Methods for landscape monitoring compared

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Abstract

An assessment of the suitability of methods for policy-oriented landscape monitoring in the Netherlands shows that a mix of methods is the most effective approach. Whereas reliable data on new buildings, as well as data on infrastructure and land use, can be gathered from existing GISs, these GISs do not allow monitoring of landscape elements like wooded banks and hedgerows. The best source of information for this kind of data was found to be aerial photographs. Field work is only necessary to check the information gained from such photographs.

1 Introduction

There is currently no systematic monitoring programme on physical changes in the landscape being carried out in the Netherlands. Although the public's appreciation of the landscape is monitored by means of a recently introduced programme of questionnaire surveys (Crommentuijn et al. 2007), it is hard to relate any changes in this appreciation to physical changes in the landscape itself without monitoring such landscape changes. In addition, the lack of systematically gathered data on physical landscape features makes it difficult to describe the current state of the landscape and any emerging trends, and to evaluate the effectiveness of landscape policy, which sets targets for such physical landscape features.

Various aspects of the Dutch landscape have been studied in recent years, to meet the demand for information on changes in the landscape and the effectiveness of policies. Such studies have included research into urbanisation (e.g. Dirkx et al. 2005), into the development of linear plantations (e.g. Koomen et al. 2007) and into changes in the scale of landscapes (e.g. Roos-Klein Lankhorst et al. 2004). The lack of systematically gathered data, however, means that in each new study new methods have been developed and new data sources explored for the required analyses.

The present paper tries to compare the various methods that have been developed in these studies and to evaluate the advantages and disadvantages of each. On the basis of the questions that need to be answered for policy evaluation, it also explores the available options to analyse the current state and development of the landscape as efficiently as possible, despite the present lack of systematic monitoring data.

2 Methodological aspects and data

Given the current developments in the Dutch landscape and the policy efforts that the government is using to control these developments, the demand for data focuses on a number of landscape features:

- Built-up areas (towns, industrial estates), infrastructure and scattered buildings in rural areas.
- Linear plantations (wooded banks, hedgerows, etc.).
- Open landscapes with an unobstructed view of the horizon.
- Parcel shapes.
- Relief.

Since the research is intended to supply information to the Dutch national government, data on these landscape features must be gathered for the Netherlands as a whole. On the other hand, the required level of detail is limited, as the data are to be used in analyses for the whole of the Netherlands, and the results that have to be presented relate to the whole country, to specific provinces or to one of the 11 landscape types that are distinguished in the Netherlands.

The studies underlying the present paper have used various methods and sources to gather data

on landscape changes. The sources used can roughly be divided into three categories:

1. National GISs.
2. Aerial photographs.
3. Local situation in the field.

National GISs contain information gathered by third parties, from which landscape information can be quickly extracted with the help of automated analyses, making them the preferred data source for analysing the current state of the landscape and any emerging trends.

One aspect of the use of these GISs that needs to be addressed is the suitability of their data for analyses of the state of the landscape and emerging trends, since the GISs were constructed for other purposes than landscape monitoring. This means that the choices made when interpreting the basic data for the GIS may limit the value of these systems for landscape monitoring. Various researchers have tried to analyse the reliability of the data (e.g. Koomen et al. 2006; De Jong et al. 2009). We have used these studies to evaluate whether these GISs are suitable for analysing the state and developments of the landscape.

The use of aerial photographs or field surveys is only required for those landscape features for which no suitable national GISs are available. In these cases, there is no need to assess the reliability of the source, since in the field the reality is being monitored and photographs simply provide images of this reality. Extracting information from the field situation or from aerial photographs does however involve interpretation or field work, which is time-consuming and raises the question what is the best method to extract the relevant information from the photographs or from the field with a minimum of effort.

One option is the use of automated methods to analyse aerial photographs, using remote sensing techniques. Although early attempts to extract information on linear plantations from satellite images by means of such remote sensing techniques yielded disappointing results (e.g. Dirkx et al. 1989), there are now promising new techniques available which not only evaluate the spectra of each individual pixel, but also use automated pattern recognition. A preliminary explorative study has assessed whether such automated analyses of aerial photographs yield acceptable results (Kramer et al. in prep.).

In addition, the many years of experience gained with 'manual' interpretation of aerial photographs ensure that this interpretation is methodologically unproblematic. The use of spot checks to reduce the time investment for manual interpretation of photographs and field surveys has also been investigated.

3 Results

3.1 National databases

The 1: 10,000 topographical map of the Netherlands has been available in digital form since the 1990s; the so-called Top10vector database. Like any topographical map, the database contains spatial information on the topographical features of the landscape, such as buildings and infrastructure, linear plantations, land use and parcel boundaries.

Top10vector is based on aerial photographs and field surveys carried out by the Topographic Service of the Netherlands. The maps are updated every four years. Top10vector is sufficiently detailed and is updated frequently enough to provide a suitable source for analyses of the current state and development of the landscape.

On the other hand, the database also has certain limitations, one of which is the way it is updated. The information is being updated during a four-year cycle. Each year, a quarter of the map sheets are updated. Different sheets therefore represent topographical information from different years. As a result, analyses of changes across the country as a whole show changes over different periods. In other words, an analysis of changes over the 2000–2005 period actually compares the changes over a four-year period around the year 2000 (e.g. 1999–2002) with the situation around the year 2005 (e.g. 2004–2007). In a dynamic landscape like that in the Netherlands, this may lead to significant errors.

A second characteristic limiting the use of Top10vector for landscape monitoring is the fact that the database is being composed for the purpose of preparing topographical maps. Since the topographers aim to produce readable maps, they necessarily have to omit certain objects, even in 1: 10,000 scale map. Any map is inevitably a simplified representation of reality. The choices that the topographers have to make are stipulated in protocols, which show that not everything that would be important for analyses of the state and development

of the landscape would necessarily also be regarded as important by the topographers. For instance, linear plantations (rows of trees, hedgerows, etc.) have a lower priority than buildings, roads, etc.

Koomen et al. (2006) compared the information from Top10vector with field observations, and found that whereas Top10vector did provide reliable information on land use, buildings, infrastructure and parcel shapes, as well as on whether a landscape is open or more intimate, the information on linear plantations and relief was not very reliable.

De Jong et al. (2009) compared the data on linear plantations in Top10vector with the information from aerial photographs for a few larger areas, and found that an average of 15 % of the linear plantations that were visible on the photographs were not included in the Top10vector database.

Although relief cannot be analysed accurately with Top10vector either, an alternative national GIS is available for this, the so-called AHN, which contains data on ground level elevations collected by means of airborne laser altimetry. This database offers detailed information on elevation, with a resolution of at least one data point per 16 m2. Koomen et al. (2006) concluded that the AHN was suitable for relief monitoring.

3.2 Aerial photographs

The combination of Top10vector and AHN turns out to be suitable for the analysis of all relevant landscape features except linear plantations. Since no alternative national GIS with accurate data on linear plantations is available, we have looked for other sources of information on these elements. We first examined the suitability of aerial photographs.

A set of digital high-resolution aerial photographs covering the whole of the Netherlands at a resolution of 50 cm has been available since 2003. The photographs were taken in 4 spectra: blue, green, red and near-infrared, allowing vegetation to be clearly visualised. New series of aerial photographs are currently being produced at a rate of once every two years. Since all of the country is photographed within one or two months' time, very little time elapses between the individual images.

This series of aerial photographs represents an excellent source of information for landscape monitoring, and Koomen et al. (2006) therefore concluded that field work is only required to verify the results. On the other hand, the analysis of landscape features does require interpretation of the images. So far, it has proved difficult to extract information about linear plantations from the aerial photographs using remote sensing techniques (Kramer et al. in prep.), as quite a number of elements remain undetected in the analysis. In addition, a great deal of time is required for preprocessing before the automated analysis can be started, due to differences between the photographs in terms of colour and perspective, and due to the effect of shadows on the images. As a result, manual analysis is currently still the most suitable interpretation method. The amount of work involved in this interpretation can be reduced by using random spot checks. Koomen et al. (2006) discussed the statistical aspects of such spot checks in detail for the Dutch situation, and concluded that a sample of approximately 200 spots would allow changes in the length of linear plantations to be assessed with 95 % reliability and a 200 m resolution.

4. Discussion

1. Our comparison of landscape monitoring methods shows that national GISs provide a useful source of data for the analysis of the current state of the Dutch landscape and any emerging trends. The data in these GISs appear sufficiently reliable for the monitoring of nearly all relevant landscape features, although no systematic reliability test has so far been undertaken. Koomen et al. (2006) compared the information from the Top10vector database with field data from the sample of 72 1km2 spots provided by Koomen et al. (2004). However, since this sample was not selected with the intention of testing the reliability of Top10vector, it remains unclear whether the results of their comparison accurately reflect this reliability. The design of the study by De Jong et al. (2009), which compared information on linear plantations from Top10vector with aerial photographs covering large areas, was not sufficiently systematic to allow generalised conclusions on the reliability of Top10vector. A more systematic trial would be required to assess whether Top10vector can be reliably used for this purpose.
2. Another issue that will need to be addressed, besides the reliability of the databases as such, is the required reliability for our national analyses. Although preliminary analyses allow us to conclude that the Top10vector database is

insufficiently reliable as regards linear plantations, it is too early to indicate the level of reliability that is required for these analyses. We will need to examine what level of reliability is required to draw useful conclusions.

3. A decision to use the national GISs would mean that the question whether the relevant analyses can be carried out will depend very much on the availability of these databases. This does not appear to be a problem as regards Top10vector, as the Topographical Map of the Netherlands is produced at the request of the government, regardless of demand. The situation is different, however, for databases like the AHN (elevation): whether updated versions of this database will be made available depends on the demand by its users.
4. Results of attempts to generate information on linear plantations from aerial photographs by means of automated analyses have so far been disappointing. The results might possibly be improved by combining the information from the photographs with AHN elevation data. In this respect, the increased resolution (25 cm) of the photographs made available since 2008 might also offer new opportunities.
5. Although the reliability of the Top10vector data has not yet been fully tested, this database currently seems to be the most suitable data source for analyses of almost all types of information. Supplementary information would only be required for linear plantations and relief. In the process of producing the Topographical Map of the Netherlands, the topographers do observe the linear plantation elements, as they work on the basis of aerial photographs and field checks. It is then up to them, however, to decide whether to include such elements in the map, based on protocols. It might be useful to examine the feasibility of including all plantations in the GIS, with the choice of which ones to include in the map being postponed to the moment when the actual map is produced.

References

Crommentuijn, L.E.M., Farjon, J.M.J., Den Dekker, C. & Van der Wulp, N. 2007. Belevingswaardemonitor Nota Ruimte 2006. Nulmeting landschap en groen in en om de stad. MNP, Bilthoven.

De Jong, J.J., Os, J. & Smidt, R.A. 2009. Inventarisatie en beheerskosten van landschapselementen. WOT-werkdocument 138. WOT Natuur & Milieu, Wageningen-UR, Wageningen.

Dirkx, G.H.P., De Veer, A.A., Thunnissen, H.A.M. & Van der Laan, F.B. 1989. SPOT voor landschap. Methodeontwikkeling voor het gebruik van SPOT-beelden voor de bijstelling van het gegevensbestand 'schaal van het landschap'. BCRS rapport 89–18. BCRS, Delft.

Dirkx, G.H.P., Agricola, H.J., Roos-Klein-Lankhorst, J. & Farjon, J.M.J. 2006. Landschap in Natuurbalans 2005. Signalen over landsschapsdynamiek en ruimtegebruik. Rapport 408763009/2006. Milieu- en Natuurplanbureau, Bilthoven.

Koomen, A.J.M., Nieuwenhuizen, W., Brus, D.J., Keunen, L.J., Maas, G.J., Van der Maat, T.N.M. & Weijschede, T.J. 2004. Steekproef Landschap. Actuele veranderingen in het Nederlandse landschap. Alterra-rapport 1049. Alterra, Wageningen-UR, Wageningen.

Koomen, A.J.M., Nieuwenhuizen, W., Roos-Klein Lankhorst, J., Brus, D.J. & Vereijcken, P.F.G. 2006. Monitoring Landschap. Gebruik van steekproeven en landsdekkende databestanden. WOT-werkdocument 41. WOT Natuur & Milieu, Wageningen-UR, Wageningen.

Koomen, A.J.M., Maas, G.J. & Weijschede, T.J. 2007. Veranderingen in lijnvormige cultuurhistorische landschapselementen. Resultaten van een steekproef over de periode 1900–2003. WOT-Rapport 34. WOT Natuur & Milieu, Wageningen-UR, Wageningen.

Kramer, H., Oldengarm, J. & Roupioz, L. in prep. Groenclassificatie met behulp van luchtfoto's. Een onderzoek naar de classificatie van groen in een stedelijke omgeving en opgaand groen in het landelijk gebied. WOT-werkdocument. WOT Natuur & Milieu, Wageningen-UR, Wageningen.

Roos-Klein Lankhorst, J., Nieuwenhuizen, W., Bloemmen, M.H.I., Blok, S. & Farjon, J.M.J. 2004. Verstedelijking en landschap 1989–2030. Berekende, waargenomen en verbeelde effecten van bebouwing. Alterra-rapport 1056. Alterra, Wageningen-UR, Wageningen.