in the field, it should be possible to print the displayed maps. The data should be updated with a frequency of five years.

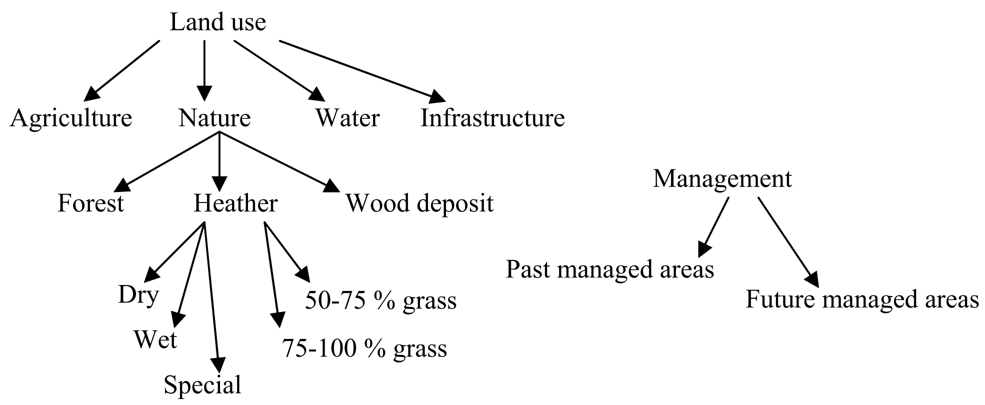


Figure 4.1 The thematic classes and subclasses of interest for the nature manager

To the fourth question about the provision of data, the nature manager answered that she can provide analogue data on management happened in the past. The thematics on the nature areas have to be recorded in the field or a search has to be made for possible topographic datasets that contain these thematic classes of Appel-Zuid.

Table 4.2 The thematic (sub)classes of interest for the nature manager and its data format and geometry

Thematic classes	Format	Geometry
Vegetation types heather: Wet, dry, special	raster	10m cell size
Grassiness: 50%-75%, 75%-100%	raster	10m cell size
Wood deposit: Forest, wood deposit, heather	raster	10m cell size
Management: Year of execution	raster	5m cell size

Identification - Administrator

For the administrator first of all, the purpose of using digital geo-information is on the one hand to achieve a decrease of the time spent on retrieving information needed for subsidy applications and on the other to support the administration of renters. The two goals have their own requirements. For the first, the requirements are based on those issued by the different subsidy regulations. Land use is in this case subdivided into forest, water, roads and standard topographic classes as used in the ANWB atlas. The other goal will support the office administration as well as the legal registration of rented parcels by the ‘Grond kamer’, a national institute that registers all ground transactions. For this administration, the cadastral and topographic boundaries of parcels are needed in order to rent these parcels to third parties. Of the rented parcels, thematics such as user and owner are included. An overview both thematic classes and subclasses is given in Figure 4.2.

Secondly, these thematic requirements have the geometry as displayed in Table 4.3. The data format should be vector because the topographic maps used so far in both subsidy applications and administration also have vector data. The geometric accuracy for the land use classes depends on the costs involved but preferably, data would have a 1 meter accuracy. The unknown geometry for the administration depends on the available datasets used for extracting the data about the rented parcels.

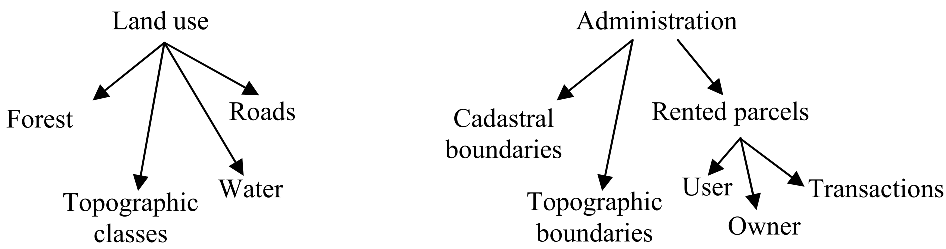


Figure 4.3 The thematic classes and subclasses of interest for the administrator

Thirdly, the data should be presented in a table or a map and it should be possible to send resulting information digitally to other stakeholders. And the last question gave the following response. The administrator has access to past subsidy applications, the cadastral data on paper as well as online, and the general topographic maps of the area. There also exists a digital database with information on renters such as names, date of transactions and the type of rent. Of all transactions, there is a file with a map of the bought and sold parcels and a self-made rental agreement. The administrator would prefer to be in control of the information flows that concern the private properties of land. As the areas are private, information should be accessed and used carefully. The database about the renters will not be provided to third parties.

Table 4.3 The thematic (sub)classes of interest for the administrator and their data format and geometry

Thematic classes	Format	Geometry
Land use: Forest, roads, water, agriculture (accuracy depends on costs)	vector	1m
Administration: Area, owner, transactions, user	vector	unknown

Feasibility

The functionalities that could assist the answering of the requirements of the nature manager were the display of a map, the overlay of different data layers. For the administrator the overlay of different data layers, querying of a digital map, selection of certain map features and the display of the area of them, a zoom functionality and the possibility to add data to the underlying attribute tables could assist the requirements. The selected area or geographic features should be exportable in table or the map to a picture format to other software programs and it should be possible to print the digital data. The display of a map became the 'must have', the query of a map the 'should have' and all other functionalities were regarded as a 'could have'. It was decided that one prototype would be made based on both stakeholders' functionalities because Appel-Zuid is one geographic unit. Therefore, all of these functionalities were prioritized using MoSCoW.

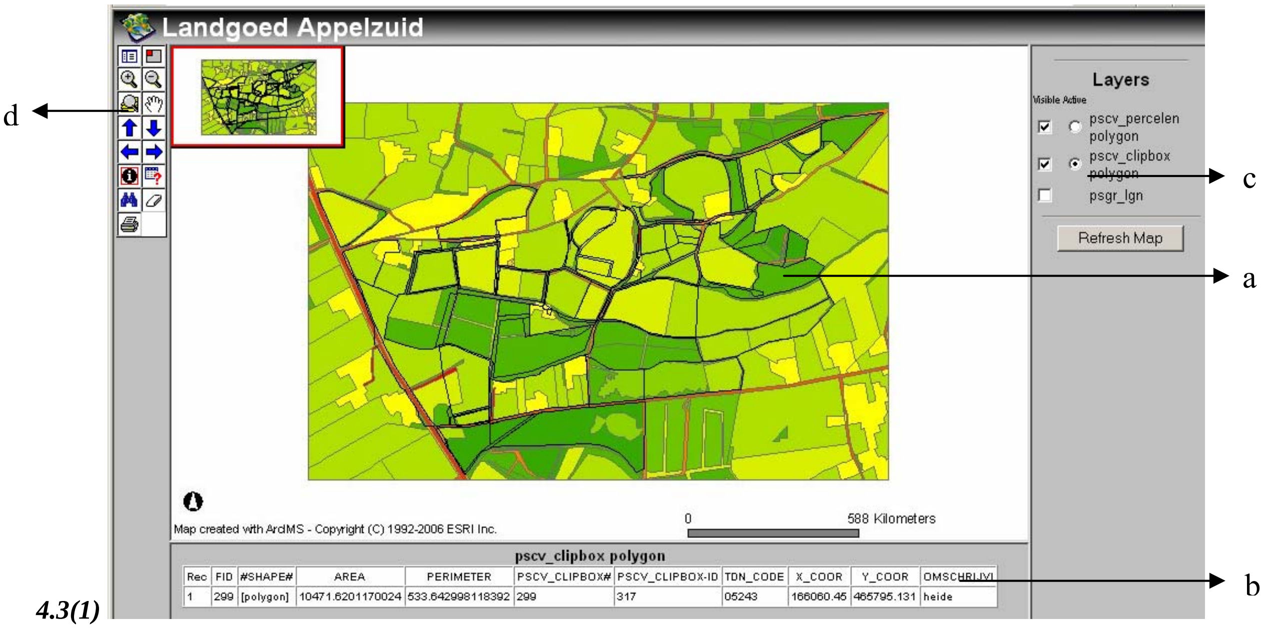
Implementation

To display the map of Appel-Zuid a web based service was chosen that was supported by an ArcMap application. More information about the technical details can be found in 3.2.2. Two screen shots of the prototype are shown in Figure 4.3. With using ArcIMS, not only the display of the map was a functionality it also contained querying the map data when a vector data layer was active, the map could be zoomed in and out, an overlay could be made of different data layers, and a print out could be made from the screen with legend, north arrow, scale (although incorrect) and toggle window. The printouts of the application showing the two different topographic maps with legend and the overlaid cadastral boundaries for orientation of the stakeholders can be found in Appendix D. The use of topographic datasets with two data formats was chosen to fulfil both stakeholders' requirements. And in one prototype, these two layers could make a comparison of data formats possible.

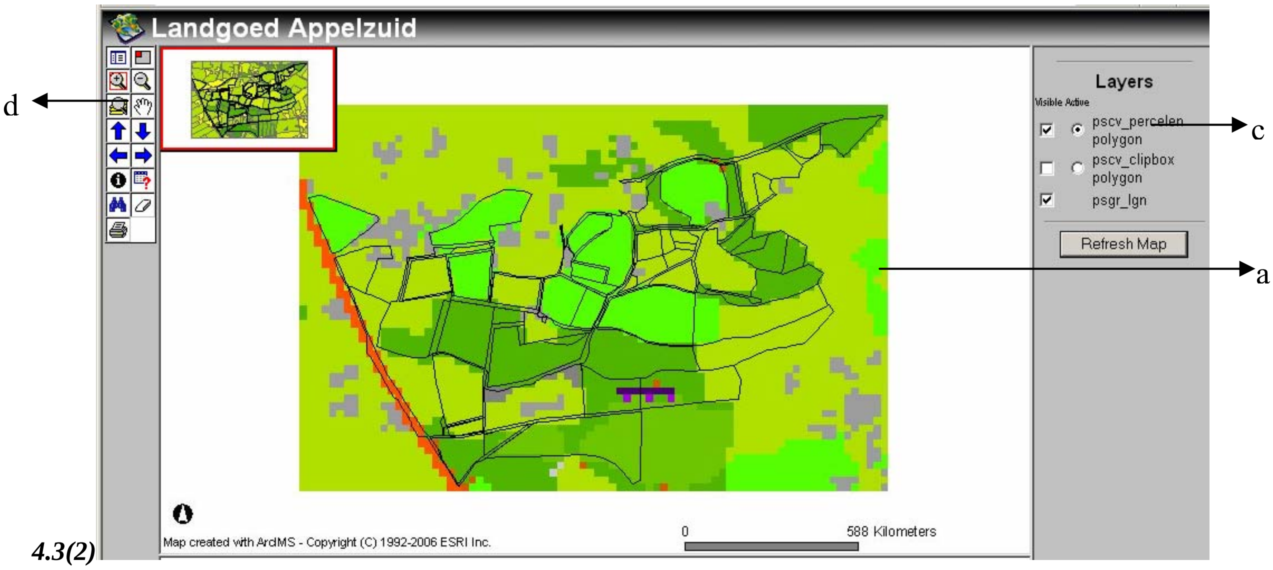
Evaluation – Nature manager

After showing the nature manager what information could be extracted for her requirements, the prototype received the following comments. Firstly, the goal of optimizing management could not be fulfilled. There was not enough detailed information in the thematic heather classes. An overview of the land use was only obtained. Both datasets showed inconsistencies compared to the real situation. For example, heather areas in the 'top10vector' layer were classified as forest in the 'LGN4'. Grassed heather was classified in the map, but in reality, the heather had already been managed. The accuracy of the thematic classifications was too low to be able to plan management based on these data.

Secondly, the raster format of the 'LGN4' was found to be a useful format for the thematic classification; the vector format showed the shape of a feature. Thirdly, the nature manager considered the user interface difficult to read due to the different shades of green used for the vegetation. Some of the attributes in the datasets such as the area and perimeter had more decimals than were perceived as meaningful by the nature manager.



4.3(1)



4.3(2)

Figure 4.3 Two screenshots of the first prototype where the cadastral boundaries in vector format overlay (1): the 'top10vector' in vector format, (2): the 'LGN4' in raster format. a: displayed map, b: table with attribute information, c: activated layers d: other functionalities.

Evaluation – Administrator

First of all, the administrator could answer his information requirement about the subsidy applications although the thematic classes should then be generalized in the displayed map in the only five classes mentioned by the NSW-subsidy (Natuur Schoon Wet, DR, 2005). The present dataset should however not be changed. The second information requirement for the administrator could not be fulfilled with the data available. The administrator deals with parts of cadastral parcels there is a need for those boundaries within the cadastral parcels.

Secondly, the raster format of data was considered to be annoying. The accuracy of a dataset would depend on the accuracy of the available datasets. Thirdly, the administrator did not make any comments on the user interface. Only the need to change the colours for different subsidy applications was stressed.

4.2.2 Cycle 2

In Table 4.4, the changed geo-information requirements of the stakeholders are presented.

Identification – Nature manager

For the second cycle, again the four assessment questions were answered. The nature manager argued that to be able to plan management in heather areas, more thematic sub classes would be needed than those offered by available datasets. Also, a higher thematic accuracy was needed than offered by the LGN4 dataset. Consequently, the data collection on these thematics would have to be done by the organization. From this line of thinking, a new information requirement came up. What are the experiences of other nature management organizations with digital geo-data and information?

To the second assessment question, the nature manager answered that the thematics mentioned in the first identification were still valid. The 10 meter cell size as resolution for the raster data seemed to be too detailed for collection of data. Better was to use the 25 meter cell size of the LGN4 raster. She also remarked that the thematics of the data should not be focused on subsidy regulations as these change now and then. The necessary information for a subsidy application should be extracted from the management dataset.

Thirdly, the data should also be analogue available as the map supports the management in the field. Fewer colours should be used in the map to be able to print it correctly with an average printer.

Table 4.4 The changed geo-information requirements of the stakeholders

Stakeholder	Thematic classes	Format	Geometric accuracy
Nature manager	Heather subclasses with higher accuracy than accuracy of LGN4	raster	25m cell size
Administrator	Administration: Cadastral parcels divided into rented parts of cadastral parcels Subsidy application: Topographic dataset thematic classes into NSW-subsidy classes	vector	unknown

Identification – administrator

The goals of the geo-information requirements did not change for the administrator. However, the requirements did for both the administration and subsidy application. As the administrator deals with parts of cadastral parcels and not with cadastral parcels entirely, the following geo-information questions were formulated:

- Which plots are rented by 'Dhr. Jansen'?
- Who rents this part of the cadastral parcel?
- Who are the renters of this cadastral parcel?
- What is the area of this partly cadastral parcel?

In addition, the administration would be helped when rental agreements could be made digitally.

The thematics needed for this administration goal are the user, the area, and the unique identifier of the parts of cadastral parcels that are rented to third parties. The thematics for the subsidy application should be generalized into the five classes shown in Figure 4.4. In the topographic dataset, the thematic classes should not be changed. After viewing some of the heather classes, the administrator also would like to have thematics where what type of management has been done and when this happened.

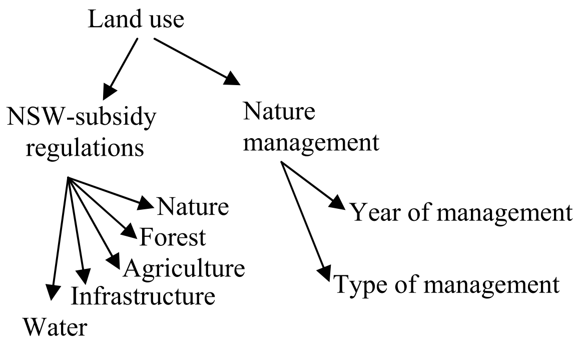


Figure 4.4 The thematic classes and subclasses of interest for the administrator

Thirdly, the user interface should have the colours mentioned in the NSW subsidy regulations. The fourth question about the provision of data was answered with showing an analogue file of a renter. The parts of cadastral parcels are documented with their unique identifier, and surface, only in these files. The database with the names of renters does not contain this identifier. In addition, an analogue rental agreement was shown.

Feasibility

The technical functionalities that could assist the extraction of information needed by the nature manager were a print option in grey-tones or a map with fewer colours. The administrator would be supported by the following functionalities. To label features in the displayed map and print these in grey-tones including a north arrow, scale and legend are required functionalities. Also, the ability to make rental agreements and to digitally draw a part of a cadastral parcel using cadastral and topographic data as background would be helpful. In addition, a fixed zoom at scales of 1:2000, 1:10000 and 1:25000 would support the requirements. Preferably, the 1:25000 topographic dataset would be used making the 'top10vector' dataset unnecessary.

Implementation

The functionalities were prioritized again and feature labelling became a 'must have', the drawing possibilities a 'should have', the fixed zoom a 'could have' and the print in grey-tones a 'won't have'. The feature labelling was worked out by creating a web-based service that contained a link between a digital map and a database. The cadastral parcels were used as data for the spatial index. The existing database with data on renters was not suitable for this prototype, because it missed the identifier of the parts of the cadastral parcels. Therefore, an Access database was created with as identifier an attribute with the cadastral numbers of the parcels and another attribute with fictive names of renters. After clicking on a parcel in the displayed map, the data of this parcel within the database was extracted and displayed in the table (b) shown in the screenshot of Figure 4.5

The possibilities concerning the digitizing and use of parts of cadastral parcels were worked out by the researcher. In ArcMap and ArcView, four fictive parcels were drawn based on topographic boundaries crossing cadastral parcels and the cadastral boundaries. Attributes were added to these new features and a print out was made similar to the rental agreements used by the office. Such an agreement can be found in Appendix E.

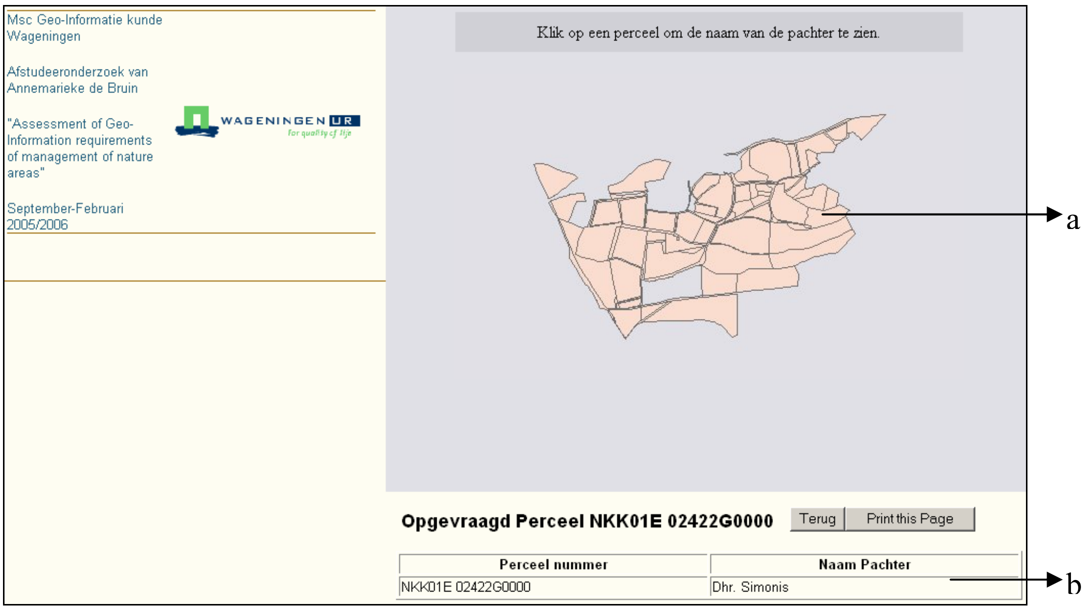


Figure 4.5 A screenshot of prototype 2. a: the displayed map, b: the table with data on the number of a parcel and the name of the user.

In addition, the ArcMap representation in the first prototype was changed into thematic classes and colour codes as prescribed by the NSW-subsidy. The interview with the ecologist F. van Belle of nature management organization Natuur Monumenten was also held. His experience with digital geo-information within nature management can be described as follows. This organization has a personal developed GIS application based on ArcView in which many data layers of the Netherlands are present. Every employee of Natuur Monumenten can access this system with restricted functionalities. This system is used as background information to manage nature areas. In the field, the management plan is designed and communicated with other stakeholders through wooden sticks that indicate the areas where management activities should take place. A possible source of background information for the nature manager of Appel-Zuid could be the recently developed GI-portal www.natuurgegevens.nl. This geo-information portal provides several digital data layers such as governmental plans, ecological regulations, soil types and habitat rules.

Evaluation – Nature manager

As the nature manager did not change her geo-information goals and requirements any further, the four assessment questions will not be answered here. The reaction to the information about Natuur Monumenten is however valuable to see her view on the possible format of a more digital GIM.

The nature manager considered it a valuable preview on what a digital GIM could do for an organization. However, the two organizations have different ways of working with geo-information because their role is different. The Bosgroep Midden-Nederland works for third parties and the Natuur Monumenten manages its own land properties. For the nature manager it would take too much time to go in the field several times to make the management plan and communicate this with the contracted stakeholders.

Evaluation – Administrator

The administrator had changed his requirements during identification. Therefore, the four assessment questions could be answered again. First of all, the prototype showed the possibility to link a database to a displayed map but this application would not support the goal of administration. There was more a need for an overview of the rental situation of the entire property than the data about one parcel.

The thematics would be the same as mentioned in the identification of the second cycle, but within the displayed map the data should be visible. A reclassification of parcels on the names of renters or the period of rent would support the administration more. The rental agreements that were made could support the administration requirement goal.

The requirement of the administrator about information for a subsidy application was available, but also here another requirement came up based on the same subsidy. The different landscape elements had to be identified separately. Every thematic group of polygons lying adjacent to each other should get a different number indicating it as another element.

To the provision of data, the administrator remarked that he could manually add the data needed for this last subsidy classification within the existing topographic dataset. The areas for subsidy were always small and therefore it would not be too much work.

4.3 The review

In this assessment, the expected benefits as formulated in the first assessment of the ‘current’ situation were evaluated and the willingness of the stakeholders to invest in changing their GIM was discussed.

The nature manager argued the following after having an assessment of her geo-information requirements. A digital GIM will give a professional look to the organization and the collection and use of digital data will save time. However, training is needed with all GIS tools and the purchase of GIS software and hardware is costly. When an organization does not have GIS tools, it cannot use digital data. She considers the use of analogue data just as good as digital data. It is not more accurate than analogue data although it seems more accurate because of the high number of decimals of some attributes. From a more digitally based GIM the nature manager could extract the required geo-information.

For the nature manager the willingness to invest in a change of the GIM is high. Simultaneous to this research the nature manager experimented in the field with GPS and measured the boundaries and surface of some management areas. This activity was time consuming. The benefit of it would be that when this activity would be repeated on a yearly basis the heather management could be monitored precisely. Also, a GIS specialist has been appointed within the period of this research supporting the digital subsidy applications. This organization has access to the data used by the government for these applications. Although the use is restricted, the organization benefits greatly from this agreement and is on its way to use more digital geo-data and information within its GIM.

The administrator considers a digital geographic information system to give a more accurate presentation. The accuracy in the data might be similar to that of analogue data but during the process of retrieving the correct information, analogue data will get a higher inaccuracy than digital data. Besides, digital geo-data and information will give a better look than in analogue form. Information is better accepted when put into a smooth format, which a digital form can more easily accomplish.

The administrator foresees a large input when the GIM should be changed. The digitizing of the large amount of analogue maps of the parcels that are part of cadastral parcels will be very time consuming. He expects that over time a changed GIM could be time saving because digital outputs can then be used more than once and the information retrieval will become easier. A digital system can give the information that is required by the administrator.

Chapter 5 Discussion

5.1 Geographic information requirements

The answer to the four assessment questions can now be summarized. The nature manager has the following geo-information requirements.

- The goal is to plan nature management and optimize it in the future.
- The thematic classes needed for this are specific heather characteristics, data on species and grass percentages with more thematic accuracy than the data in the 'LGN4' dataset. Management data are also needed on when where what type of management has been done. The raster format can be used for the different thematic classes of heather and for the management. The vector format can be used to indicate the shape of different land use classes. The resolution of the thematic classes should be 25 meter cell size.
- The user interface should be expressive, data in the underlying dataset should have a meaningful amount of decimals and better graphics design with other use of colours is preferred. A print option should be included and the map display should have to be shown in grey-tones.
- The nature manager cannot provide data for the requirement. The data have to collected in the field.

The administrators' geo-information requirements can be described as follows.

- Administration would be helped with a spatial overview of the rental situation and digitally produced rental agreements, and subsidy applications need to be done digitally as well.
- The thematic classes needed for this are names, transaction data and year of rent of all renters, and the identifier of each sub-rented part of a cadastral parcel with a thematic accuracy of 100%. For the NSW-subsidy application thematics are land use classes of agriculture, forest, nature, water and infrastructure, with the accuracy of the topographic dataset 'top10vector'. For the NSW-subsidy the numbering of the landscape elements need to be included. The vector format has to be used for all data and geometric accuracy of the topographic and cadastral dataset is the accuracy that is needed.
- The user interface should be expressive in order to draw rental agreements and update the overview of rented parcels. Also the land use dataset will be used in an expressive process to make new classifications for other subsidies and for landscape elements needed in the NSW subsidy.
- The administrator has access to the cadastral dataset of the area. A database exists with all thematics needed on renters, but without the parcel number identifier. An archive is available with files ordered by name of renter that include analogue maps of the parts of cadastral parcels.

Requirement development of nature manager

The geo-information requirements of both stakeholders were supported by the assessment and some requirement development could be seen. The nature manager knew her goals and thematics precisely and these did not change during the assessment. However, she did adapt the thematic accuracy to be at least higher than that of the 'LGN4' dataset. She adopted the integration of raster and vector format although at first she only required raster. For this raster format, the needed resolution was changed because she realized that she had to do the data collection and data on every 100 m^2 plot would be more work to collect data than on plots of 625 m^2. The user interface should be expressive because management data will be combined with topographic data layers. Also the digital management plans need to be printed for use in the field.

The data collection was at first a drawback for the nature manager but in the time of this assessment, she went into the field and measured boundaries of managed plots using GPS. She required doing more with digital geo-data than the organization 'Natuur Monumenten' did. There digital data were used as background information for the management planning in the field.

Requirement development of administrator

The administrator changed his requirements during the assessment. At first, the administration goal was fulfilled when the cadastral map would indicate renters, owners, transactions and the topographic dataset was included. However, it turned out that not the cadastral parcels were rented to others but parts of these cadastral parcels. New questions were formulated, for example: which parts of these parcels does a person rent? In addition, a digitally made rental agreement became a requirement. Then in the last evaluation, not the data of a part of a cadastral parcel was needed but an overview of the rental situation in the entire property. The subsidy application requirement of the administrator at the beginning would be answered with topographic thematic classes available. After evaluation, these classes were too detailed and the required five classes of the subsidy regulations had to be displayed. The administrator approved this but the geometry was not correct. At the end, these classes should be displayed as landscape elements with a different number indicating every group of polygons lying adjacent to each other as another element.

When the administrator saw the management classes of heather in one displayed dataset of the first prototype, he argued that the data on management would be interesting as well. These would however not serve a requirement other than knowing when management had happened somewhere. In this final overview of the requirements, it is not included as it is a geo-information flow of the nature manager to the administrator.

The vector format and the accuracy that depended on the available datasets were constant throughout the assessment. The user interface requirements and the numbers of added functionalities for expressive use of the data were increasing with every phase in the looping. For example, first a table and a map display would be sufficient, in the end a pop-up of names of renters within the displayed map was a required functionality.

The administrator has a difficulty with his analogue archive with all parts of cadastral parcels indexed by the names of renters and the digital database with other data on renters also indexed by the names of renters. The used index is a non-spatial attribute and to be able to use non-spatial data in a digital spatial display it has to be linked to a location on the earths' surface. This could be done using the parts of the cadastral parcels but consequently these sub-parcels would have to be digitized. This turned out to be an obstruction for the administrator to fulfil his geo-information requirement on administration.

5.2 Assessment of geo-information requirements

5.2.1 Requirement development

In chapter 2, it was said that requirements develop over time and therefore an assessment is needed every now and then. In the case of both stakeholders, the context had changed by the government using digital data and they had seen applications of GIS in other organizations. They developed ideas about possible benefits that GIS could offer them as well. Their GIM was not valid anymore with these new ideas and vague requirements. Therefore, this assessment was held.

In the assessment, the stakeholders were supported to formulate their requirements more precisely by seeing the possibilities and possible limitations of GI-technology for their requirements. The requirements at the start of the assessment were different from or formulated more precisely than those at the end of the assessment. However, these requirements are again a momentary outcome. When the looping would be done another time or again in half a year, the requirements would probably be different from the ones mentioned as 'outcome' of this assessment.

5.2.2 Participation of stakeholders

The assessment was based on semi-structured interviews with both stakeholders using prototyping as technical input. It was meaningful to use the maximum level of participation (Senge, 1990), where the researcher consulted these stakeholders several times throughout the process. The researcher did not always understand the requirements correctly. For example, the administrator did not rent cadastral parcels to others but parts of cadastral parcels. Through the interviews and looping these misunderstandings were clarified. The input of stakeholders avoids the situations as visualized in Figure 2.1.

During the interviews, the researcher would discuss the comments made by the stakeholders in order to bridge the discourses of the stakeholders and of the researcher. The comments were discussed until the formulation was agreed upon. This created the opportunity to comprise the various opinions as mentioned by Herweg and Steiner (2002). In addition, the reasoning of the stakeholders behind the comments became visible.

5.2.3 Prototyping

As Reeve and Petch (1999) argued, the prototype would increase the familiarity of the stakeholders with the possible technical solutions to the requirements. This was also observed during the assessment. The stakeholders were able to criticize the prototype and by showing them some of the possibilities of GI-technology, their requirements were developed in more technical detail.

The danger when using prototyping is that stakeholders are limited to what they see and therefore do not see the prototype as a tool (Reeve and Petch, 1999) but already as an end product. As first reaction to the prototype, the stakeholders often commented on the user interface, the colours and the displayed map. However, due to the semi-structured interviews, the comments of the stakeholders during the evaluation of the prototype could be redirected to the geo-information requirements.

The first prototype was created based on both stakeholders requirements. It was assumed that as they work on the same geographical unit their requirements would be compatible. This resulted in the comment of the administrator that he would also like to have management information. Both stakeholders were also influenced by seeing other types of data formats than they had requested. After the evaluation of this first prototype, it became clear that the two stakeholders had different requirements that could not be put in one prototype. Therefore, the second prototype had different elements specifically developed for one of the stakeholders. For example, the interview with the organization 'Natuur Monumenten' was not shared with the administrator and the rental agreement was not shared with the nature manager.

MoSCoW was used as method for the prioritization of functionalities. Before any software was selected, the researcher prioritized the functionalities mentioned by both stakeholders. After studying ArcIMS, it turned out that the software contained more functionalities requested by the stakeholders In this case, these functionalities were added to the prototype and the prioritization was 'overruled'. For the second prototype, again MoSCoW was used but this time followed through in the implementation phase. What can be learned from this is that it is important to prioritize of functionalities requested by the stakeholders but that this priority list can be positively influenced by available functionalities in software. A danger when using this method is that the difference between geo-information requirements and functionalities is lost out of sight. Consequently, information requirements are prioritized although the goal of prototyping is to assess these. For example, the thematic classes that are required by a stakeholder should not be prioritized but the display of a map or the querying of these thematic data. This happened in the case of the nature manager requirements, as the datasets that were used did not contain 'species of heather' as thematic data; during the second identification, she mentioned this again as thematic requirement.

5.2.4 Cost and benefits

Both stakeholders were dealing with their expected benefits of a more digital GIM. Although their opinions are positive on what digital geo-information and data could do for both of them, the answer to whether the change in their requirements would mean a change in their current GIM was different for both.

The administrator considered the foreseen costs and benefits of a changed GIM to have more costs than benefits. The large investment costs to convert all available data into usable digital data counterbalanced the foreseen long-term benefits. The benefits mainly consist of the time saved when using digital data for administration and subsidy application. When time would be saved there would be an amount of new private properties that could be contracted and managed in that time. When the owners of the private properties that the administrator manages at the moment however, are willing to invest in a digital GIM, the administrator is willing to take the necessary steps. The current GIM actually contains digital mapping. A third party, a specialized GIS-company, is sometimes contracted to make the digital outputs. The administrator cannot use these digital files but at least the print out has the professional look of a digital map. Besides, according to the administrator this company can make these products cheaper than the office could ever do, although the outputs can only be used one time. This way investment costs are avoided and the responsibility of the outputs is in the hands of a GIS specialist.

The organization of the nature manager, as explained in the results when presenting the currently changed GIM has the opportunity to invest in data, software and even a GIS-specialist. For this organization it is clear that more and more parts of the analogue geo-information flows will be digitized.

Chapter 6 Conclusions

In this research, the assessment was done of geo-information requirements of two stakeholders who work within the private land property Appel-Zuid. The stakeholders were supported to formulate their requirements more precisely by seeing the possibilities and possible limitations of GI-technology for their requirements. The requirements at the end of the assessment were different from or formulated more precisely than those at the start of the assessment. Through the looping of semi-structured interviews and prototyping, it was possible to clarify and sharpen the requirements. It was meaningful to use the maximum level of participation to bridge the discourses of the stakeholders and of the researcher. Prototyping increased the familiarity of the stakeholders with the possible technical solutions to the requirements.

After this assessment, the requirements of both stakeholders are not supported by the current GIMs of both organizations as the requirements deal with digital geo data and information and the current GIM is analogue. It seems logic that therefore the GIM will have to be changed. This depends however on resources the organizations have. The nature manager is part of an organization with access to geo-data and GIS tools. This organization can introduce the use of digital geo data and information the use of GI-technology. The administrator however, is part of an office that does not have access to these data and does not have the resources to prepare its analogue data for digital use in its GIM. The administrator's office is a small and local organization with limited resources in comparison with other organizations in its context. It will not be able to use GI-technology and will therefore be disadvantaged in handling spatial issues from a technological point of view. However, the office will be able to keep on working when looking at the organization from the concept of GIM. This was introduced to include analogue data and people besides hard- and software. The only disadvantage is that the shortcomings of the current GIM framework are not taken away and the expected gain in time of digital retrieval of information will not happen.

The working hypothesis was that the assessment of geo-information requirements helps to bridge the gap between the technology and the requirements of stakeholders and consequently will increase the successfulness of the implementation of GI technology in organizations. This is supported by this assessment where users played an active role in the process and shaped their requirements as such that these could be used in the implementation of the changes of the GIM necessary to make it adapted to these new information requirements. By doing such an assessment, the organizations still have the possibility to decide not to change their GIM, just as the administrator. With assessing geo-information requirements, the overall GI-technology is addressed from a socio-technical point of view. People are included in the process, making it a technology that people can handle and over which they have exit rights. Possible organizational impacts can than be discussed by stakeholders. The gap between GI-technology and the requirements of people is decreased. Whether the necessary changes are implemented or not and what impacts are welcomed are decisions of the organization. The chance that the new GIM fails to deliver expected benefits is little.

However, future research should be done to verify this result. From theory as well as from this case study the research question could be answered positively. Yes, the assessment of geo-information requirements can bridge the gap between GI-technology and geo-information requirements. It would be interesting to see whether different organizations that also work local and have developed ideas about expected benefits of using GI-technology will have the same disadvantage as the administrator. Another interesting theme would be to test the methodology in another setting with more stakeholders. Maybe this looping would then take too much time or the discussions would become too lengthy that it will result in using a different participation level.

The developments will continue just as in the 1980’s and 1990’s when GIS matured into a GI-technology. The technology will expand its spatial problem solving, querying, retrieval of information and scenario building possibilities. The contexts of organizations will change as well. When requirements have developed and the GIM cannot support these anymore or when benefits are foreseen when changing the GIM, the organization would benefit from doing an assessment of the geo-information requirements of the organizational stakeholders before implementing any changes. The GIM can then be adapted to the needs of the stakeholders in such a way that they would not even realize that GI-technology was there.

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Figure 1.1, The map of the Netherlands: http://www.svgb.nl/frameset.asp?strUrl=%2Fcontent%2Fcustom%2Fop_register.asp%3Fid%3D1

Figure 2.1: http://www.geo-informatie.nl/projects/gipsy/Eindrapportages/gipsy_2004_2.pdf

Appendix A1, First interview, identification

Enquête over geografische informatie uitwisseling op het landgoed Appel-Zuid.

Datum: ……………
Naam: ……………

Het huidige systeem

1. Wie wisselt informatie uit met betrekking tot het beheer binnen het landgoed Appel-zuid? (de naam en is er uitwisseling (ja) of niet (nee))

2a. Welke geografische informatie wordt uitgewisseld? (bijv. locatie percelen tussen kantoor en pachters)

	Geo-informatie	Tussen wie?	2b. Wat wordt uitgewisseld?	Hoe wordt dit gedaan? (elektronisch/papier)
1				

2b. Wat wordt uitgewisseld tussen de verschillende groepen (bijv. tekening/ foto)?

1. …………………..
2. …………………..
3. …………………..

3. Welke geografische informatie gebruikt u intern? Wat gebruikt u hiervoor (zie 2b)?

Geo-informatie	2b. Wat wordt uitgewisseld?	Hoe wordt dit gedaan? (elektr/papier)

4. Welke geo-data gebruikt u voor welke geo informatie (1, 2, 3, 4)?

O kadastraal : ………………….
O topografisch : ……………….
O luchtfoto’s : …………………
O zelf opgemeten/getekend: ……
O uitbesteed opgemeten: …………
O ……………… ………………

5. Wat zijn de tekortkomingen van de huidige informatie uitwisseling van geografische informatie in volgorde van belangrijkheid?

O tijdrovend
O onnauwkeurig
O achterhaalde gegevens
O onoverzichtelijk
O duur
O geen eigen inbreng bij data verzameling
O ……………………………..
O ……………………………..

Het digitale systeem

6a. Welke voordelen levert digitale informatie uitwisseling op?
O tijdbesparing
O kostenbesparing
O nauwkeuriger
O up-to-date
O makkelijk te veranderen
O persoonlijke dataset
O in eigen beheer
O ………………
O ………………

6b. Voor welke informatiestroom (bijv. kantoor-overheid) zou een digitaal systeem deze voordelen opleveren?

- ……………………………………………..
- ……………………………………………..

7. Welke geo-data moet beschikbaar zijn in de digitale informatie uitwisseling (in volgorde van ‘meest-gewenst’ tot ‘zou-ook-kunnen’)?

	Geo-data	Nauwkeurigheid		11. Hoe recent?
		8. geometrisch (m)	10. thematisch (%)	
1				
2				
3				
4				
5				
6				

8. Wat is de grootte van objecten die u nog wilt kunnen onderscheiden (bijv. kleinste perceel)?
- ………………………….
- ………………………….

9. Uitleg bij geometrische nauwkeurigheid
- sub meter…..…
- sub decimeter…
- 5 meter……
- 10 meter………
- 10 m2 ....……
- 20 m2……..…..
- ………………..

10. Uitleg bij thematische nauwkeurigheid
- percentages …………..
- …………..

11. Hoe recent moet de geo-data zijn?
- <u>nu</u>: de werkelijke situatie
- <u>2 mnd</u>: de situatie van twee maanden geleden is goed genoeg
- <u>½ jaar</u>: de situatie van een half jaar geleden is goed genoeg
- <u>1 jaar</u>: de situatie van een jaar geleden is goed genoeg

12. Hoe moet de informatie gepresenteerd worden?

O verschillende kaarten over elkaar

O een luchtfoto als achtergrond

O bevraagbaar zijn

O elektronisch / papier

O ……………………………..

13. Wie krijgt toegang tot welke delen van de data?

O niemand anders dan het kantoor

O bosgroep midden ………………………………………………..

O boeren …………………………………………………………

O derden …………………………………………………………

O ……………………………………………………………………

14. Wie zal de data onderhouden?

O het kantoor

O uitbesteed aan een bedrijf

O anders, namelijk: ……………..

15. Welke data kunt u leveren over Appel-Zuid?
- ……………………………………………………………
- ……………………………………………………………

Appendix A2, Second interview, evaluation and identification

Vragen over prototype 1, ArcIMS applicatie met topografische en kadastrale data
Webadres: http://kgr1883/website/landgoed_appelzuid

Uit het vorige interview kwamen een aantal geo-informatievragen naar voren. Met deze applicatie is een keuze gemaakt voor de drie meest belangrijke vragen. Zijn deze vragen nu te beantwoorden, hoe gebeurt dat en is deze selectie van hoofdvragen correct geweest?

1. Waar is landgebruik 'heide'?
2. Welke percelen worden gepacht door 'G. Hendriks'?
3. Waar is de heide 'sterk' vergrast?

Na een uitleg van de website, zullen we de hoofdvragen nogmaals langslopen en de opmerkingen en vragen die naar voren komen worden genoteerd. Daarnaast zijn er ook een paar specifieke vragen.

De informatievragen:
1. Welke topografische percelen hebben als landgebruik 'heide'?
- Correcte informatievraag?
- Welke data worden gebruikt?
- Geeft de applicatie voldoende informatie?
- Andere vragen die onbeantwoord zijn/ interessanter?
- Zo ja: welke (geo-)data zijn hiervoor nodig?

2. Welke kadastrale percelen worden gepacht door 'G. Hendriks'?
- Correcte informatievraag?
- Welke data worden gebruikt?
- Geeft de applicatie voldoende informatie?
- Andere vragen die onbeantwoord zijn/ interessanter?
- Zo ja: welke (geo-)data zijn hiervoor nodig?

3. Op welke topografische percelen is de heide 'sterk' vergrast?
- Correcte informatievraag?
- Welke data worden gebruikt?
- Geeft de applicatie voldoende informatie?
- Andere vragen die onbeantwoord zijn/ interessanter?
- Zo ja: welke (geo-)data zijn hiervoor nodig?

Visualisatie: (Heideklasse is in lgn onderverdeeld in matig vergrast: 25-75% en sterk: >75%)
- Welke klassen zijn overbodig?
- Welke klassen missen er?
- Zijn de klassen goed weergegeven (kleur, omlijning)?

Tekst:
- Welke attributen zijn overbodig?
- Welke attributen missen?
- Naamgeving van attributen is duidelijk? Welke naamgeving past beter?

Geometrie:
Vlakken en vakjes: verschil in informatie of hetzelfde?
Print optie:
- Opmerkingen hierover?

Andere opmerkingen/ontwikkelingen op datagebied?

Appendix A3, Third interview, evaluation

Gebaseerd op de voorgaande interviews zijn de volgende dingen uitgezocht.

De informatievraag "Wie pacht dit kadastrale perceel?" gaf nieuwe vragen:
Wie pacht dit perceel (kadastraal/gedeeltelijk)?
Welke percelen worden gepacht door Dhr. Hendriks
Wat is de oppervlakte van dit gedeeltelijk perceel

Hieruit zijn de volgende zaken ontwikkeld.

- Prototype website geeft link van kaartje met database. Het zijn kadastrale percelen gelinked met een Accessdatabase. (Verandering in database, beperkte attributen te zien) Is deze link duidelijk en nodig?

De attributen die je ziet, zijn die geven die genoeg informatie voor de info-vragen?

- Hiervoor moeten wel in de database de perceelsnumers komen bij de pachters en de gedeeltelijke percelen ingetekend op de computer. Twee percelen gedigitaliseerd door topo en kadastrale grenzen te gebuiken. De pachtcontracten kunnen digitaal gemaakt worden. ArcView en ArcMap resultaat. Zwart/wit, vaste schaal zit in software, tekst toevoegen, labellen, schaal. Zijn deze posters informatief? Op en aanmerkingen?

- Topografiche kaart 1:25000 bestaat niet en is gebaseerd op 1:10000. Nu NSW klassificatie met in tabel meer gegevens. Is dit zoals de bedoeling was?

Appendix A4, Questionnaire

Vragenlijst

Bent u het met de stelling volledig eens zet dan een kruisje in het rechter vakje, bent u het met de stelling heel erg oneens zet dan een kruisje in het linker vakje. Heeft u geen mening hierover dan geeft u dat aan met het middelste vakje.

Een digitaal geografisch informatie systeem….	**mee oneens**				**mee eens**
Geeft een professionelere uitstraling					
Bespaart tijd					
Is nauwkeuriger					
Is makkelijk te veranderen					
Is net zo goed als analoog werken					
Is niet saai					
Is niet tijdrovend					
Geeft een resultaat dat niet eenmalig is					
Kan het knip-plak-tipex-kleur-copieer-werk vervangen					
Presenteert de informatie die nodig is op de juiste manier					

Uit een digitaal systeem kun ik de informatie halen die ik nodig heb					
Dit kantoor zal digitale geografische informatie gaan gebruiken					

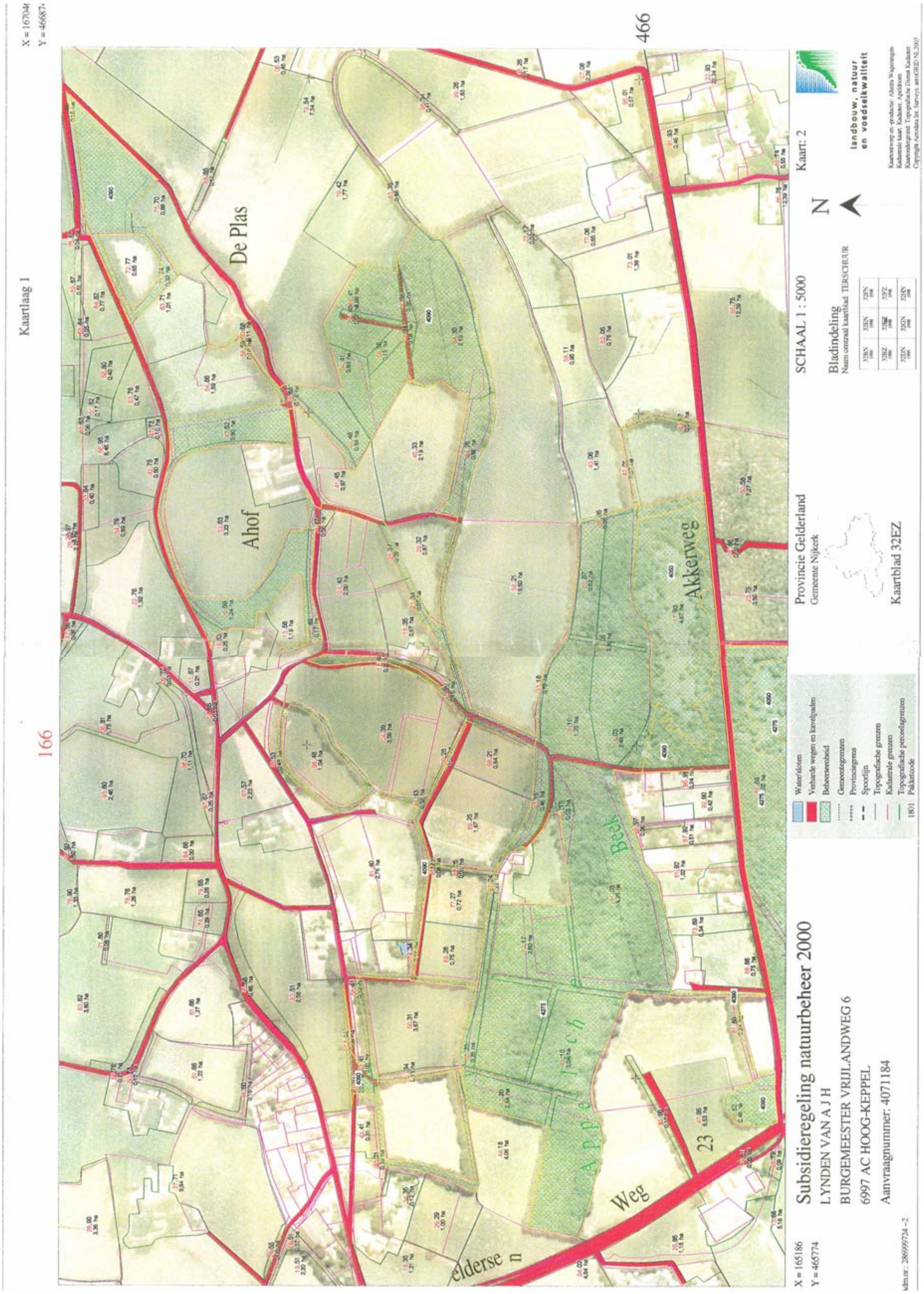
Bent u bereid….

	ja	**nee**	(evt. maximale bedrag)
Te investeren in de database			
Te investeren in de digitalisering van gedeeltelijke percelen			
Topografische data te kopen			
Kadastrale data te kopen			
Software aan te schaffen			
Tijd te steken in een training gerelateerd aan de software			
Te investeren in een persoonlijk gemaakt GIS door een extern bedrijf			
Tijd te steken in het bijhouden van gegevens en de software			

	mee oneens				**mee eens**
Heeft u een beter beeld gekregen van de mogelijkheden van GIS?					
Heeft u een beter beeld van uw geografische informatie behoefte?					
Bent u tevreden met de manier waarop het proces is gegaan?					
Hebben de prototypen bijgedragen aan het proces?					

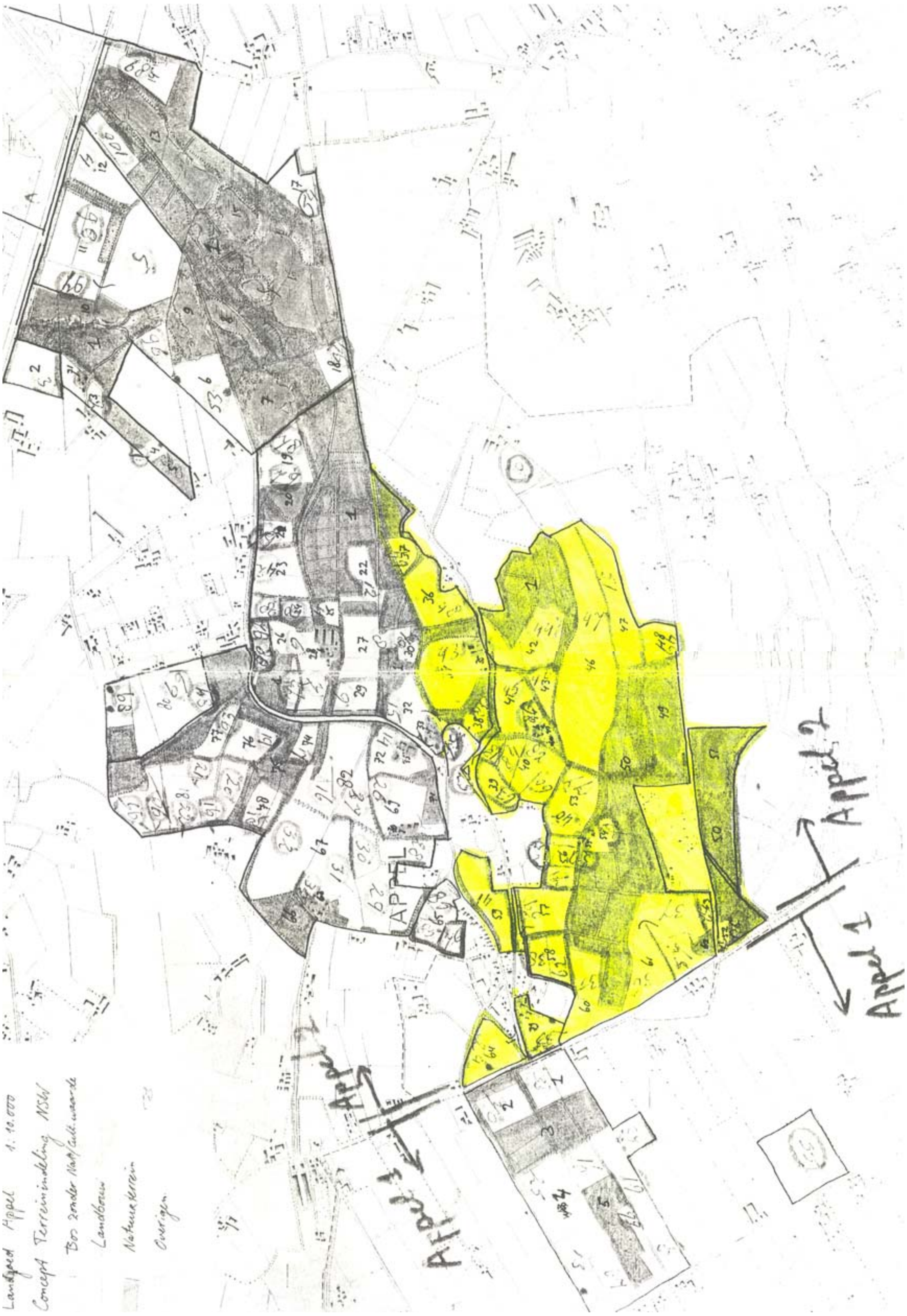
Appendix B, Governmental map of a subsidy application

A map accompanying the subsidy application when returned by the government.

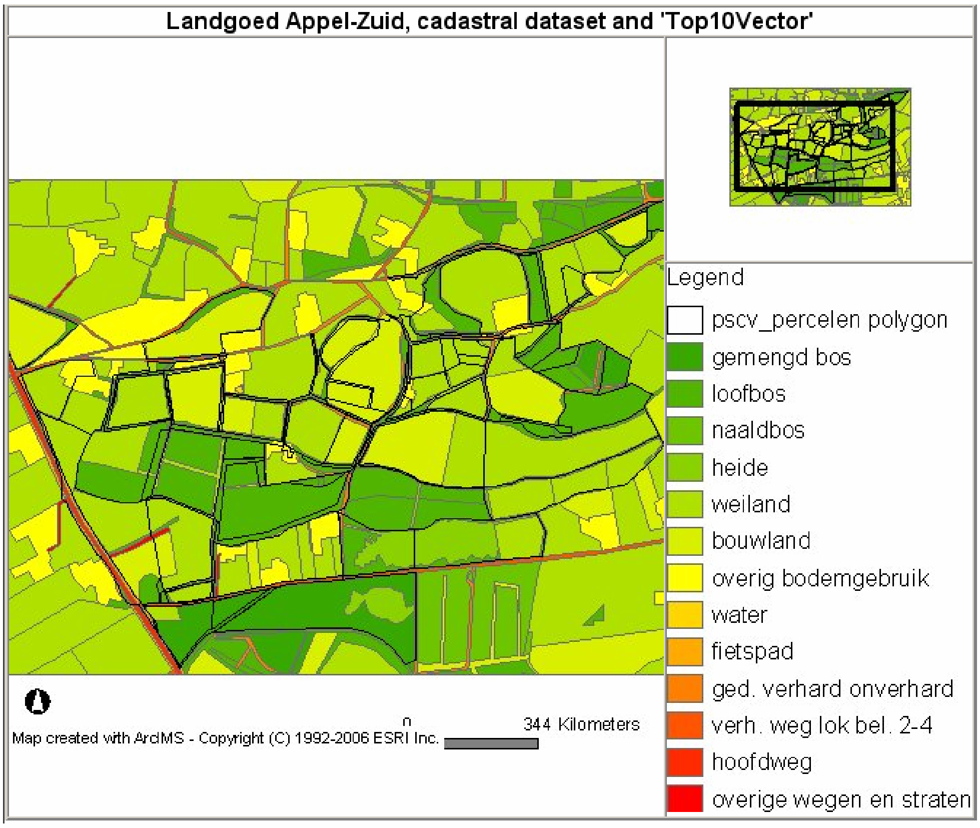


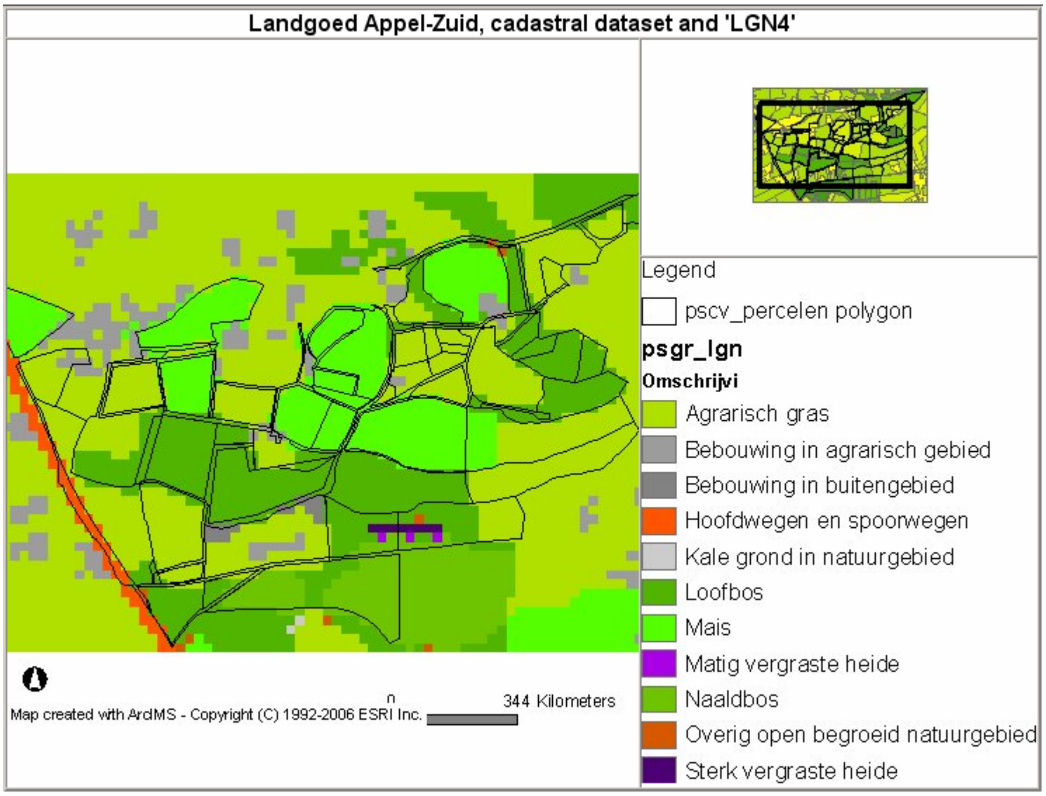
Appendix C, Administrator's map to apply for a subsidy

A self-made NSW subsidy application map of the administrator in grey tones. The highlighted area shows Appel-Zuid.



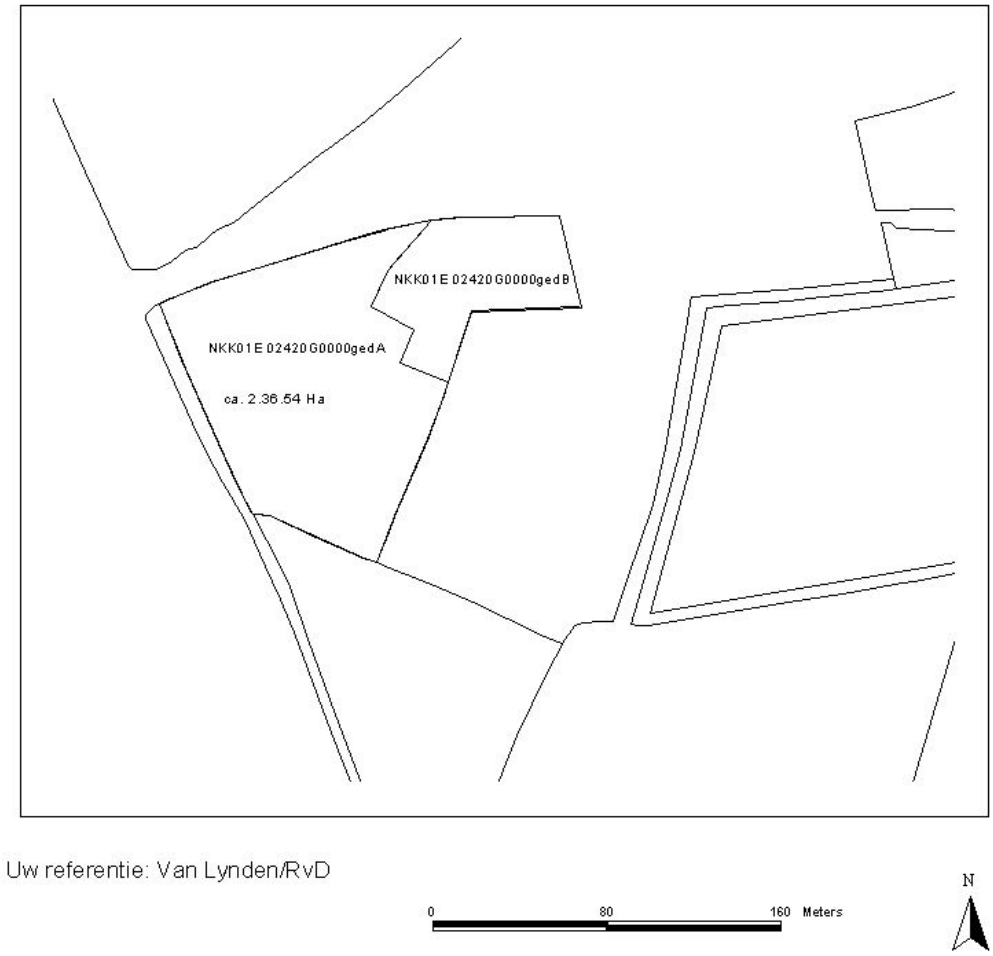
Appendix D, Two print outputs of prototype 1





Appendix E, Rental agreement

This picture is output from drawing two parts of cadastral parcels in ArcView.



Voor Akkoord

Pachter: Verpachter: