

## A GIS-assisted method for defining an integrated vision of a climate proof Groningen

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**Abstract.** Geographical Information Systems (GIS) are commonly assumed to be useful tools for spatial planning. However, attempts to support planning processes often result in technology-driven comprehensive solutions that risk enforcement of excessive constraints on the users. We present a study in which GIS is used as a flexible integration tool that provides maximum freedom to different stakeholders to jointly define a spatial plan. In this case many collaboratively created qualitative visions of the future were integrated into one consistent map of spatial adaptations for climate change as part of the preparation for a new strategic spatial plan for the province of Groningen in the Netherlands. The paper describes a GIS-based integration method and furthermore explores the usefulness of spatial analysis methods and a ‘Touch Table’ in this collaborative planning process. Sector-specific adaptation measures were selected, more accurately defined and manually relocated to minimize spatial overlap. The resulting integration map showed a combination of adjusted adaptation measures that was accepted by the stake-holders in the planning process. This user-centered case study shows that flexible, generic GIS-based tools are useful to: 1) make different sector-specific planning visions more concrete by making them become spatially explicit; and 2) support their integration.

### INTRODUCTION

According to James Throgmorton (2003) planning is persuasive story telling about the future. In this perspective planners are reshaping many stories and visions into one narration of how space needs to change. A planner’s task is thus collecting and integrating the views of many while being able to be held accountable for the resulting narrative. Throgmorton’s perspective is but one perspective on planning and probably unfamiliar to those generally involved in Geographical Information Systems (GIS). However, it provides a fitting analogy for the subject of this paper. Presented here is a case in which a GIS based methodology is explored and tested for the *integration* of many views on required spatial changes. The tested methodology has been driven by images of the future that various stakeholders created. The main question of this paper is: how can GIS support the integration of various spatially explicit views on the future that are extremely different in form, nature and objective.

Endeavours to structurally aid spatial planning have founded a class of so-called Planning Support Systems (PSS), broadly described by Te Brömmelstroet (2010) as ‘any kind of infrastructure which systematically introduces relevant (spatial) information to a specific process of related planning actions’. The list of available PSS is long (Geertman, 2002; 2009; Klosterman, 2001). Notably, some have explored the possibilities GIS offer in collaborative spatial planning (MacEachren, 2001; Van den Brink, 2007). In the greater share of PSS studies, technological improvements are the focal point of the research. Attempts to facilitate the planning process with a user focus, in which users’ input impose constraints on the methodology, seem scarce.

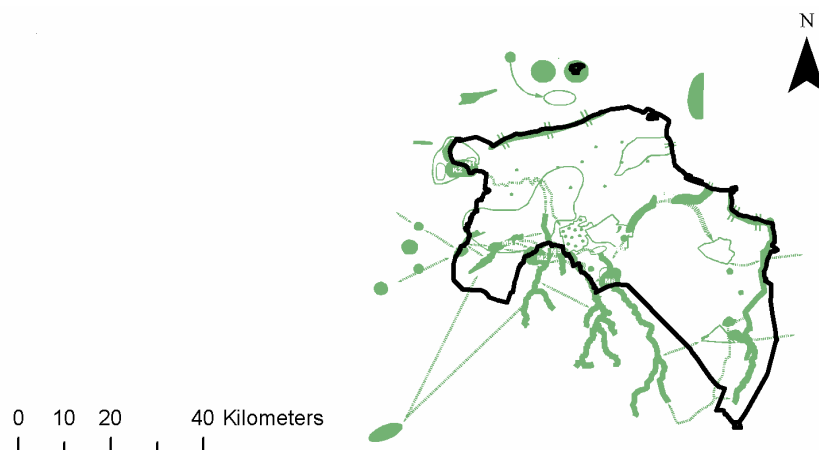
The integration of narratives presented in this paper has been done in the preparatory stages for a strategic regional plan for Groningen province in the north of the Netherlands. As is common in Dutch strategic regional planning most actors in this process were sectoral stakeholders, with sometimes conflicting interests (Hajer, 2000). The created narrative focuses on climate change and the spatial climate adaptation policies it requires. The results were foremost meant to make the public and politicians more aware of the impacts and necessities of climate adaptation.

Initial ideas on spatial adaptation measures have been produced and collected in the ‘hotspot Groningen’ process during a number of workshops with stakeholders (Roggema, 2009). Sessions were organized to identify the goals and aims of organizations working in the following sectors: water supply, energy supply, surface water, coastal safety, agriculture and ecology. In these sessions, participants collaboratively: 1) defined how climate change is likely to affect their sector; and 2) proposed measures to mitigate or adapt to the effects of climate change. In all sessions sets of proposed sector-specific adaptation measures were sketched on paper maps. The participants had substantial freedom in sketching these maps. No rules of classification, spatial accuracy, timeframe or ambition were imposed on the sketches and proposals. In total, four sessions produced 28 separate maps that were subsequently digitized into vector format GIS files with only nominal classifications as attributes.

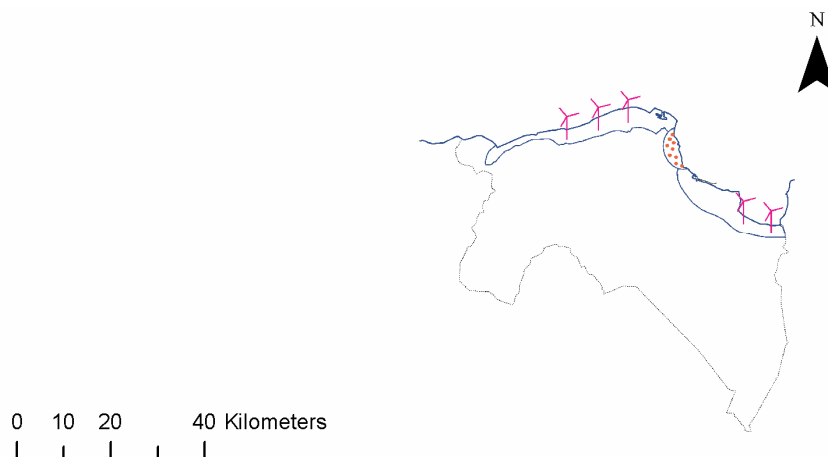
Eventually, the available session result maps had to be integrated into a single map of proposed adaptation measures. The authors and local representatives of Groningen province have collaboratively integrated these measures. Such an integration of many differing and possibly conflicting ideas on climate adaptation required a robust, user-centered integration method that makes use of specific analysis and interaction tools. This method will be described in the next section.

## METHODOLOGY

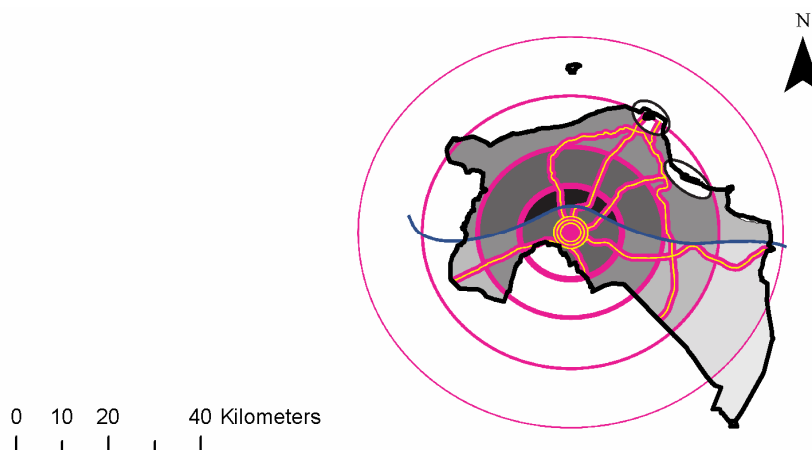
Elements of different sectoral views needed to be integrated into one *consistent* narrative of *feasible* and *effective* adaptation measures. For a consistent story all elements on the final result map needed to be non-conflicting. Thus our initial attention focused on clarifying whether potential conflicts occurred. The integration was, however, severely constrained by the extremely heterogeneous character of the different maps with adaptation measures. These maps were ontologically inconsistent and often lacking spatial detail: some maps showed concise claims of land to cope with climate change (see Figure 1), while others combined spatially explicit and implicit information by including, for example, decorative elements, indicatively designated areas or randomly chosen locations (Figure 2). Yet other maps provided purely conceptual ideas, depicting only schematic system designs (Figure 3). Lastly, the way map elements related to current land use, the environment and each other was not defined comprehensively. It was clear that substantial transformations of the original material were necessary. Too drastic transformations were not possible, however, as the resulting maps had to be acceptable for the initial stakeholders. Therefore, the integration was performed with the help of a limited number of local and sector-specific experts.



**Figure 1:** Land necessary for climate-change proofed ecological structure in Groningen.



**Figure 2:** Ideas of a sustainably used coastal protection area; combining coastal protection areas and wind turbines as decorative elements.



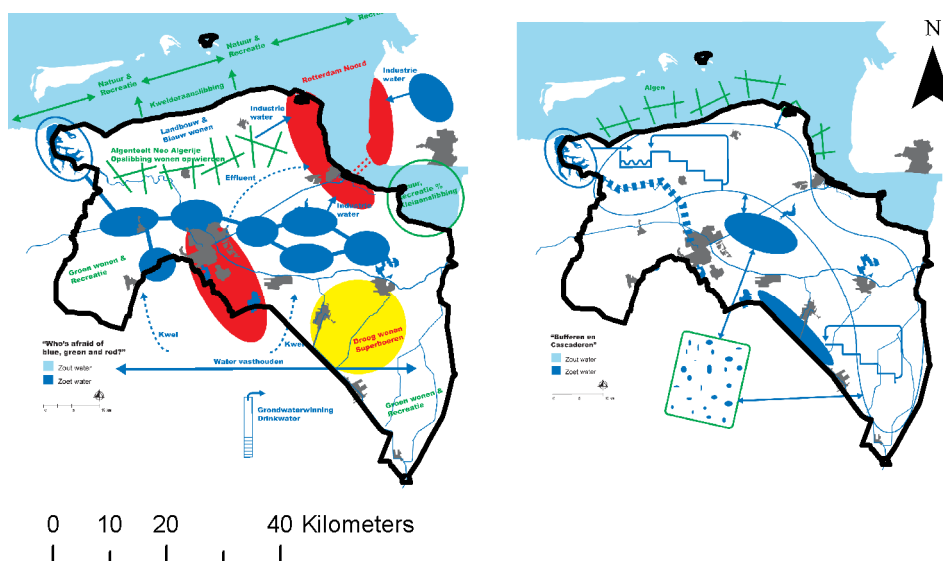
**Figure 3:** Conceptual visualization indicating measures of energy-use sustainability of urban land-uses at a location.

The elements on the available maps were only comparable as nominal entities that consisted of a location, an amount of covered area and a classification. No further clarification or valuation was possible. The integrators therefore decided to compare sectoral sets of adaptation measures by the area that the adaptation measures occupied on maps. All adaptation measures proposed by a single sector were assumed not to conflict internally. Spatial overlaps between elements of different sectors were assumed to be potentially conflicting.

The integrators chose to aim for one map with only spatially explicit, accurately defined and accurately located features with the least overlap possible. The integrators then integrated the available material by first *selecting* and then iteratively *defining*, *localizing* and *combining* adaptation measures. These steps are illustrated below with the steps taken to integrate the maps for water supply. In the subsequent sections, two specific GIS-assisted elements of the integration method (overlay analysis and interaction stimulation) are highlighted.

### Integration steps

First, measures were *selected*: to reduce the selection to comparable measures, only spatially explicit features on the maps were considered for further processing. Text and features with a solely decorative or communicative purpose were removed from the maps. Features that presented opportunities or planned adaptation measures for other sectors were removed as well. Maps that contained schematics rather than land use were initially left out of the analysis while the related sector experts were asked to specify their ideas into land claims. The maps created for water supply are a good example. One workshop on water supply yielded four maps that showed system schematics on some maps, elements that did not relate to water supply on other maps. In general the water supply-maps seemed conflicting with each other (see Figure 4). Only for water supply, all maps were rejected and an intermediate workshop was organized to better define that sector's adaptation measures.

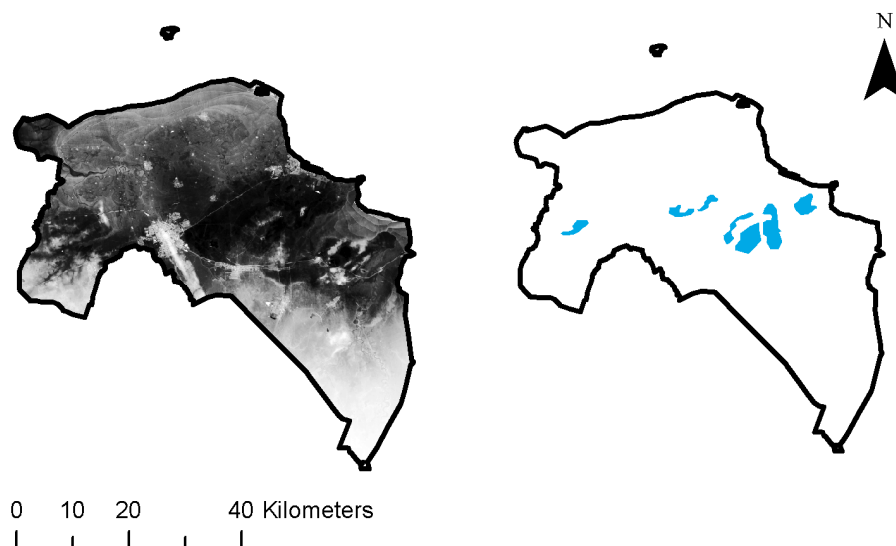


**Figure 4:** Two of the four initial water supply concepts: left a visualization of possible freshwater supplies and related suitable areas for urban and agricultural land uses; right a diagram indicating how a climate proof water supply system could function.

Next, the spatial implications of adaptation measures were more specifically *defined*. In this stage, features of which the purpose, meaning or amount of occupied land was unclear were more accurately defined, while system schematics were turned into estimates of necessary locations and areas for a sector. For example, during the intermediate workshop water supply necessities were more accurately defined as 100 hectares land in the province.

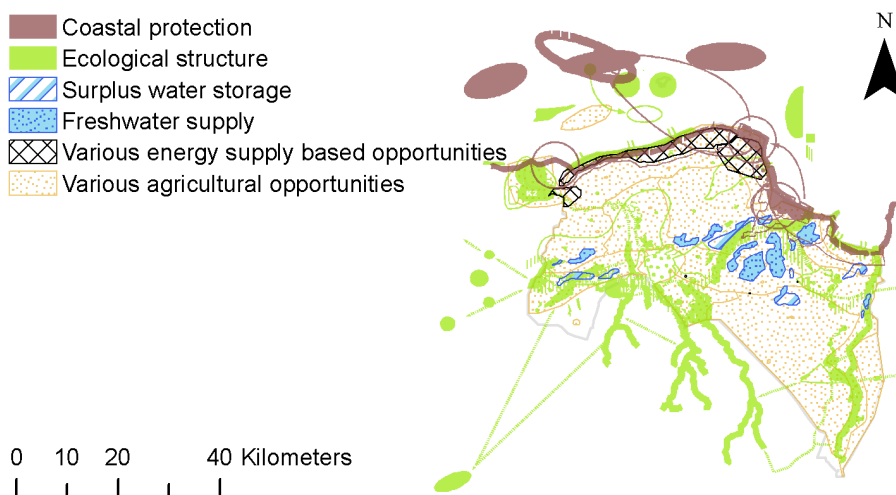
Third, adaptation measures were *localized*. In this stage conflicting or unclearly located features were (re)located. For example, in the intermediate workshop criteria for water supply locations were defined: low-lying areas, outside built-up areas. Subsequently a GIS analysis was performed to specify the most suitable areas for freshwater supply (Figure 5).

Fourth, sets of adaptation measures were *combined*. In the combination stage, layers containing all sector maps were visualized. Between the layers potential conflicts were then sought. The resulting combination was then again tested for conflicts.



**Figure 5:** Example of localization step using height map (in left map, lighter areas are more elevated; source: AHN) to designate locations for freshwater supplies in times of drought (in right map in blue).

Eventually integration resulted in the map depicted in Figure 6. In a later presentation this map was accepted by stakeholders as the final comprehensive map of spatial adaptation measures for Groningen. This map served as foundation for a subsequent scenario analysis of future climate adaptation options and was furthermore used as a reference map in the discussions on strategic spatial planning in Groningen (Roggema, 2009).

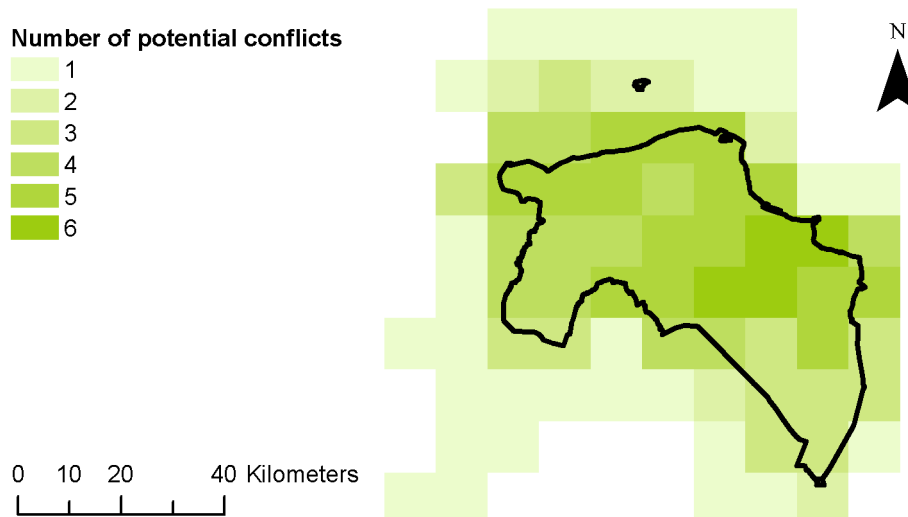


**Figure 6:** Integrated sector-specific adaptation measures resulting from the expert sessions in the hotspot Groningen process (simplified for clarity).

### Pinpointing potentially conflicting claims

To pinpoint those areas where different claims offer potential spatial conflicts, a straightforward raster-based overlay was applied. Various 'Claim Overlap' indicators were calculated by counting the number of sectors that occupy land within rectangular grids of different dimensions covering the province. A grid resolution of 10 x 10 km was found to be most informative for this analysis. The results show that most potential conflicts are concentrated in a low-lying area slightly east of the centre of the province (see Figure 7).

More elaborate methods could have been used to underpin transformation choices. For example system dynamics methods (Anderson, 1997) could have been used to define the influence elements have on each other, enabling more precise assessment of the nature of the conflicts. Alternatively, techniques such as Multi Criteria Analysis could have been used to assess potential solutions for conflicts. However, such more elaborate techniques require more specific information on the functional and locational characteristics of adaptation and such information was not available. In fact, more detailed conflict analyses were not considered to be useful in this preliminary stage of the planning process.



**Figure 7:** Result of claim overlap analysis showing possible conflicts between sector-specific ideas.

### Stimulating stakeholder involvement

In previous participatory sessions the authors observed that, especially when a varied group of participants attend, workshops often suffer from lack of participant involvement; in such sessions many participants neither interact with each other nor contribute to the final result. A so-called Touch Table was therefore used to stimulate stakeholder involvement during two workshops that were attended by a varied group of stakeholders. A Touch Table facilitates interaction between a limited number of participants and spatial data stored in a computer (Scotta, 2006). The device showed the collected spatial information in a GIS application (ArcGIS) on a table surface. It furthermore allowed participants to sketch and comment on the surface (see Figure 8).

The Touch Table was used in the collaborative sessions for a number of reasons. First, using a GIS was expected to allow user-friendly (and automatically geo-referenced) drawing and editing of maps; the results would subsequently be easily presentable. Second, using a GIS made an abundance of data

and analysis options available to participants, which was expected to add value in the session. Third, the table setting was expected to better facilitate face-to-face communication than a 'behind-the-screen' setting. Fourth, the novelty of the table was expected to entice participants to interact and share on the table.

During the sessions GIS was only used as a drawing and presentation tool. Little additional GIS functionality was used by the participants, who, in fact, mostly asked a moderator to manipulate the system. Although an extensive amount of sector-specific adaption options and background information was available as data layers in the GIS, only the initially projected integrated map was used in the session. Apparently, the participants, mostly sectoral experts working in the province, had sufficient knowledge of the region's characteristics and did not need additional information. That little GIS functionality was used, may be related to the fact that participants were unaware of the capacities of GIS. Furthermore, the off-the-shelf ArcGIS graphical user interface did not allow moderator-free interaction with the Touch Table.

Several benefits of using GIS in combination with a tangible user interface were observed. Using a GIS instead of paper maps allowed the participants to copy, paste, change and delete elements after they added them; a feature they used often. The table setting allowed four to five people at a time to view the work and communicate comfortably. The simultaneous projection of intermediate steps and resulting maps on a wall enabled larger groups to follow the work in progress more clearly than possible with 'paper maps on a table' or 'behind the computer screen' settings. This led to a moderate degree of group participation. Finally, the participants enjoyed using the Touch Table. Whether novelty value or intrinsic value of the technology, it worked enticingly.



**Figure 8:** The Touch Table setup used during the final session.

## CONCLUSIONS

This paper presents a method to integrate sectoral adaptation measures into a single map. The adaptation measures were defined by sector experts for themes such as water supply, ecology and coastal protection in creative, interactive sessions without posing specific constraints for subsequent integration. The resulting heterogeneous nature of the available adaptation maps offered a considerable challenge for developing an integration methodology. We focused on the unifying component of all adaptation measures: their spatial dimension. Several steps were followed in the integration of the available maps with adaptation measures. First, the spatially explicit elements were selected, then they were more specifically defined and localized and, finally, they were combined into a coherent map. The resulting, integrated map was accepted by all participants and laid the foundation for two consistent scenarios of future climate adaptation that were subsequently developed. The participants and the planning authority wished to convey the urgency and the impact of climate change for their region. If anything, the resulting map tells this narrative splendidly.

Some GIS-assisted analysis and user interaction possibilities were explored in the integration process. A straightforward claim overlap analysis allowed the pinpointing of regions of potential conflicts between different adaptation options. We pose that, especially when participant input is abundant, methods like the applied claim overlap analysis are a useful addition to planning support. The stakeholders in the planning process did not show interest in further quantitative methods for underpinning decisions; nor was the explorative, early-stage nature of the process suited for such methods. To support stakeholder interaction in two integrative sessions that aimed to define a coherent integration map a so-called Touch Table was used. The participants enjoyed using this tangible user interface to add and edit information on maps. The presentation and drawing options and the general workshop setting around the table added value to participatory interaction. However, GIS and Touch Table functionalities were used less than possible, indicating that advanced analytical tools and vast collections of spatial data sets are not essential in the preparatory stages of a planning process. A flexible presentation tool with basic, intuitive drawing options and a storage option seems to suffice here.

It is apparent that the user-centred approach that we chose to support the planning process is different from the more quantitatively-oriented and technology-focused tools that are commonly described in Planning Support System (PSS) literature (Geertman, 2002; 2009). In spite of great research efforts, these systems remain underused in spatial planning (Te Brömmelstroet, 2010; Vonk, 2005). From our experiences with the planning process of Groningen province we conclude that there is a large gap between what a PSS generally offers and what the planning community needs in the preparatory stages of a planning process. We pose that stakeholders need flexible, intuitive tools with limited analytical capabilities for their collaborative efforts to make strategic plans.

## ACKNOWLEDGEMENTS

The authors wish to thank the Dutch research programme Climate changes Spatial Planning for enabling this project. In particular we thank Rob Roggema who, during this project, proved to be an innovative and inspiring counterpart at the province of Groningen.

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