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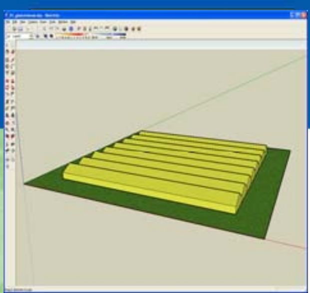
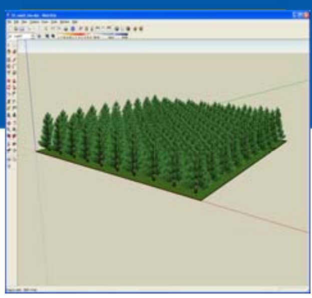
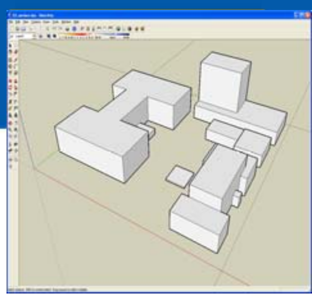
Google Earth based visualization of Sustainable Outlook (GESO)

R. van Lammeren, M. Hilferink, A. Bergsma, M. van Beek







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Google Earth based visualisation of Sustainable Outlook (GESO)

R. van Lammeren, M. Hilferink, A. Bergsma, M. van Beek

Project GESO
in order of the Netherlands Environmental Assessment Agency.

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ABSTRACT

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GESO is a tool to prepare a Google Earth visualisation of the Dutch land use scenarios as created by the Netherlands Environmental Assessment Agency. This Google Earth for the Sustainable Outlook application, named GESO, forms an update of the previous VisualScan attempt. The GESO application aims to be an effective, easy and low cost way to study Sustainable Outlook data via an interactive 3D visualization that integrates the land use icon and landscape feature approach as presented in the VisualScan study.
The concept and implementation of GESO are explained and many examples of using GESO are given. The final chapter concludes and discusses the results and gives content-wise and technical recommendations for follow up projects.

Keywords: 3D visualization, Google Earth, Sustainable Outlook, Visualscan, Sketch up, land use change, 3D models

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Foreword

During december 2007 the Netherlands Environmental Assessment Agency invited us to develop a tool that should make it possible to visualize the Sustainable Outlook data by Google Earth. It was not a completely new challenge because some years before this type of geo-visualisation had to be proofed to be feasible via the VisualScan project.
Thanks to the programming skills of Maarten Hilferink,Martin van Beek, both from Objectvison bv, and Aldo Bergsma, Wageningen University, the first version of GESO was available in February 2009.
Thanks to parallel projects of Stefan Colijn, Jan Jaap van Donselaar, MSc students University Utrecht, and Bram van Rooij, MSc student Wageningen University, the first version had been criticized and updated.
Also the reviewing team of BLP by Frans Lips, Wim Evers, Filip de Blois offered us suggestions for improvement. Especially the help and co-operation of Bas van Bemmel is very much appreciated. Finally we like to thank Judith Borsboom-van Beurden and Arno Bouman for their continuous support and enthusiasm in this quest to a usable three-dimensionally visualization of the Sustainable Outlook data.

Ron van Lammeren

Summary

This report describes GESO, a tool to prepare a Google Earth visualization of the Dutch land use scenarios as created by the Netherlands Environmental Assessment Agency. This Google Earth for the Sustainable Outlook, named GESO, application forms an update of the previous VisualScan attempt. The GESO application aims to be an effective, easy and low cost way to study Sustainable outlook data via an interactive 3D visualization that integrates the land use icon and landscape feature approach as presented in the VisualScan study.
The first chapter refers to this previous study and outlines the objectives of GESO. The second chapter explains the architecture of the GESO application and the data that should be presented. The third chapter describes the GESO input data, intermediate data sets and the output data. The last, in KML format, may be visualized by Google Earth. Chapter four explains some of the implementations, like the programming tool DMS, the role of tables, the classifications used, the types of visualization and the geo-data tiling.
Chapter five shows what kinds of visualization via Google Earth are possible with the constructed KML files. The last chapter concludes and discusses the results as realized and recommends content-wise and technical follow ups.

1. Introduction

Maps of future land use are one of the means used by the Netherlands Environmental Assessment Agency to support preparation of policy-making. These maps are usually based on the (geo)data output of land use simulation models. A number of environmental, ecological and spatial effects however are hardly interpretable from these maps: for example the effects of low density residential development on open landscapes or the effects of scale enlargement in agriculture. A change of colour in such a map only depicts the transition to a different type of land use. 3D visualizations might help to communicate the environmental, ecological and spatial effects to stakeholders and policy-makers.

With the aim of complementing the future land use maps, output of the Land Use Scanner model has been coupled to 3D visualisation software in two different ways for the "Spatial Impressions" project (Borsboom-van Beurden, 2006).
Recent experiences started with enriching geodata with 3D iconic representation (Lammeren, 2004). In these first attempts grid data on future and current land use are transformed into 3D scenes by linking the grid cells to a 3D icons database. After linking the rendering took place (fig.1). The tools used were 3D studio max to generate the 3D iconic representations, Land Use scanner to project land use changes (respresented by a 2D raster of land use class ids), MS-access to link 3D icons to land use classes and Virtools to construct and render the 3D scene. This approach implies that real world phenomena like eg. landmarks, paths and nodes (Al-Kodmany, 2001) are not represented.

For that last reason another approach has been elaborated upon (Momot, 2004), that tried to link the scenario based grid data with topographical data. The tools used were the Land Use Scanner to project land use changes , GIS software (ArcGIS) to query, transform and alter the datasets (land use scanner results and the Dutch Topographical Dataset) with 3D visualisation capabilities (ArcMap and ArcScene) to define and render the presentations in maps, stills and animations (fig 2).

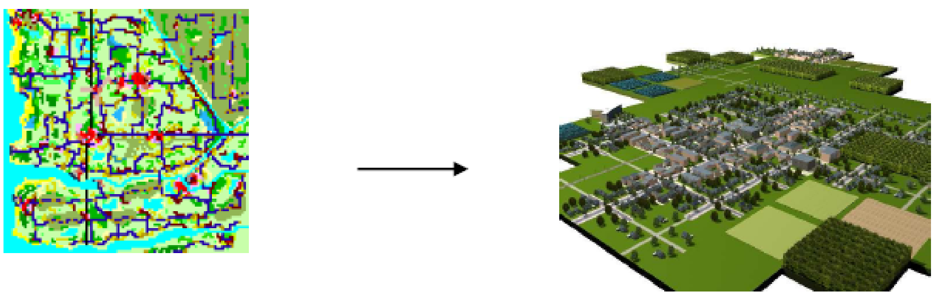


Fig 1: from 2D rasters into 3D visualisation (Lammeren, et al, 2004)

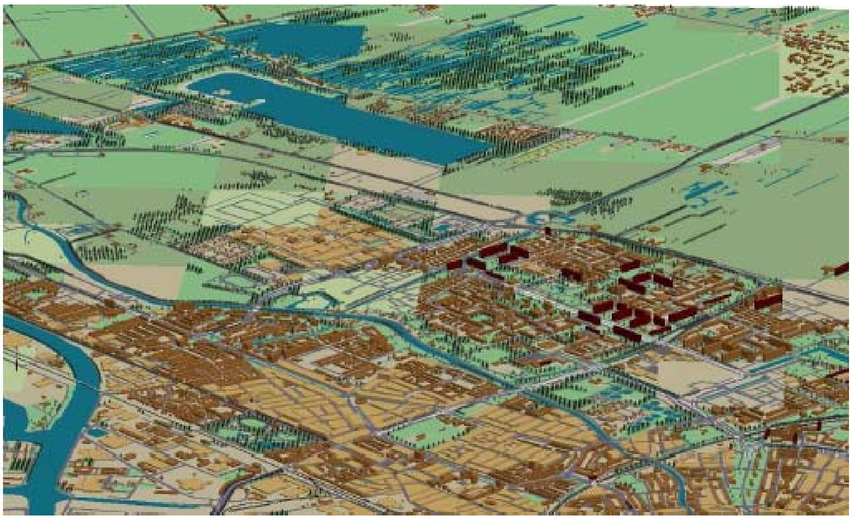


Figure 2: land use change visualisation (Momot, 2004)

Both approaches appeared to have pros and cons. The Land Use Icon approach succeeded in the delivery of highly realistic results in the form of 3D scenes by which an end-users may navigate. Despite this achievement, the synthetic character of the results, the lack of phenomena to recognize landscapes, and the artificial grid-based spatial structure are seen as major drawbacks, leading to a missing link with the cognitive maps of end users (see Sheppard, 2001). The benefit of the Landscape Feature approach seems to be the better link with user's cognitive maps. The drawback of the latter is the limited visual expression of the grid cells that represent the expected land use change and consequently the landscape transition, and interactivity (like navigation) is missing.

A technological drawback of both approaches deals with the possibilities to address the end-user, because both approaches are not really easy to set up and to distribute. Google Earth shows since its launch that these distribution and navigation items have effectively tackled. In relation to tools like SketchUp it offers a challenging platform for 3D scenes that presents near realistic worlds. Many pilots have started to explore these opportunities (Rodrıguez Lloreta, 2008).

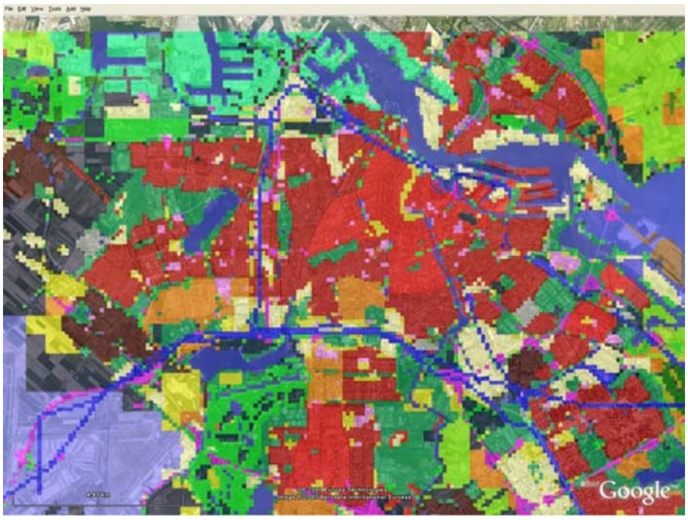


Fig 3: raster data in Google Earth (OV,2007)

Currently Google Earth (GE) offers options to visualise raster data, like the Aerial photo sets or the Sustainability Outlook 2 (SO2) results (fig 3). These raster data could be transformed into vector data and presented 3-dimensionally via extrusion of objects based on a Z-value that may present any variable. Figure 4 shows an example of this principle. In case of the SO2 outcomes one may think of immovable properties prices, environmental quality properties or risk levels.

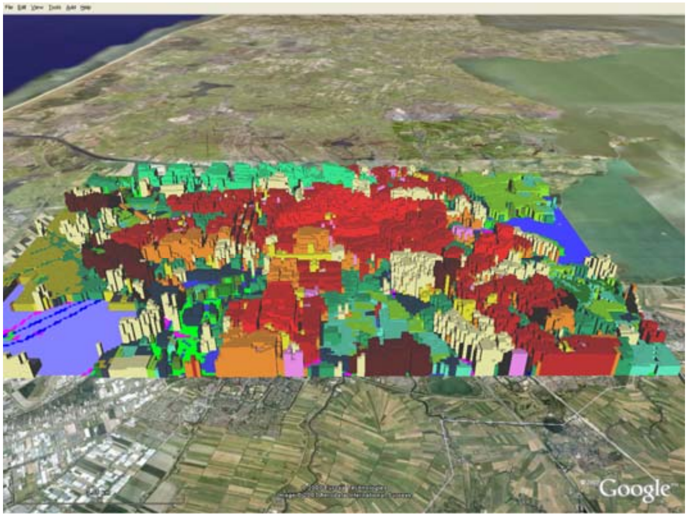


Fig 4: transformed raster data extruded

Finally the combination of raster and vector data presentation can be extended by adding 3-dimensional objects (3dShapes). Figure 5 shows an example of the presentation of the 3D-icon like visualisation of houses via 3dShapes. Such type of visualization put forward a better insight in the possible landscape configuration related to land use types as simulated by SO2 .

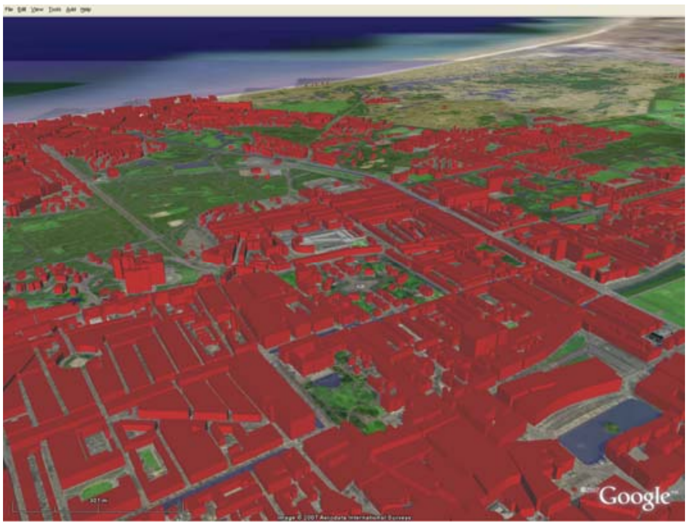


Fig 5: Visualization based on 3dShapes

Besides, considerable progress has also been made with respect to the underlying data sets. A new version of the Land Use Scanner generates land use data with another spatial resolution (100 * 100 meters) and a different land use classification, a set of digital aerial photos (2.5 * 2.5 meters) has become available, like the Elevation Data (5 * 5 meters default) of the Netherlands (Actueel Hoogtebestand Nederland – AHN-) and topographic data (Top10vector) have been updated and completed since 2004.

Taking these developments into account an exploration of 3D visualisation for communicating long term changes in the physical environment by applying new datasets and latest techniques offered by Google Earth (GE) is in need. Doing so, it will be expected that the end-user will finally become better informed about Sustainable Outlook impacts (Lammeren, 2007). This expectation is based on improvement of:

- the end-user interface that references to reality by aerial photos, terrain elevation and 3 dimensions of buildings and a visual representation, also by 3D icons, of land use changes. In fact it integrates both previous approaches.
- navigation because of the GE Interface
- information by abilities of the GE Interface to link other web sources
- portability because of the free of charge (for individual use) GE application and plug-in.
- scalability of the database structure that GE supports so that representations of larger areas can be disclosed

This report describes the development and use of a Google Earth application that three-dimensionally visualises the outcomes of the SO2 (RuimteScanner – NL Later-) via Google Earth for the whole of the Dutch Randstad area, based on combining SO2 , AHN, Top10Vec and icon datasets. This development supports the visualisation of the SO2 (Ruimtescanner) results by combining the techniques as are able to use via Google Earth.

The usability of the application will be tested in a separate project.

The report addresses subsequently the following objectives:

- Conceptual design
- Data inventory and preparation
- Implementation
- Application overview and evaluation
- Conclusion, discussion and recommendation

2. Conceptual design

The conceptual design is based on the constraints that the Google Earth platform offers:

- high resolution (50 cm resolution) aerial photographs not older then 3 years;
- SRTM terrain model of 90 meters resolution;
- a versatile 3D viewer;
- a portable data format (KML, KMZ).

All these made it possible to offer the full range from 2D and 3D presentations of the Sustainable Outlook data (fig. 6)

Fig. 6 Based on Rodrıguez Lloreta, 2008

The conceptual design intends to address the following user scenario:
"A policy maker starts up Internet to find out the latest scenarios – story lines and model outcomes - for land use in the near future. Via a web viewer, in this case Google Earth, the policy maker is able to look at the intended land use changes. Via navigation over and through the Dutch land area as presented by recently collected high resolution aerial photos and added 3D presentations of built up areas and vegetation (fig 7.a) the impact situations.
Depending on the height of the user viewpoint the land use information will change of details. On the lowest viewpoint (man eye's view) 3D-objects related to new and current land use classes can be seen (fig 7.b). On higher viewpoints (bird's eye view and higher) the 3D-objects will change into textures and colours.

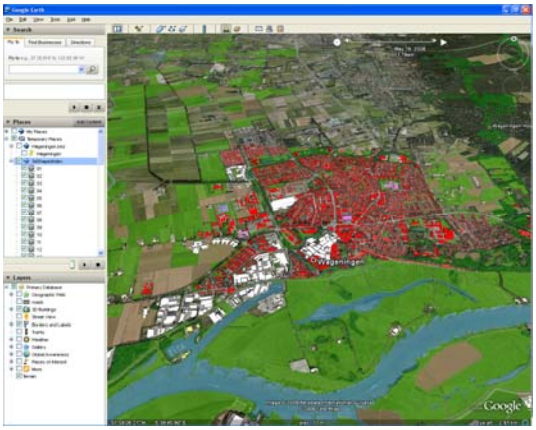
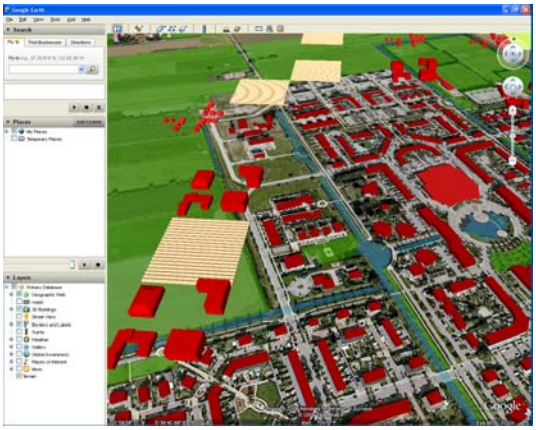


Fig. 7.a Current situation



7.b Iconic representation of Land use change

This user scenario has become reality because of the GESO application. GESO is an acronym of Google Earth visualisation of Sustainable Outlook data.
GESO is an application that prepares the different geo-data sets into a visualisation-format (KML) for the whole of the Netherlands that could be viewed in the Google Earth (version 4.2.x) application.

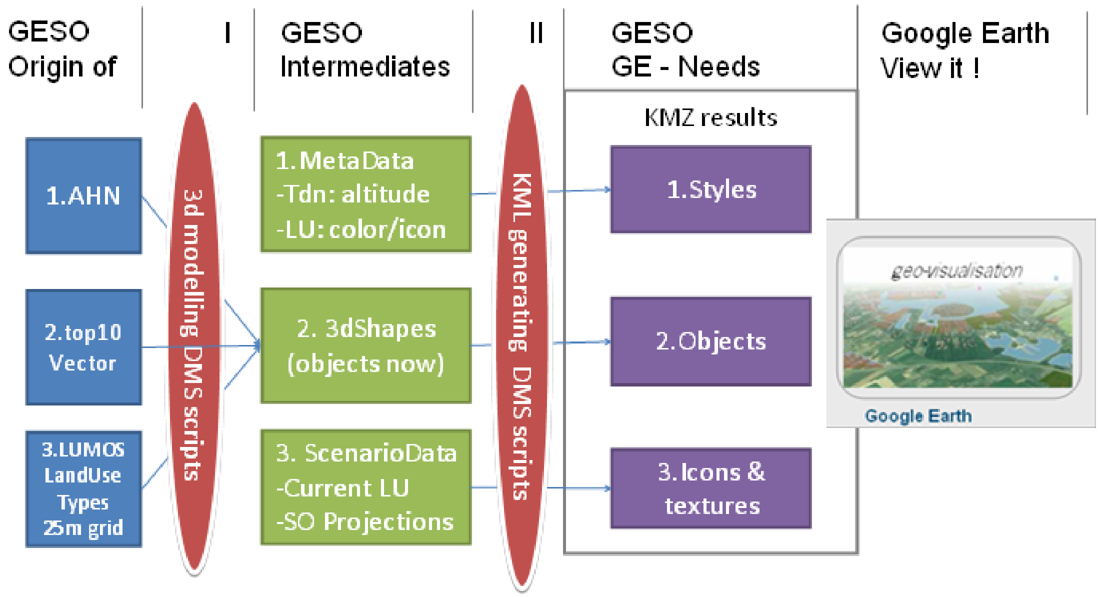


Fig 8. GESO-conceptual design

The GESO concept (fig.8) includes:

- the data (purple boxes) to view by Google Earth (GE-needs: KMZ/KML files),
- the functions (II – red polygon) to generate these files,
- some GESO intermediate files (green boxes) needed for this file generation
- and functions (I – red polygon) to construct some of the intermediates
- out of authorized data (blue boxes) like the Dutch elevation data (AHN), the Dutch topographic data set (top10 vector) and the Sustainable outlook results as generated by LUMOS (GESO origin of)

Extending the Google Earth constraints the conceptual design will include:

- sets of 3D models (land use icons or 3D icons), color and texture files (green box – 1);
- 3dShapes representing the functional use and intensity (height) of topographical objects (green box - 2);
- a database with related attributes and graphic variables of importance for classification, visualisation style and rendering (green box – 3).

Via function II a number of data components are included in the KMZ/KML file eg. styles (purple box - 1), objects derived from 3dshapes (purple box -2) to visualise current land use, and land use (3D) icons and 2D textures (purple box 3) to visualise land use changes.

Doing so, Sustainable Outlook results of the land use scanner (SO) could be linked to 2D textures and 3D-icons that visualises landscape types related to certain land use classes, will have a proper geo-reference (WGS84) and a data structure (KMZ,KML) that supplies data to Google Earth in such away that the user will benefit of the Google Earth's database scalability and navigation principles. The latter item means that higher viewpoints offer lower levels of graphical detail. Lower viewpoints give 3D details of high detail. High detail means 3D geometry and many high resolution textures (Lammeren, 2004).
For the construction of 3D icons the interoperable format of Collada has been used. This format is shared by many 3D modelling software packages including SkecthUp and 3D StudioMax.

3. Data inventory and preparation

According the conceptual design and in line of the initial requirements the following datasets form a starting point.

By default:

- Google Earth Aerial Images [1] form the underlying data of the GESO application. These data are not pre processed by us.
- Google Earth elevation data (SRTM, 2006 [2]) form another underlying data of the GESO application. These data are processed neither by us.

Origin of GESO:

- top10Vec
- AHN-1
- LUMOS sustainable outlook format of the Dutch National Planning Office Sustainable Outlook data (SO) has to be transformed into a KML / KMZ -format readable by Google Earth.
- Model database

GESO intermediates:

- VisualScan Land Use icons, 3D icons (Lammeren, 2004), of the VisualScan project have been transformed from 3D studio max format into Collada format. Besides, the icons have been adapted to the GESO applications. Latter is done by using SketchUp. If current 3D object libraries [3] do not meet requirements, examples of new objects have to be designed.
- 2D textures (designed by the PBL)

GESO results to view by Google Earth

- KMZ/KML

Figure 9. Visualisation of the 3dShapes

Besides, the land use functions of the Lumos database combined with Elevation data [4] and Topographic data [5] has to be used in order to represent land use functions. The 3Dshapes (appendix 3) dataset does offer this combination. Figure 9 shows the result of this dataset.

4. Implementation

The GESO generator has been constructed by making use of the DMS script-language. Finally this generator generates data in a Google Earth format (like KML) in a hierarchical folder structure.

Data sets of 3D icons have been developed (see appendix 1.a and 1.b) and were based on the original VisualScan icons (appendix 5), but many other architectural styles could have been used. Currently the 3D icons have been kept geometrically simple and coloured by the rgb-values as used on every level of detail (figure 10).
.
Tables define the relations between the 17 or 9 land use classes that have been used to represent the results of the Sustainable Outlook and the colours, textures and 3D icons that are used for their visualisation (see also appendix 4).

gg17 : Table

Name	ID	Label	Descr	r	g	b	useAHN	relHei	trar	ResourceDir	TextureN	IconName	Textu	IconL
woon_csbc	0	wonen - stedelijk	wonen - stedelijk	204	0	0	☑		ff	gg17/wonen_cs		01_wonen_	32	32
woon_gscd	1	wonen - groen ste	wonen - groen stedelijk	255	26	26	☑		ff	gg17/wonen_gs		02_wonen_	32	32
woon_lw	2	wonen - landelijk	wonen - landelijk	255	204	204	☑		ff	gg17/wonen_lw		03_wonen_	32	32
recr_verblijfsparken	3	recreatie - verblijf	vakantiehuisjes, volkst	230	204	255	☑		ff	gg17/recreatie_v		04_recreat	32	32
recr_dagrec	4	recreatie -dagrecre	dagrecreatie	255	179	51	☑		ff	gg17/recreatie_d		05_recreat	32	32
werk_bedrijven	5	bedrijven	werk_bedrijven	255	166	255	☑		ff	gg17/bedrijfsterreir		06_bedrijfs	32	32
werk_kantoren	6	kantoren	werk_kantoren	179	51	255	☑		ff	gg17/kantoren		07_kantore	32	32
werk_zeehaven	7	zeehavens	werk_zeehaven	0	0	102	☑		ff	gg17/zeehavens		08_zeehav	32	32
natuur	8	natuur	natuur	0	204	0	☐	0	77	gg17/natuur	nature.jp	09_natuur.	16	32
agr_AkkerTuin	9	akkerbouw	akkerbouw	247	198	150	☐	0	77	gg17/akkerbouw		10_akkerb	32	32
agr_vee_grond	10	grondgebonden ve	grondgebonden veetee	33	156	76	☐	0	77	gg17/veeteelt_gg		11_veeteel	32	32
agr_glastuinbouw	11	glastuinbouw	glastuinbouw	32	32	64	☐	4	77	gg17/glastuinbouw		12_glastuir	32	32
agr_vee_intensief	12	intensieve veeteelt	intensieve veeteelt	77	77	0	☐	0	77	gg17/veeteelt_in		13_veeteel	32	32
agr_boomgaard	13	boomgaard	boomteelt, laanbomen	255	255	128	☐	10	77	gg17/boomgaard		14_boomg:	32	32
agr_kwekerij	14	kwekerijen	kwekerijen	217	255	102	☐	10	77	gg17/kwekerij		15_kweker	32	32
overig	15	overig	overig	0	0	0	☐	0	77	gg17/overig		16_overig.c	32	32
water	16	rivieren bestaand	rivieren bestaand	64	140	215	☐	0	77	gg17/water	texture0	17_water.d	16	32

Table 1: Representation of GG17 land use classes

gg9 : Table

ID	Name	Label	Descr	r	g	b	usAHN	relHeight	transp	ResourceD	IconName	TextureName	Textu	IconL
0	wonen	wonen	wonen	255	0	0	☑		ff	gg9/werker	files/SUPreview2	files/texture1.	16	32
1	recreatie	recreatie	recreatie	193	204	115	☑		ff	gg9/recreat	files/SUPreview2	files/texture1.	16	32
2	werken	werken	werken	255	255	0	☑		77	gg9/werker	files/SUPreview2	files/texture1.	16	32
3	natuur	natuur	natuur	0	128	0	☐	0	77	gg9/natuur	files/SUPreview2	files/nature.jp	16	32
4	agrarisch	agrarisch	agrarisch	128	255	128	☐	5	77	gg9/gras	files/SUPreview2	files/texture0.	16	32
5	infrastruct	infrastructuur	infrastructuu	0	0	0	☐	0	77	gg9/overig	files/SUPreview2	files/texture0.	16	32
6	overig	overig	overig	128	128	128	☐	0	77	gg9/overig	files/SUPreview2	files/texture0.	16	32
7	buitenland	buitenland	buitenland	192	192	192	☐	0	77	gg9/overig	files/SUPreview2	files/texture0.	16	32
8	water	water	water	128	255	255	☐	0	77	gg9/water	files/SUPreview2	files/texture0.	16	32

Table 2: Representation of GG9 land use classes

Tables 1 and 2 show the attributes and attribute values that realize these definitions. If we take a closer look at table 2 the following attributes are available:

ID: the identifier of a land use class
Name: description of the land use class
Lable: label of the land use class
Descr: extra description of the land use class
R: red value on a RGB colour scheme
G: green value on a RGB colour scheme
B: blue value on a RGB colour scheme
The RGB value is used in monochronous representations of land functions

useAHN: boolean variable that determines whether an absolute height should be applied
relHeight: if 3Dshape value isn't active a fixed height value will be applied, which is relative to the terrain model of GE.
transparency: transparency level of a 3dShape
ResourceDir: reference to storage location
IconName: reference to storage location of a 3D-Icon file
TextureName: refernce to strorage location of a texture file
TextureLevel: view point level to activate textures as lower level of detail
IconLevel: view point level to activate icon as higher level of detail

The attributes are the same for the 17 land use classes (table 1). Only the attribute values differ because of the increased number of land use classes.
The related 3D icons and textures are presented in appendix 1.a, 1.b and 2.

The DMS uses the relations as defined via the tables to generate files and their related structure to be visualized via Google Earth.

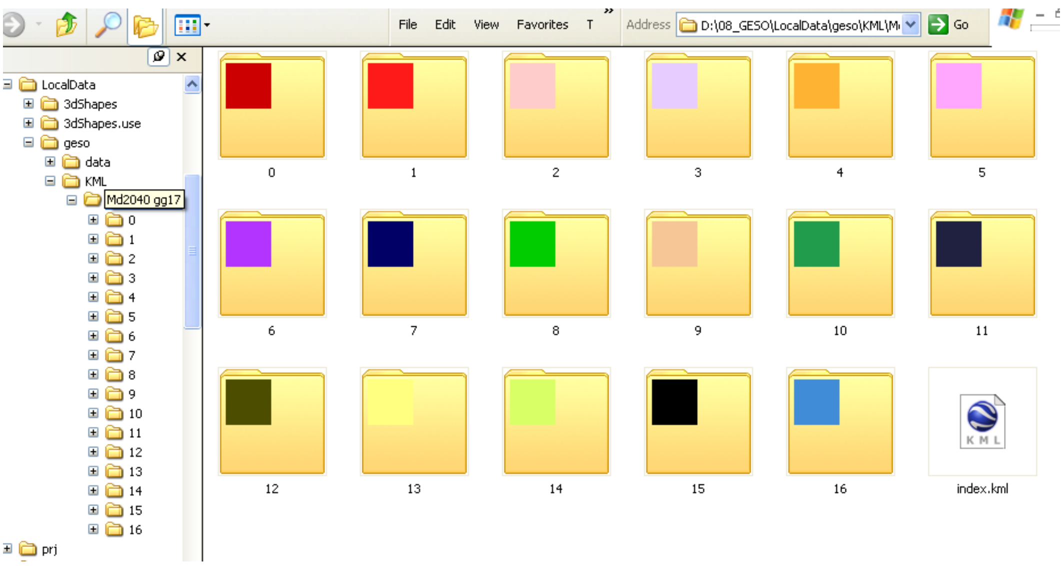


Figure 10: The finally generated GESO folder structure

Figure 10 puts forward the results that may be visualized via Google Earth. Every folder is, via its number and colour (RGB – values), referring to a land use class and offers a hierarchical structure of KML files and related objects to visualize the current and changed land use classes. The folder name in figure 10 refers to a certain scenario. In this case MD2040 gg17 which means medium pressure scenario for 2040 and expressed via 17 land use classes. Each land use class specific folder contains sub folders with information per block (the Lumos modeling area of 270 km x 325 km is divided in 12 x 13 blocks of each 22.5 km x 25 km) and each block folder can contain up to 9x10 pack folders (a pack a an area of 2.5 km x 2.5 km) which can contain up to 5 x 5 tile folders (a tile contains the representation info of 5 x 5 raster cells of 1ha each).

The structure and files are constructed via the DMS engine. Table 3 shows that 'engine' and the order the software processes the different datasets in favour of generating the tiles and their related land use changes objects (cells and 3D icons).

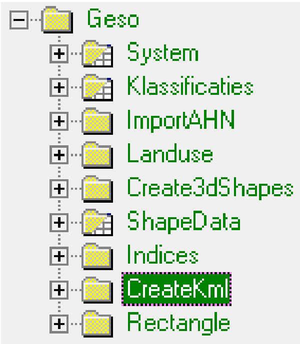


Table 3: DMS engine structure

A 3 level hierarchical spatial index structure has been implemented to make all objects of a projected land use change representation accessible for the whole of the Netherlands via Google Earth. For the 3dShapes, a 2 level hierarchical spatial index structure has been used based on 70 maps of the Netherlands of 40 km x 25 km that are further divided in 8x4 sheets of 5km x 6.25 km each as defined by the Dutch Ordnance survey (Kadaster, 2007).

5. Results

As soon as the folders have been generated the data may be viewed via Google Earth. Start Google Earth and open via the function File| Open| the GESO folder (for example LocalData\geso\KML\Md2040gg17\index.kml). Via the Google Earth tab Places (Plaatsen) the 17 available layers – if one uses the 17 land use classes data sets – could be made visible (fig. 11).

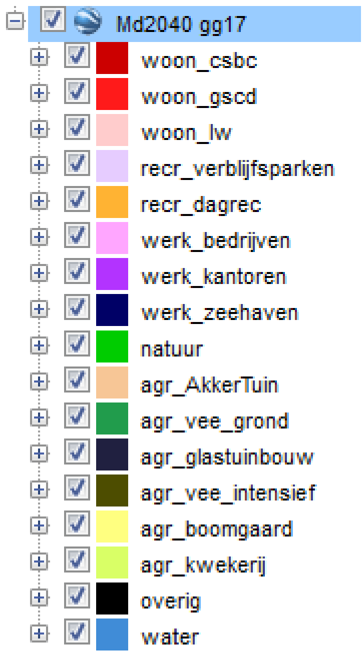


Figure 11: The gg17 layers available via the Places Tab in Google Earth

In the same way the current land use may become available via the 3dShapes layers (figure 12).

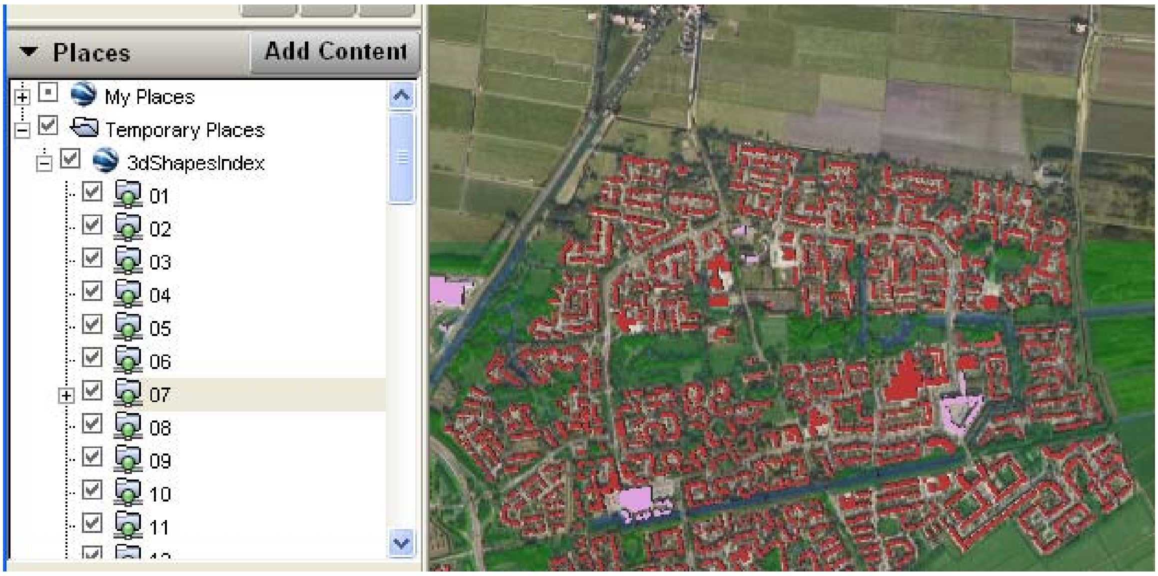


Figure 12: 3dShapes layers

All the land use changes of that scenario will be visualised upon the default aerial photo background as offered by Google Earth. In fact there could be four modes (figure 13a – 13d).

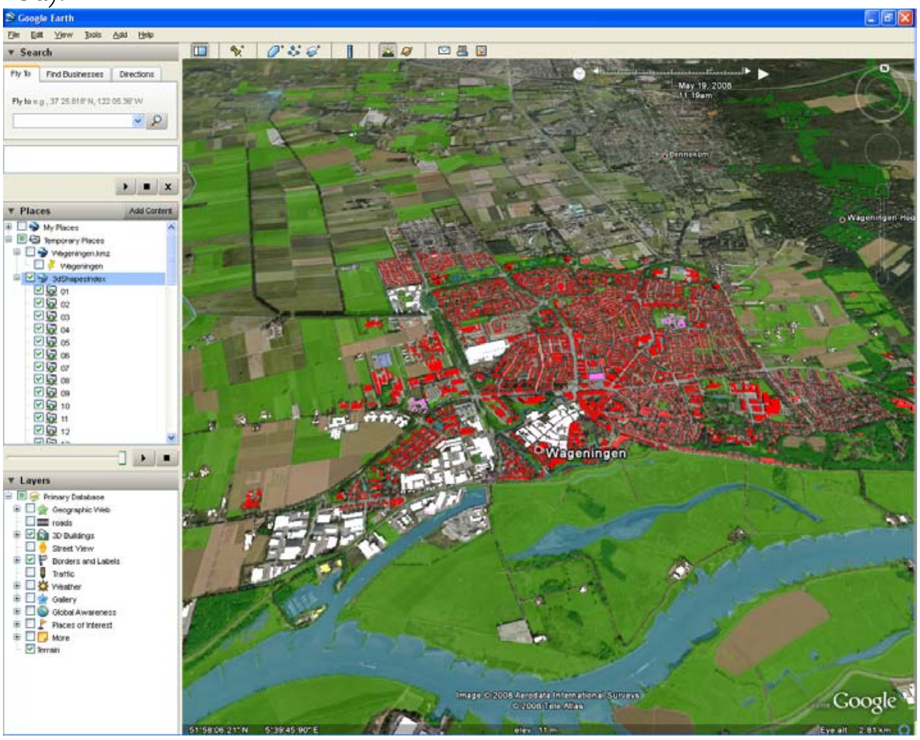


Figure 13a: Current land use`

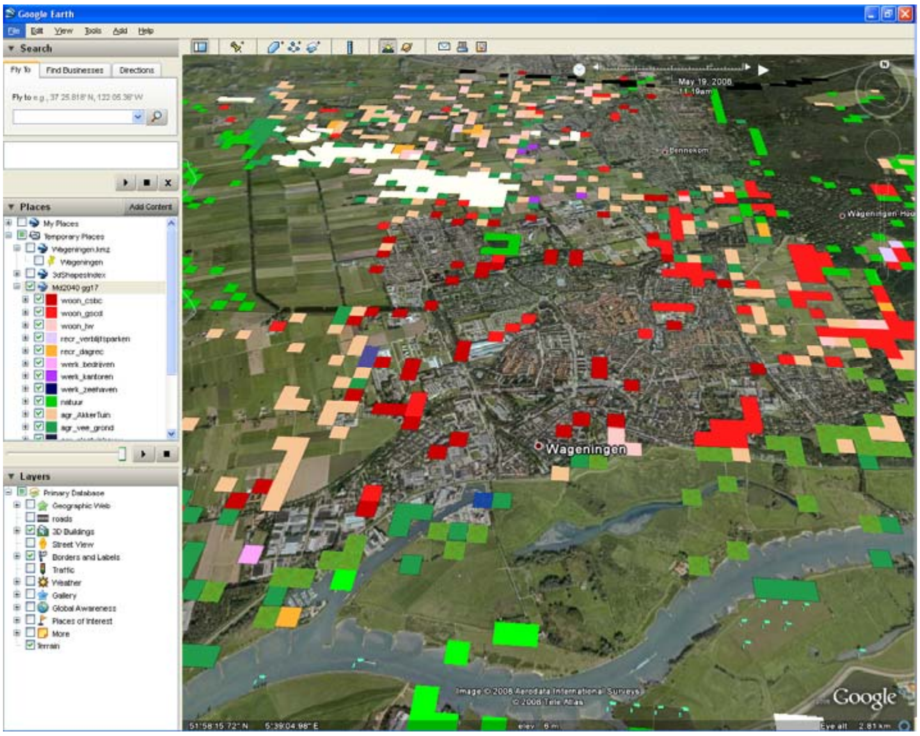


Figure 13b: Future land use

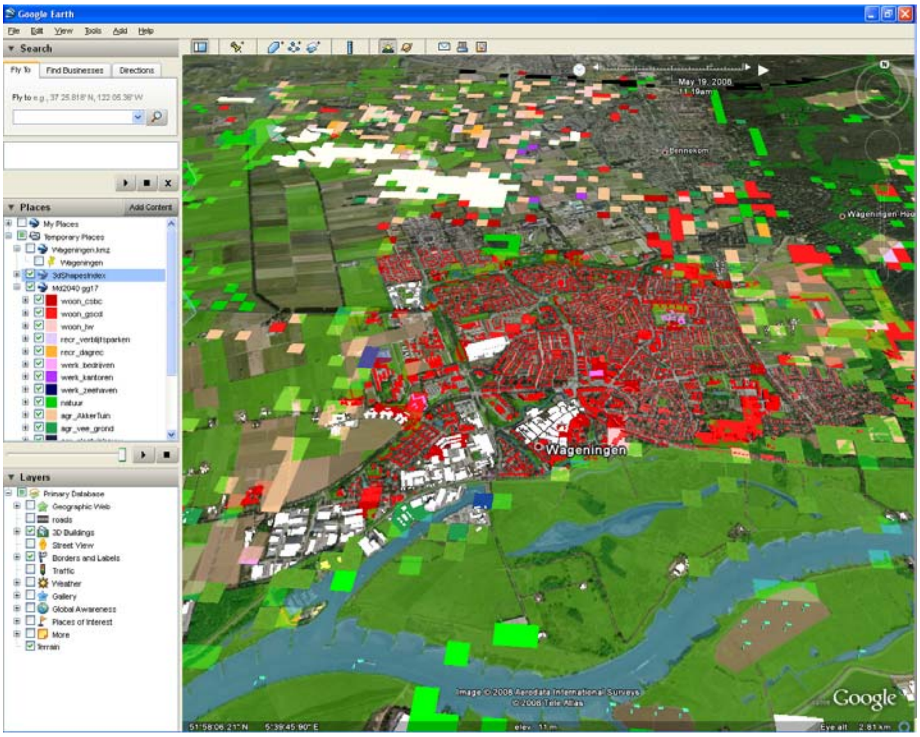


Figure 13c: Current and future land use (texture level of detail)

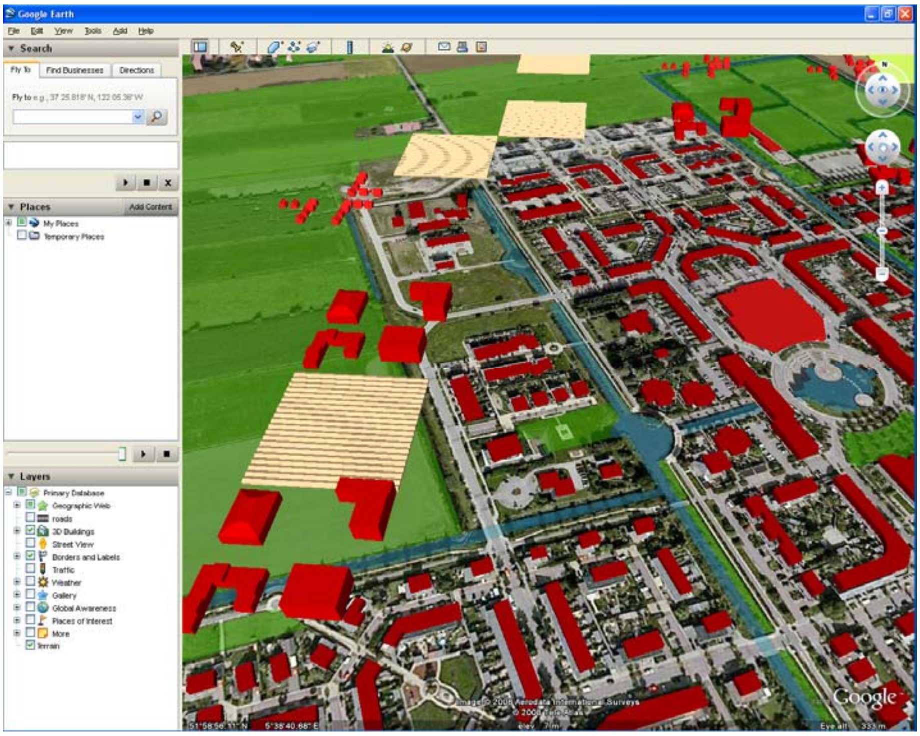


Figure 13d: Current and future land use (3D icon level of detail

The modes of visualisation differ in use of 3dShapes (current land use) and 3dIcons (future land use). Figure 12a presents the current land use based on using 3dShapes. Future land use, as far as it will change, is presented by figure 12b. The combination of current and future lands use shows figure 12c. In figure 12d the same combination of future and current land use is presented again but in this case on a higher level of detail. The higher level is realized by rendering the 3DIcons.

6. Conclusion, discussion and recommendation

This chapter concludes on and discusses the results of the GESO project. Finally recommendations are given for further improvement.

o 6.1 Conclusion

Regarding the objectives of the GESO project we could state that:

- the SO2 (bijv. duurzaamheidsverkenningen en NL Later-) could be three-dimensionally visualised via the Google Earth interface for the Dutch Randstad and even for the whole of the Netherlands land surface;
- the visualization is as well based on the Dutch national authorized data for topography (Top10Vec) and elevation (AHN). These data have been combined to create a three-dimension presentation of current land use;
- colours, textures and 3D-icons have been defined and digitally created to present land use changes on several levels of detail.
- as a reference to landscape patterns the default Google Earth aerial pictures have been used as a visual background;
- the project gives an outlook on new technical and content-wise options for further improvement of such a visualization of data for spatial policy making.

o 6.2 Discussion

This discussion is written in terms of comparison with the VisualScan approach (advantages, limitations and possible further research).
The viewer of GESO is the well known freeware Google Earth (GE) interface, which is very well supported by a world wide community. Visualscan has to be viewed via the freeware Virtools [6] viewer (VT). However the benefits of GE in comparison with VT are currently the availability of high resolution aerial images, a geographical coordinates reference, an open language (KML) and data and a small set of functions are rather easy to adapt for a user community.
A small geographical extent, one level of detail and the same set of 3D models for changed and unchanged land use classes were the major problems of the VisualScan application. Now.the GESO-application offers the whole of the Netherlands as extent, four levels of detail by default and visual differences between changed and unchanged land use classes within one view, as well as the representation of current land use and areal photo's as a reference.

To enrich SO data for 3D visualization the GESO application has been developed in the DMS language (open source). For Visualscan this has been done by the Virtools programme language which is not open source. The GESO application offers by now more functionality. One may combine Top10Vec and AHN data into 3Dshapes and, could transform SO data and 3D shapes into KML data by using libraries like the 3D icons.
The 3D icons made via SketchUp, another open source and freeware tool, could easily be made and changed while the 3D icons in Visualscan were made via 3Dstudio Max that is not freeware and needs a more steep learning curve.

The constructed 3D icons can be used over and over again in all scenarios to be visualised. Besides, the 3D icons may be shared via the 3D model database of the Sketchup community.
For reasons of performance the level of detail of the 3D models needs a trade off between geometrical details and detailed texture mapping.

Another point of discussion is linked to the tiling principle used in the GESO-application for creating 3D shapes and the impact on the readability of the current land use by buildings.
In the main line of discussion the orientation of the 3D icons as visualized could lead to mis-understanding, because the don't always match with landscape patterns like parcellation, bases of cultivation and other landscape structuring principles.

Besides the improvement of technology (more, easier, sharable, interoperable) there is still an important question to answer: "Does the GESO application seriously support the Sustainable Outlook users community?". For the impact on the users a separate usability study has to be performed, because this GESO project deals with the conceptual development and its implementation.

o 6.3 Recommendation

The usability of GESO needs still a thorough research. The potential of users as well as their demands for support by a tool as GESO should be recognized and understood. Such a research has to focus on several cognitive topics like easy-of-use, understanding of information and the supportive meaning of the information. For the support of such users oriented research some tracking software could support this.

In addition to the cognitive mapping modes of the potential variety of users the visualization as such need some extensions. Some of these extensions could be:

- construction of more and diverse 3D icons per land use class, because icons could refer to specific cultural, economic and social meanings;
- selection of 3D icons to render via conditions that could support regional variety, land use intensities, landscape openness,e tc.). Extra data will be needed to implement such an approach.

Another important extension should be the link to other source of information. For example via a mouse-over and pop-up windows the user could read about the location or land use class specific decisions, ideas and motivation to (un)change land use.

Another topic of interest could be the link to the expected temporal development of land use changes. In the graphical interface a time slider could show the gradual changes as simulated. The confrontation of these predicted data with known procedural constraints like legislative and political could give hints for a more realistic view on the real World implementation. The visualization could present graphically such continuities and anomalies between simulated outcomes and planning practice procedures.

Also the item of landscape features and structure should be addressed again. The current GESO application did not fully support this discussion on the fitting of changed land use classes in a landscape pattern. The technical way of supporting this could be the clipping of structuring landscape features like main waterways, highways, etc. .

In a more technology sense the visualization of the 3Dshapes could also be used to present other variables instead of elevation statistics, like basic prices of land properties, immovable properties prices, environmental quality indicators and other commodities. This put forward a related recommendation to assess the 3Dshapes data quality.

Finally the SO data, 3Dshapes and 3D icons could be made available via a web service. There are many opportunities to develop such a full web service via offering it by the open Google Earth community [7] or via an intranet like Google Earth Enterprise license [8]. This web service could be improved via the dedicated kml generation application that is available under a GNP GPL (open source) license [9].

We plan to make the 3dShapes available as binary files under CC-BY-NC-SA/3.0/NL license (http://creativecommons.org/licenses/by-nc-sa/3.0/nl/) as soon as the legal issues with the Dutch Kadaster are resolved; check http://www.objectvision.nl/ [10] for updates.

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Sheppard, S.R.J., 2001. Guidance for crystal ball gazers: developing a code of ethics for landscape visualisation. *Landscape and Urban Planning* 54(1–4): 183–199.

URL (july 2008)

[1] http://bbs.keyhole.com/ubb/postlist.php/Cat/0/Board/latest

[2] http://en.wikipedia.org/wiki/SRTM / http://www2.jpl.nasa.gov/srtm/

[3] http://sketchup.google.com/bonuspacks.html

[4] http://www.ahn.nl/english.php

[5] http://www.tdn.nl/index_frames.html?inhoud=/particulier/producten/onze_producten_topografie.html&navig=/particulier/nav_serverside.html%3Fscript%3D1

[6] http://www.virtools.com/

[7] http://bbs.keyhole.com/ubb/ubbthreads.php/Cat/0

[8] http://earth.google.com/enterprise/earth_enterprise.html

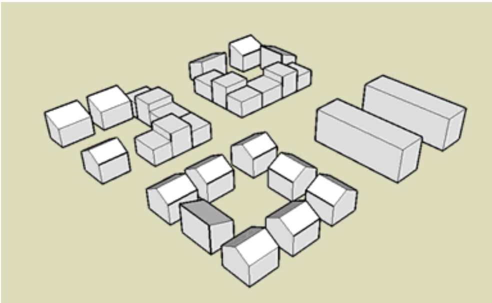
[9] http://code.google.com/apis/earth/

[10] http://www.objectvision.nl/Downloads

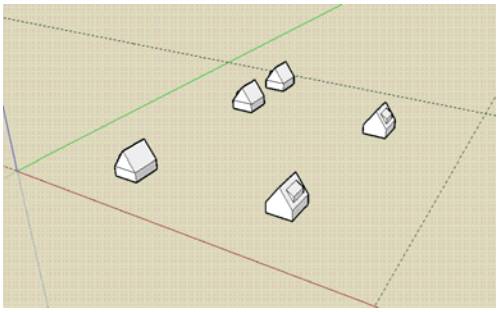
[11] http://www.feweb.vu.nl/gis/research/lumos/geso/GeSoT3.h

Appendices

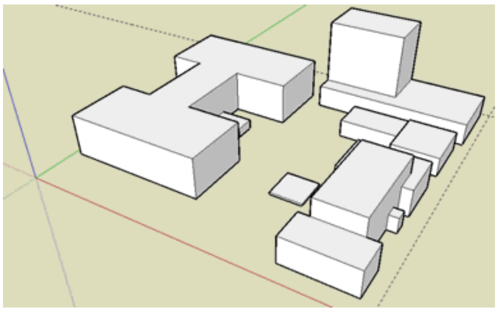
0 1a 3D Icons – GG9



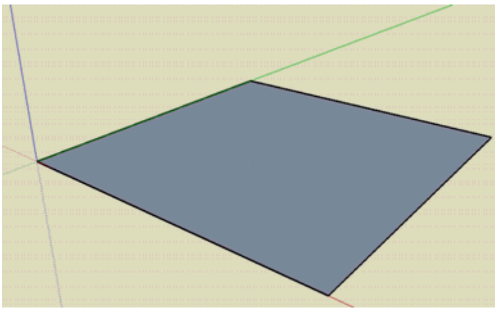
GG9 – 00 – residential (wonen)



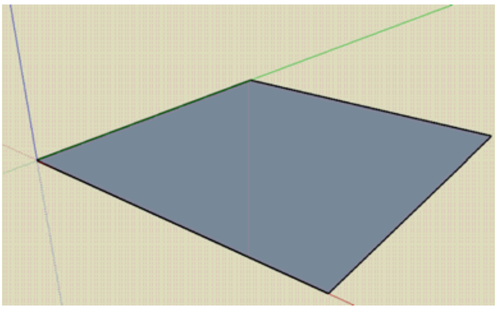
GG9 – 01 – recreation (recreatie)



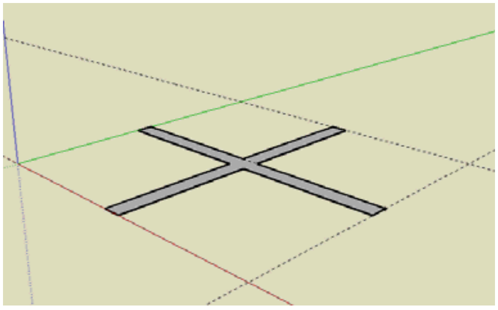
GG9 – 02 – offices (werken)



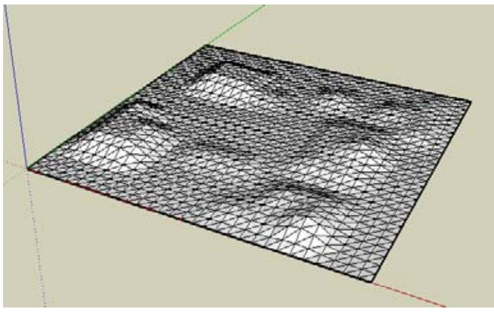
GG9 – 03 - Nature (natuur)



GG9 – 04 – agricultural (agrarisch)

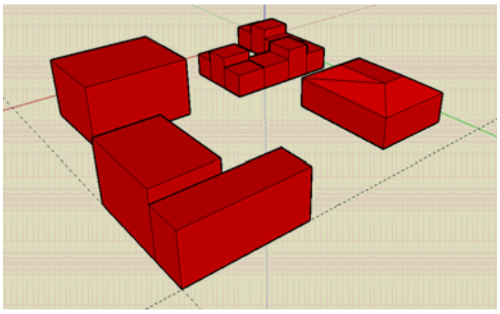


GG9 – 05 - infrastructure

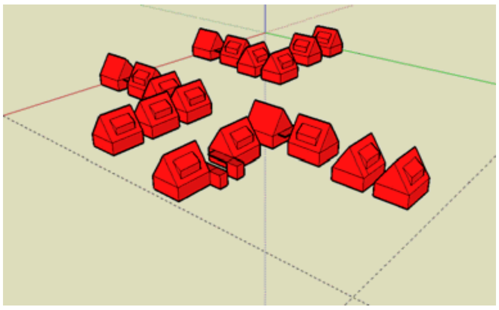


GG9 – 07 – other land use

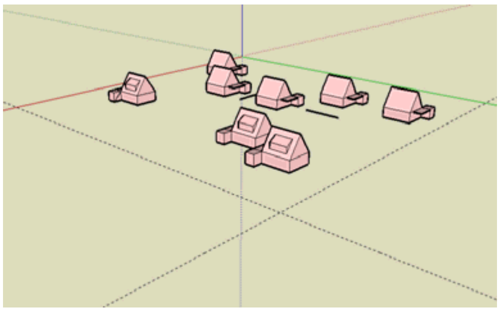
o 1b 3D Icons – GG17



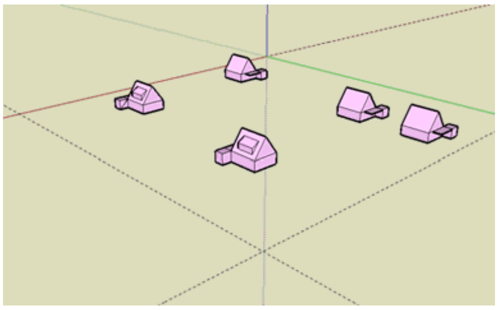
GG17 – 01 – higher density residential (wonen)



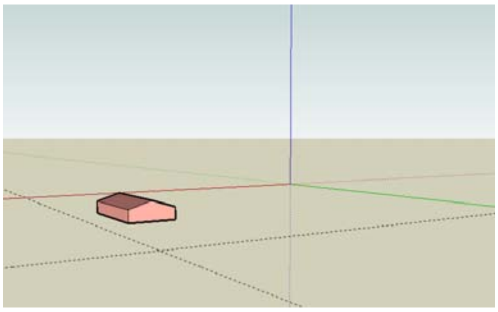
GG17 – 02 – mean density residential (wonen – 2)



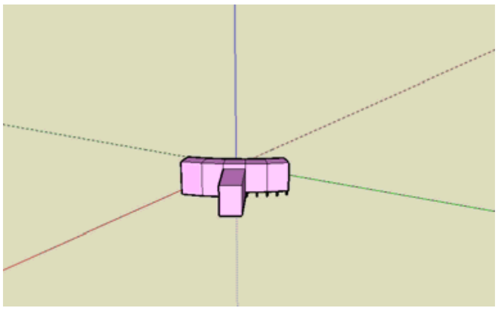
GG17 – 03 – lower density residential (wonen – 3)



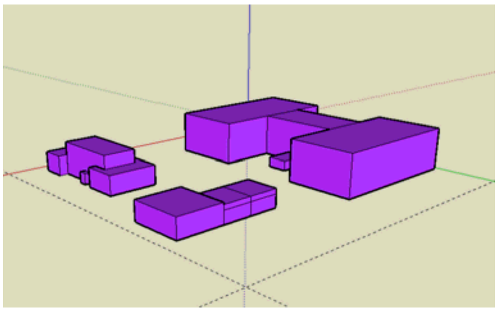
GG17 - 04 - recreation type 1 (recreatie – 1)



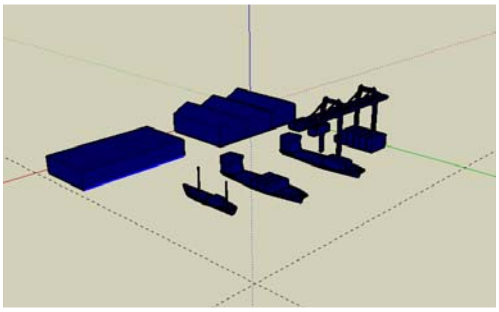
GG17 – 05 - recreation type 2 (recrecatie -2)



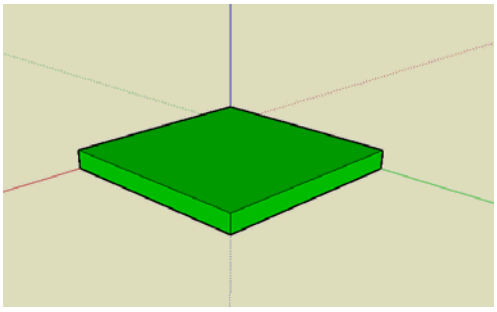
GG17 – 06 – industrial area type 1 (bedrijfsterrein – 1)



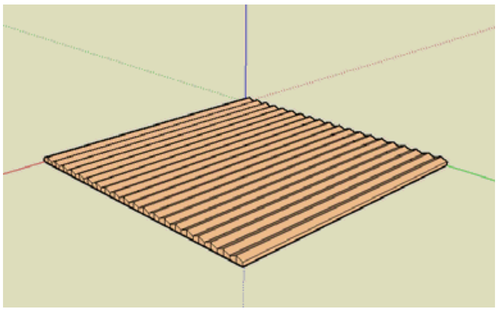
GG17 – 07 – industrial area type 2 (kantoren)



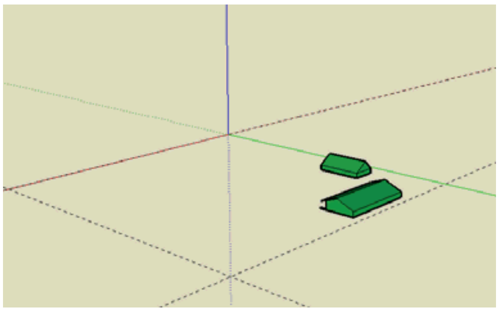
GG17 – 08 – docks and harbours (zee haven)



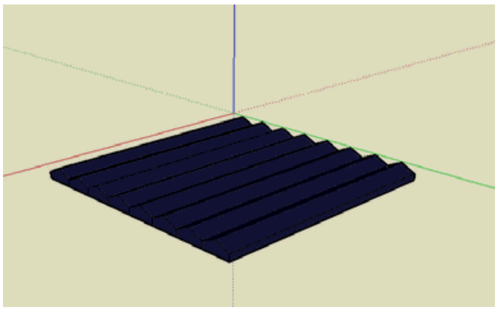
GG17 - 09 – nature
(natuur)



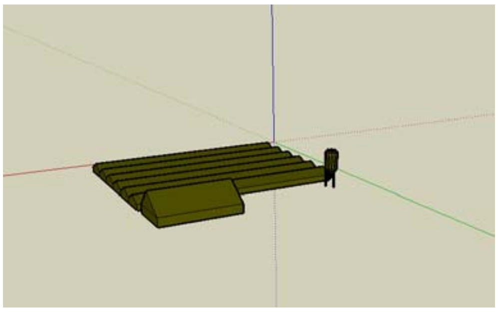
GG17 - 10 - arable land
(akkerbouw)



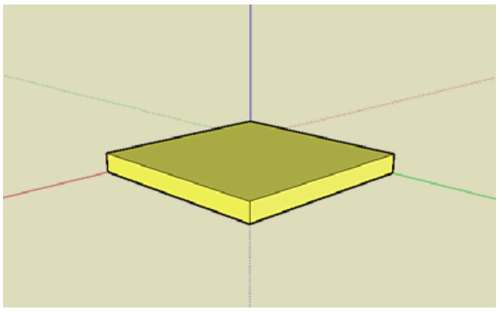
GG17 - 11 – breeding
(veeteelt)



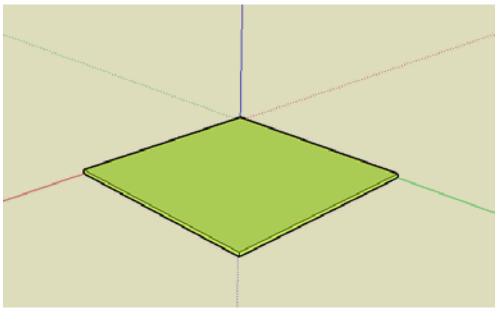
GG17 - 12 - glasshouses
(glastuinbouw)



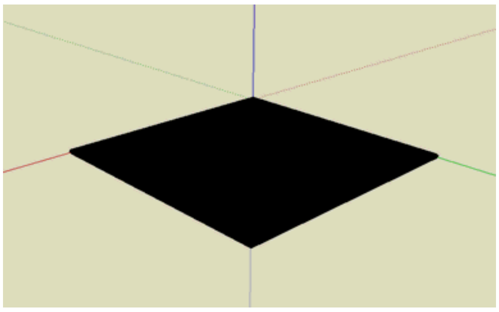
GG17 – 13 – intensive breeding
(intensieve veehouderij)



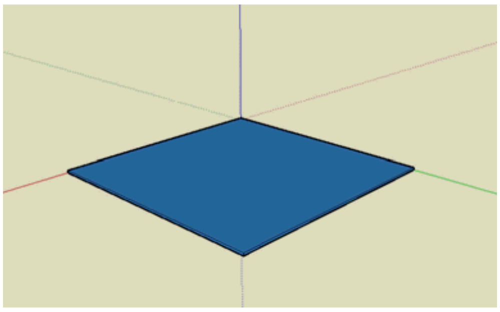
GG17 – 14 - orchards
(fruitteelt)



GG17 – 15 – nursery
(kwekerij)

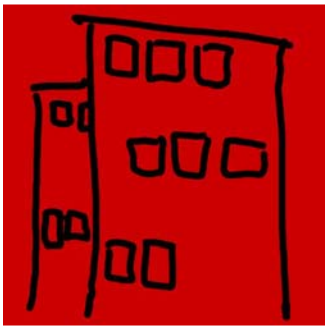


GG17 – 16 - other
(ander landgebruik)



GG17 – 17 – water
(water)

2: Symbols/Textures – GG17



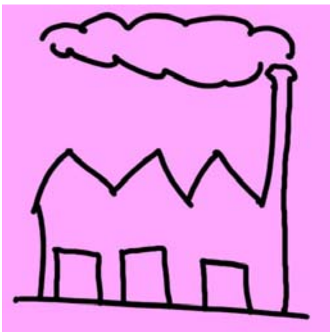
GG17 – 01 –
higher density residential
(wonen - 1)

GG17 – 02
mean density residential
(wonen – 2)

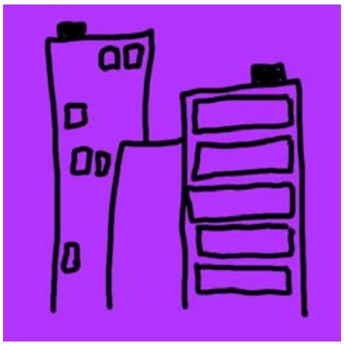
GG17 – 03
lower density residential
(wonen – 3)

GG17 - 04
recreation type 1
(recreatie – 1)

GG17 – 05 -
recreation type 2
(recrecatie -2)

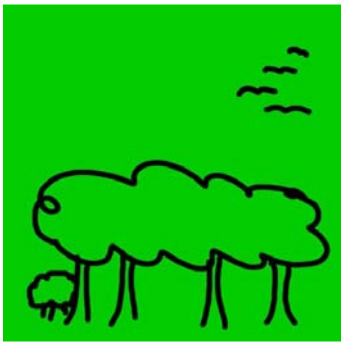


GG17 – 06
industrial area type 1
(bedrijfsterrein – 1)



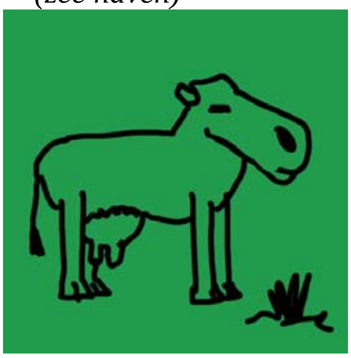
GG17 – 07
industrial area type 2
(kantoren)

GG17 – 08
docks and harbours
(zee haven)



GG17 - 09
nature
(natuur)

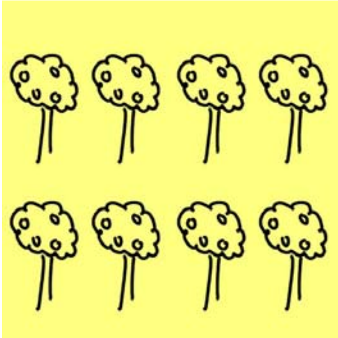
GG17 - 10
breeding
(veeteelt)



GG17 - 11
glasshouses
(glastuinbouw)

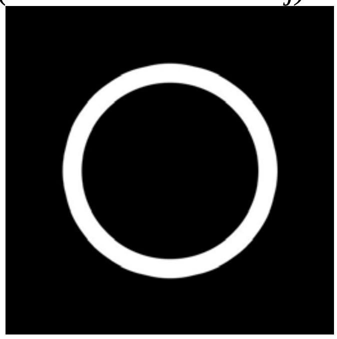
GG17 - 12
arable land
(akkerbouw)

GG17 – 13
intensive breeding
(intensieve veehouderij)

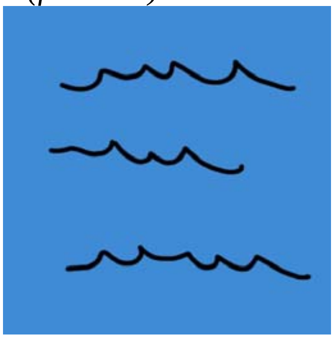


GG17 – 14
orchards
(fruitteelt)

GG17 – 15
nursery
(kwekerij)



GG17 – 16
other
(ander landgebruik)



GG17– 17
water
(water)

o 3: 3dShapes

The 3dShape dataset offers for each 70 maps of 40 (East-West) by 25 (North South) kilometers of the Netherlands land surface an overview of elevation data per topographic object. Table 1 shows the attributes available.

FID	Shape	GGMODELK	NR_AHN	HOOGTE_MIN	HOOGTE_MAX	HOOGTE_GEM	HOOGTE_STD
0	Polygon	23	24	2	3	2	33
1	Polygon	23	17	0	3	2	59
2	Polygon	23	20	0	3	2	66
3	Polygon	23	16	0	3	2	69
4	Polygon	23	7	2	3	2	34
5	Polygon	23	8	2	6	2	129
6	Polygon	23	21	0	3	2	88
7	Polygon	23	39	0	3	2	67
8	Polygon	23	21	2	3	2	29
9	Polygon	23	10	2	3	2	30
10	Polygon	23	4	2	3	2	43
11	Polygon	23	8	2	4	2	69
12	Polygon	23	18	1	2	1	22
13	Polygon	23	10	3	3	3	0
14	Polygon	23	23	0	2	1	80
15	Polygon	10	368	1	1	1	0
16	Polygon	10	10312	0	1	0	16
17	Polygon	10	24625	0	2	0	24
18	Polygon	10	11190	0	1	0	24
19	Polygon	23	3700	-1	21	0	157
20	Polygon	12	355	0	1	0	49
21	Polygon	12	415	0	5	0	72
22	Polygon	10	15870	0	2	0	26

Table 1: Attribute Table of a 3Dshape file

The attributes presents:

- the ID of each object (FID)
- the feature class (Shape)
- the land use class as determined by the Create3dShape procedure (GGMODELK) that derived the functional use from the Lumos database and the Top10 typology.
- the number of AHN points per object (NR_AHN)
- the minimum elevation height (HOOGTE_MIN) in meters
- the maximum elevation height (HOOGTE_MAX) in meters
- the mean elevation (HOOGTE_GEM) in meters
- the standard deviation (HOOGTE_STD) in centimeters

o 4: Classification of GGmodel classes, GG17 and GG9

LNR	Name	ggModelBasis	Label	lnr_nr	Descr	r	g	b
62	gesloten_duinvegetatie	natuur	gesloten duinvegetatie	62	gesloten duinveget	32	32	64
59	kwelders	natuur	kwelders	59	kwelders	112	239	16
51	bieten	agr_AkkerTuin	bieten	51	bieten	128	255	0
52	granen	agr_AkkerTuin	granen	52	granen	207	207	15
53	overige_landbouwgewassen	agr_AkkerTuin	overige landbouwgewas	53	overige landbouwge	202	202	10
54	bloembollen	agr_AkkerTuin	bloembollen	54	bloembollen	212	212	20
64	open_stuifzand	natuur	open stuifzand	64	open stuifzand	255	0	32
55	bebouwing_in_agrarisch_gebied	woon_lw	bebouwing in agrarisch	55	bebouwing in agrar	197	197	5
57	loofbos	natuur	loofbos	57	loofbos	217	217	25
58	naaldbos	natuur	naaldbos	58	naaldbos	192	192	0
29	binnenwater_voor_delfstofwinning	water_overig_ex	binnenwater voor delfst	29	binnenwater voor d	0	128	0
30	vloei_of_slibveld	water_overig_ex	vloei en/of slibveld	30	vloei en/of slibveld	0	64	0
31	overig_binnenwater	water_overig_ex	overig binnenwater	31	overig binnenwater	128	128	0
32	Waddenzee_Eems_Dollard	water_zout_exo	Waddenzee, Eems, Do	32	Waddenzee, Eems	184	184	12
33	Oosterschelde	water_zout_exo	Oosterschelde	33	Oosterschelde	190	190	6
35	noordzee	water_zout_exo	noordzee	35	noordzee	178	178	18
36	buitenland	buitenland	buitenland	36	buitenland	196	196	0
37	centrum_stedelijk	woon_csbc	centrum stedelijk	37	centrum stedelijk	78	18	78
38	buiten_centrum_stedelijk	woon_csbc	buiten centrum stedelijk	38	buiten centrum ste	96	0	96
39	groen_stedelijk	woon_gscd	groen stedelijk	39	groen stedelijk	90	6	90
40	centrum_dorps	woon_gscd	centrum dorps	40	centrum dorps	84	12	84
41	landelijk_wonen	woon_lw	landelijk wonen	41	landelijk wonen	10	214	22
42	distributie	werk_Distributie	distributie	42	distributie	0	224	32
43	gemengde_terreinen	werk_bedrijfsterr	gemengde terreinen	43	gemengde terreine	56	120	8
44	hoogwaardige_bedrijvenparken	werk_bedrijfsterr	hoogwaardige bedrijven	44	hoogwaardige bedr	48	112	16
46	zware_industrie_terreinen	werk_bedrijfsterr	zware industrie terreine	46	zware industrie terr	64	128	0
47	kantoren	werk_bedrijfsterr	kantoren	47	kantoren	0	255	0
48	agrarisch_gras	agr_vee_hoogsti	agrarisch gras	48	agrarisch gras	16	247	34
49	mais	agr_AkkerTuin	mais	49	mais	0	239	42
0	spoorterrein	infra_spoor	spoorterrein	0	spoorterrein	255	0	0
1	wegverkeersterrein	infra_weg	wegverkeersterrein	1	wegverkeersterrein	196	0	0
13	park_en_plantsoen	woon_gscd	park en plantsoen	13	park en plantsoen	20	255	32
14	sportterrein	woon_gscd	sportterrein	14	sportterrein	64	0	0
19	overig_agrarisch_terrein	agr_AkkerTuin	overig agrarisch terrein	19	overig agrarisch ter	64	128	0
12	semi_verhard_overig_terrein	bouwterrein	semi verhard overig terr	12	semi verhard overig	196	196	196
22	open_nat_natuurlijk_terrein	natuur	open nat natuurlijk terre	22	open nat natuurlijk	250	250	155
24	afgesloten_zeearm	water_zout_exo	afgesloten zeearm	24	afgesloten zeearm	245	245	150
27	spaarbekken	water_groot_zoe	spaarbekken	27	spaarbekken	255	255	160
23	IJsselmeer_markermeer	water_groot_zoe	IJsselmeer markermeer	23	IJsselmeer marker	255	128	255
66	matig_vergrasde_heide	natuur	matig vergrasde heide	66	matig vergrasde he	0	0	255
68	hoogveen	natuur	hoogveen	68	hoogveen	255	0	255
69	bos_in_hoogveengebied	natuur	bos in hoogveengebied	69	bos in hoogveengel	128	128	255
15	volkstuin	woon_gscd	volkstuin	15	volkstuin	0	160	80
16	dagrecreatief_terrein	recr_dagrec	dagrecreatief terrein	16	dagrecreatief terrei	10	150	70
21	open_droog_natuurlijk_terrein	natuur	open droog natuurlijk te	21	open droog natuurli	0	30	60
17	verblijfsrecreatief_terrein	recr_verblijfspark	verblijfsrecreatief terrein	17	verblijfsrecreatief te	7	23	53
20	bos	natuur	bos	20	bos	14	16	47
25	Rijn_en_Maas	water_rivieren_e	Rijn en Maas	25	Rijn en Maas	240	240	145
18	terrein_voor_glastuinbouw	agr_glastuinbou	terrein voor glastuinbou	18	terrein voor glastuir	214	178	214
70	overig_moerasvegetatie	natuur	overig moerasvegetatie	70	overig moerasveget	220	172	220
73	veenweidegebied2	agr_vee_hoogsti	veenweidegebied	73	veenweidegebied	76	76	243

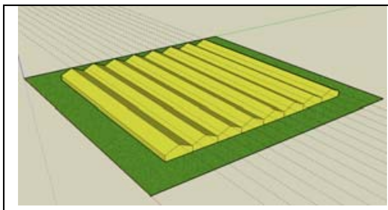
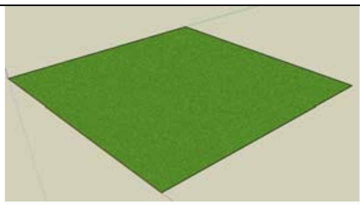
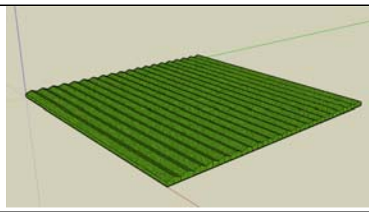
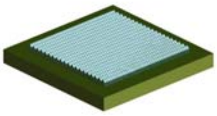
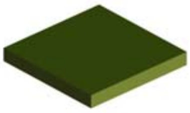
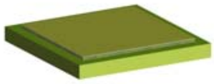
74	overig_open_begroeid_natuurgebie	natuur	overig open begroeid na	74	overig open begroe	70	58	175
77	fokvarkensbedrijven	agr_vee_intensie	fokvarkensbedrijven	77	fokvarkensbedrijver	74	74	215
79	andere_varkensbedrijven	agr_vee_intensie	andere varkensbedrijven	79	andere varkensbed	58	70	195
80	legkippen_bedrijven	agr_vee_intensie	legkippen bedrijven	80	legkippen bedrijven	52	76	195
81	vleespluimveebedrijven	agr_vee_intensie	vleespluimveebedrijven	81	vleespluimveebedrij	46	82	195
72	bos_in_moerasgebied	natuur	bos in moerasgebied	72	bos in moerasgebie	255	255	255
71	rietvegetatie	natuur	rietvegetatie	71	rietvegetatie	202	190	202
50	aardappelen	agr_AkkerTuin	aardappelen	50	aardappelen	8	255	26
63	duinheide	natuur	duinheide	63	duinheide	128	64	0
28	recreatief_binnenwater	water_overig_ex	recreatief binnenwater	28	recreatief binnenwa	0	255	128
60	open_zand_in_kustgebied	natuur	open zand in kustgebie	60	open zand in kustg	120	247	8
82	andere_pluimveebedrijven	agr_vee_intensie	andere pluimveebedrijver	82	andere pluimveebed	64	64	195
83	varkens_en_pluimveebedrijven	agr_vee_intensie	varkens en pluimveebed	83	varkens en pluimve	70	70	249
76	vleeskalverenbedrijven	agr_vee_intensie	vleeskalverenbedrijven	76	vleeskalverenbedrij	64	64	235
75	kale_grond_in_natuurgebied	natuur	kale grond in natuurgeb	75	kale grond in natuu	64	64	255
84	andere_hokdierbedrijven	agr_vee_intensie	andere hokdierbedrijven	84	andere hokdierbedr	64	64	175
85	boomgaard	agr_boomgaard	boomgaard	85	boomgaard	82	46	175
86	boomkwekerij	agr_kwekerij	boomkwekerij	86	boomkwekerij	64	64	215
65	heide	natuur	heide	65	heide	45	45	64
61	open_duinvegetatie	natuur	open duinvegetatie	61	open duinvegetatie	100	200	0
34	Westerschelde	water_zout_exo	Westerschelde	34	Westerschelde	230	230	10
26	randmeer	water_groot_zoe	randmeer	26	randmeer	226	166	226
45	zeehaventerrein	werk_zeehaven	zeehaventerrein	45	zeehaventerrein	0	0	0
56	veenweidegebied	agr_vee_hoogsti	veenweidegebied	56	veenweidegebied	0	0	0
67	sterk_vergrasde_heide	natuur	sterk vergrasde heide	67	sterk vergrasde hei	0	0	0
78	vleesvarkensbedrijven	agr_vee_intensie	vleesvarkensbedrijven	78	vleesvarkensbedrijv	0	0	0
87	fruitkwekerij	agr_kwekerij	fruitkwekerij	87	fruitkwekerij	0	0	0
2	vliegveld	infra_vliegveld	vliegveld	2	vliegveld	0	0	0
3	terrein_voor_detailhandel	werk_bedrijfsterr	terrein voor detailhandel	3	terrein voor detailha	0	0	0
4	terrein_voor_openbare_voorziening	werk_openbaarv	terrein voor openbare vo	4	terrein voor openba	0	0	0
5	terrein_voor_sociaal_culturele_voor	woon_csbc	terrein voor sociaal cultu	5	terrein voor sociaal	0	0	0
6	bedrijventerrein	werk_bedrijfsterr	bedrijventerrein	6	bedrijventerrein	0	0	0

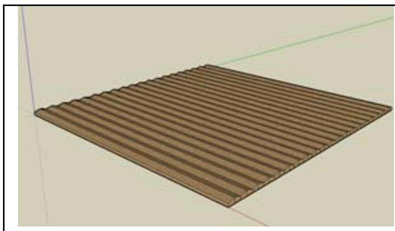
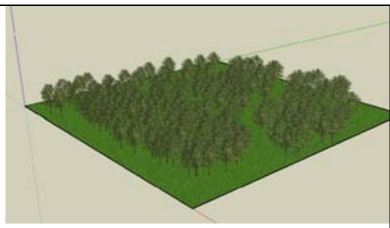
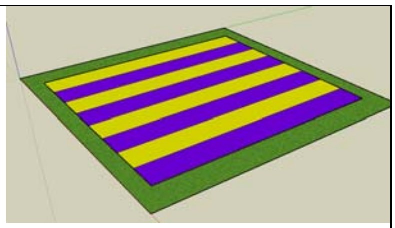
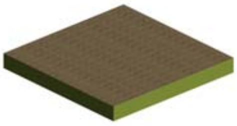
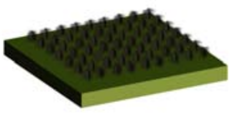
Table app4.1 Classification of land use classes in 28 GGmodel classes (ggLumos_2003)

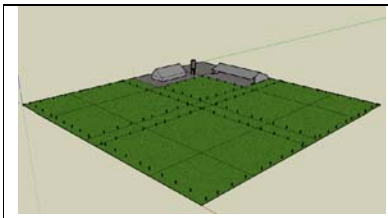
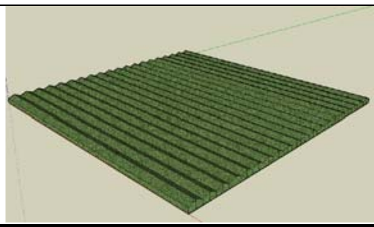
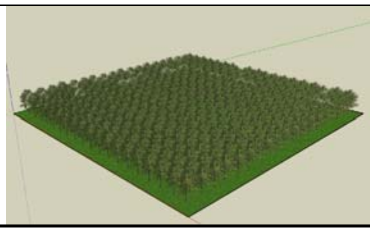
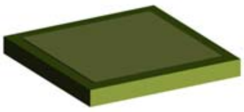
ID	Name	Labe	De	IsExc	ggS	gg9	gg17	r	g	b	IsUrba	IsO	useAHN	relH	tra	Resour	IconN	TextureN	IconL	Text
0	woon_csbc	won	wo	☐	0	wonen	woon_csbc	204	0	0	☑	☐	☑		ff	gg9/we	files/S	files/textu	16	32
1	woon_gscd	won	wo	☐	0	wonen	woon_gscd	255	26	26	☑	☐	☑		ff	gg9/we	files/S	files/textu	16	32
2	woon_lw	won	wo	☐	1	wonen	woon_lw	255	204	204	☑	☐	☑		ff	gg9/we	files/S	files/textu	16	32
3	recr_verblijfsparken	recre	val	☐	2	recreatie	recr_verblijfs	230	204	255	☑	☐	☑		ff	gg9/rec	files/S	files/textu	16	32
4	recr_dagrec	recre	da	☐	2	recreatie	recr_dagrec	255	179	51	☐	☐	☑		ff	gg9/we	files/S	files/textu	16	32
5	werk_bedrijfsterrein	bedr	we	☐	4	werken	werk_bedrijv	255	166	255	☑	☐	☑		ff	gg9/we	files/S	files/textu	16	32
6	werk_openbaarvz	ov_o	op	☐	3	werken	werk_kantor	179	51	255	☑	☐	☑		ff	gg9/we	files/S	files/textu	16	32
7	werk_Distributie	Distr	Dis	☐	3	werken	werk_bedrijv	0	0	0	☑	☐	☑		ff	gg9/we	files/S	files/textu	16	32
8	werk_zeehaven	zeeh	we	☐	4	werken	werk_zeeha	0	0	102	☑	☐	☑		ff	gg9/we	files/S	files/textu	16	32
9	natuur	natu	na	☐	5	natuur	natuur	0	204	0	☐	☐	☐	0	77	gg9/na	files/S	files/natu	16	32
10	agr_AkkerTuin	akke	ak	☐	6	agrarisch	agr_AkkerTu	247	198	150	☐	☐	☐	0	77	gg9/gra	files/S	files/textu	16	32
11	agr_vee_hoogstik	hoge		☐	7	agrarisch	agr_vee_groi	33	156	76	☐	☑	☐	0	77	gg9/gra	files/S	files/textu	16	32
12	agr_vee_midstik	midc		☐	7	agrarisch	agr_vee_groi	85	255	0	☐	☑	☐	0	77	gg9/gra	files/S	files/textu	16	32
13	agr_vee_laagstik	lage		☐	7	agrarisch	agr_vee_groi	61	214	30	☐	☑	☐	0	77	gg9/gra	files/S	files/textu	16	32
14	agr_glastuinbouw	Glas	Gl	☐	8	agrarisch	agr_glastuin	32	32	64	☑	☐	☐	4	77	gg9/gra	files/S	files/textu	16	32
15	agr_vee_intensief	Inter	Int	☐	8	agrarisch	agr_vee_inte	77	77	0	☐	☐	☐	0	77	gg9/gra	files/S	files/textu	16	32
16	agr_boomgaard	boor	bo	☐	8	agrarisch	agr_boomga	255	255	128	☐	☐	☐	10	77	gg9/gra	files/S	files/textu	16	32
17	agr_kwekerij	kwel	kw	☐	8	agrarisch	agr_kwekerij	217	255	102	☐	☐	☐	10	77	gg9/gra	files/S	files/textu	16	32
18	infra_spoor	spoc	sp	☑	9	infrastruc	overig	255	102	179	☐	☐	☐	0	77	gg9/ove	files/S	files/textu	16	32
19	infra_weg	weg	we	☑	9	infrastruc	overig	255	0	255	☐	☐	☐	0	77	gg9/ove	files/S	files/textu	16	32
20	infra_vliegveld	vlieg	vlie	☑	9	infrastruc	overig	0	0	0	☐	☐	☐	0	77	gg9/ove	files/S	files/textu	16	32
21	bouwterrein	bouv	bo	☑	1	overig	overig	196	196	196	☐	☐	☐	0	77	gg9/ove	files/S	files/textu	16	32
22	buitenland	buite	bu	☑	1	buitenlar	overig	255	255	255	☐	☐	☐	0	77	gg9/ove	files/S	files/textu	16	32
23	water_groot_zoet_exc	groo	grc	☑	1	water	water	77	217	255	☐	☐	☐	0	77	gg9/wa	files/S	files/textu	16	32
24	water_rivieren_exo	rivier	rivi	☑	1	water	water	0	77	255	☐	☐	☐	0	77	gg9/wa	files/S	files/textu	16	32
25	water_boezem_exo	boez	bo	☑	1	water	water	64	64	215	☐	☐	☐	0	77	gg9/wa	files/S	files/textu	16	32
26	water_zout_exo	zout	zo	☑	1	water	water	217	255	255	☐	☐	☐	0	77	gg9/wa	files/S	files/textu	16	32
27	water_overig_exo	overi	ove	☑	1	water	water	115	242	255	☐	☐	☐	0	77	gg9/wa	files/S	files/textu	16	32

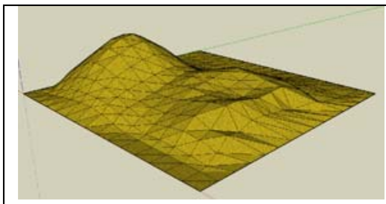
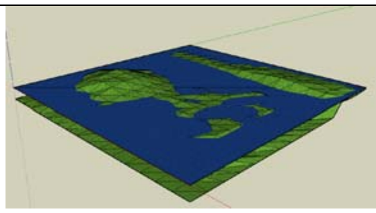
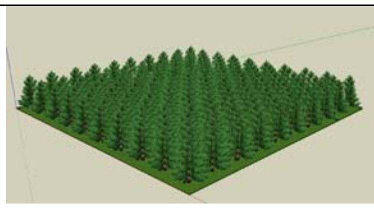
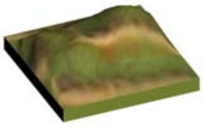
Table app4.2: Relation between GG9, GG17 and GGmodel (table ggModelBasis)

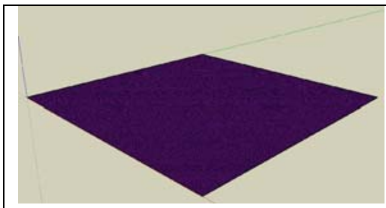
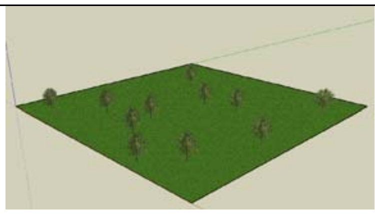
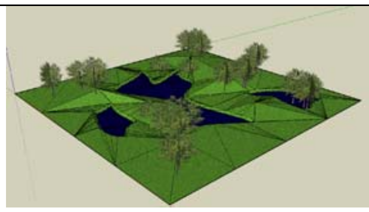
o 5: Comparison of GESO and Virtual Scan Icons

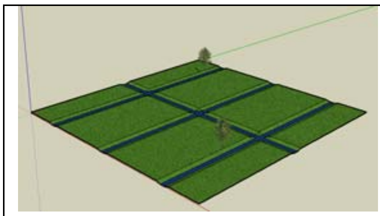
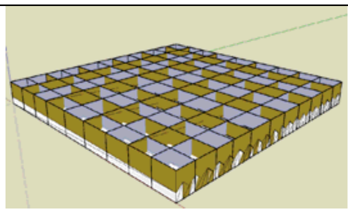
		
		
1. Greenhouses	2. Pasture	3. Maize fields

		
		
4. Agricultural fields	5. Orchards and nurseries	6. Bulb fields

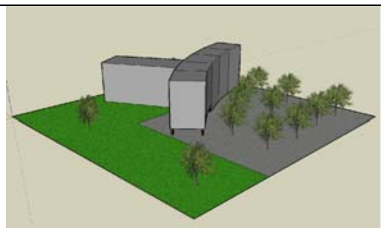
		
		
7. Other arable fields	8. Other agriculture	9. Deciduous forest

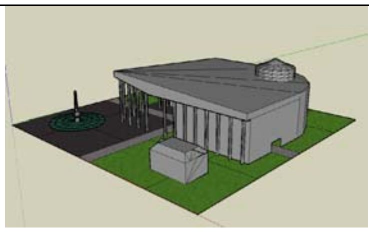
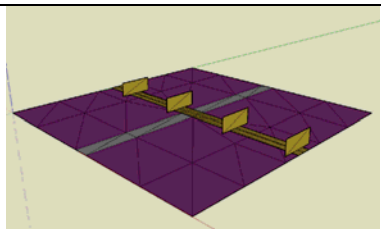
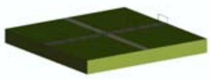
		
		
10. Coastal area	11. Wetlands	12. Coniferous forest

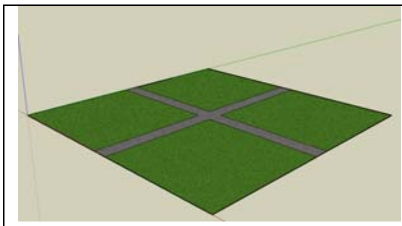
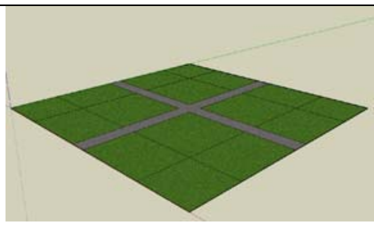
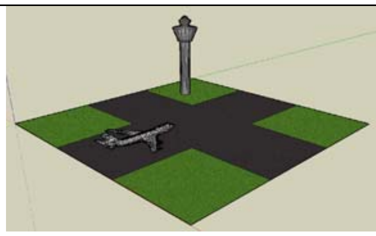
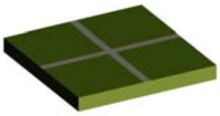
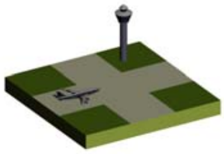
		
		
10. Moor	11. Peat and non arable	12. March

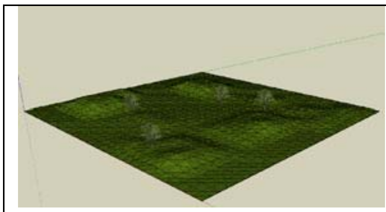
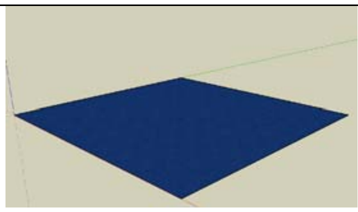
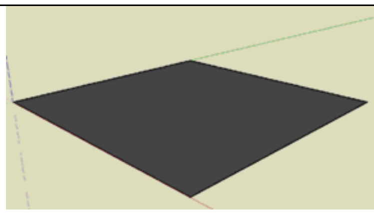
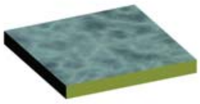
		
		
13. Peat/pasture	14. Other nature	15. Urban villas

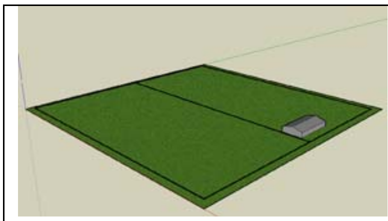
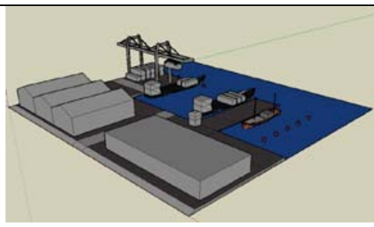
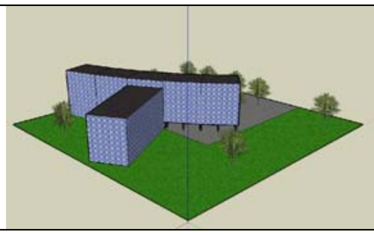
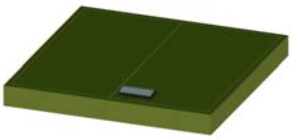
		
		
16. Urban residential	17. Urban green living	18. Rural residential

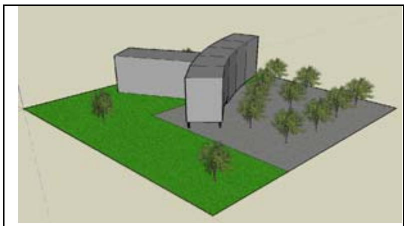
		
		
19. New rural living	20. Integrated living and working	21. bedrijfsterrein

		
		
22. Work	23. Social-cultural facilities	24. Infrastructure: railway

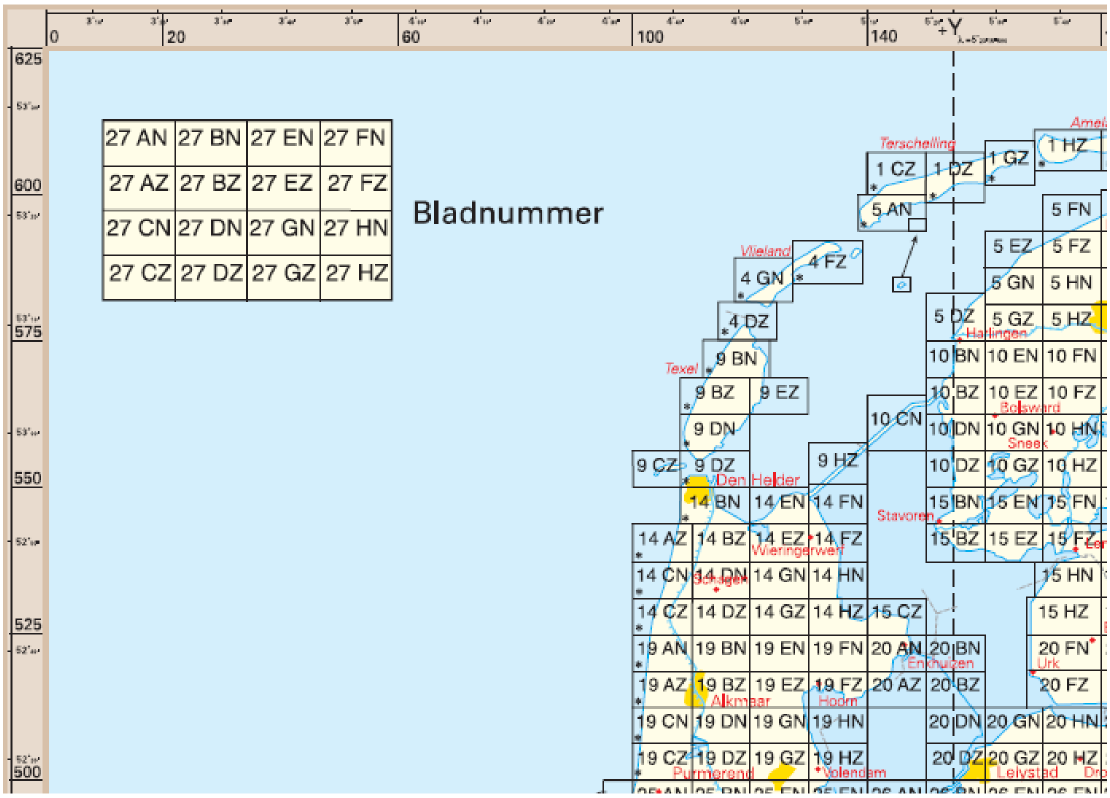
		
		
25. Infrastructure	26. Infrastructure: road	27. Airport

		
		
28. Other	29. Water	30. Abroad

		
		
31. Intensive recreation	32. Harbors	33. Company offices

		
		
34. Facilities and services	35. Extensive recreation	

0 6: Dutch Ordnance Survey Tile Index (Kadaster, 2007)



Bladindeling Top10Vec
Bladeren van Terschelling (1CZ) t/m Z-Limburg-ZuidOost (69GN)
Bladnummer zie hierboven (max. 16)

Bron: toelichting op Topografische Kaart 1:10000
http://www.tdn.nl/index_frames.html?inhoud=/particulier/producten/onze_producten_topografie.html&navig=/particulier/nav_serverside.html%3Fscript%3D1