GIS time series mapping of the Ciskei homeland

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Abstract

This study reports on the creation and evaluation of a spatio-temporal mapping of the Ciskei, one of the so-called 'Bantustans' or 'homelands' located in South Africa. The Ciskei was created as a result of race-based legislation during the colonial and apartheid periods. Its geographical extent changed over time, and the spatial changes coincided with the promulgation of different legislation. Geographic Information Systems (GIS) technology was used to create a time series animation and a static map to display the spatial change of the Ciskei boundaries. Questionnaires and interviews were used to investigate two main aspects. The questionnaire's purpose was to investigate and compare map-readers' cognition at detecting change between static and animated maps. Interviews allowed the researchers to qualitatively assess the value of such an exercise. Both the animated and static maps have advantages over each other but neither one of them has an overall clear advantage, confirming previous research. There is value of such mapping to decision-makers in government, as such an exercise can contribute to a more nuanced understanding of legislative, cadastral, planning and historical effects.

1. Introduction

The South African government's Department of Rural Development and Land Reform (DRDLR) has identified the need for research on the effects of apartheid legislation that directly affected the creation of boundaries that separated the different racial groups. In particular, a spatial visualisation and analysis of the origination and effects of the Native Lands Act[1] of 1913 (subsequently renamed Bantu Land Act, 1913 and Black Land Act of 1913, Act No. 27 of 1913) needed to be carried out. The spatial change of geographic boundaries that occurred in so-called 'homelands' (or 'Bantustans') over the years between 1913 and 1994 has been significant. In addition to this, the boundary changes that have affected the Ciskei over time is not well described. Thus the Ciskei homeland has been selected as a case study for time series mapping using Geographical Information Systems (GIS) technology. Additionally, a good understanding of the change of the Ciskei boundary over time can be utilised by government in the prioritisation of service delivery in specific district municipalities (or parts thereof).

1.1 Background

The Ciskei homeland was located in the Eastern Cape Province of South Africa. Ciskei was created as a reserve for the South African Xhosa-speaking people as part of apartheid racial segregation in 1913. Despite government rhetoric that this would encourage cultural protection and separate development of its people, the Ciskei and other homelands served to provide white South Africans with cheap, controlled labour (Christopher, 1994). Even though the Ciskei does not exist today, its legacy can be seen in the pattern of the current populated areas. A calculation of the population density using the 2011 census data shows that the towns that were in Ciskei have higher population densities than towns that were not part of the homeland in the Eastern Cape Province. The 1913 Land Act was followed by numerous legislation and acts that had a direct or indirect effect on the Ciskei boundary. In this research, the acts were linked to maps of the Ciskei, and presented as animated and static time series maps.

The spatial change in geographic boundaries that occurred in Ciskei over the years from 1913 to 1994 has been significant. According to management of the DRDLR (CD: NGI, 2015), South Africans are generally aware of the history of the Ciskei, but not of the boundary changes that have occurred over time. Thanks to a long tradition of cartography in South Africa, good quality mapping of the territory has been produced since colonial times. As a result of the development of mapping and graphic design technologies, historical maps are no longer considered as static graphic documents offering the grounds for historic, sociological or literary studies. The historical maps become an important source of spatial information, containing important geographic information related to geometry. Modern technologies offer new thinking for the study of early cartography and maps. This opens new possibilities in cartographic heritage research (Balletti, 2006). For these reasons, the Ciskei has been selected as a case study for time series mapping using GIS technology.

1.2 Time series mapping

Even though GIS and geographical databases have existed for the last few decades, it has only been in the last few years that attention has been given to the temporal dimension. This has been driven by the need to analyse spatial patterns and their change over time. The data models available within existing GIS can be used to generate snapshots of time to create a temporal series. These would then be used as spatio-temporal elements in a subsequent representation (Peuquet & Duan, 1995). This 'snapshot approach' can be recognised variously in Monmonier's (1990) strategies for the visualisation of time-series geographic data.

Dawood and Motala (2015) conducted a study in which they evaluated an animated and static time series map of District Six. Participants were asked questions based on Peuquet's (1994) conceptual framework which linked GIS to spatio-temporal dynamics. They concluded that there are advantages and disadvantages associated with static and animated map displays. This research is an extension of Dawood

& Motala's (2015) research, with a more rigorous qualitative analysis. It too compared map-readers' cognition at detecting change between static and animated mapping, and also investigated the benefits of a time series animation to governmental agencies. In addition to this, another aim of this research was to show the changing boundaries of the Ciskei together with the racist legislation that created them.

1.3   Animation

Animation in cartography can show changes in time and/or space. There are two types of animation: temporal which shows change through time, and non-temporal which is not time related but shows change in other variables such as space or attributes (Tyner, 2010). The effectiveness of an animation depends on different factors related to characteristics of the data represented (e.g. complexity, spatial and temporal resolution), and to the design of the animation (e.g. use of visual variables, controls provided, and multiple views of the data). It also depends on the purpose of the animation, characteristics of the user, and of the user environment. The complexity of interactions of these factors prevent straightforward conclusions. Additionally, the full potential of cartographic animation has not yet been fully realised. For example, interactive control of animation by the user has yet to be fully explored and exploited (Koussoulakou & Kraak, 1992, Blok, 2005).

Animations and videos are normally designed to present information that includes change over time, in such a way as to aid understanding and facilitate learning. However, in some studies, static map displays have been found to be equally beneficial and sometimes better (Arguel & Jamet, 2009). Like the District Six study (Dawood & Motala, 2015), this study evaluates the effectiveness of static and animated maps at conveying spatio-temporal information of the Ciskei.

2. Methodology

In order to produce a mapping of the Ciskei together with the legislation that created it, spatial and attribute data had to be collected from multiple sources, such as historical documents, legislation, official maps from the national mapping agency National Geo-Spatial Information (NGI), the offices of various provincial Surveyors-General, and statistical information from Statistics South Africa. The relevant legislation that played a role in the formation of the homelands was obtained mainly from the Government Gazettes that were published at the time. The Gazettes contained the proclamations that affected the boundaries of the homelands.

A static time-series map and an animated map (which was inserted into a narrated video – a digital story) were produced and evaluated. For the analysis, quantitative as well as qualitative data analysis techniques were used. Various participants took part in the study. Interviews and questionnaire data were collected from government agencies who would benefit from this research, such as NGI, the Surveyor-General's Office (East London) and the Chief Directorate: Land Restitution Support. The questionnaire's

purpose was to investigate and compare map-readers' cognition at detecting change between static and animated maps. This, together with the interviews allowed the researchers to qualitatively assess the value of such an exercise.

2.1 Static Maps

Polygon layers representing the boundaries of the Ciskei between 1913 and 1994 were first created, in order to be able to produce a static time-series map. The type of graphics called small multiples (Fish, 2010), which allow map users to distinguish the change over time, was used. The boundary and fill for each time period was symbolised according to three colours: red representing the Ciskei, yellow representing the area added to the Ciskei and blue representing the area excluded from the Ciskei.

Beside the Ciskei boundary, each map contained five layers (towns, rivers, provincial boundaries, districts municipalities' boundaries and the boundary of Transkei as it was in 1994.) These layers were displayed over a satellite image of one kilometre resolution. These additional layers provided contextual information for the viewer. In addition, each map contained information such as the legislation that affected the boundary, the year, the area of the Ciskei and the perimeter. An abbreviated form of the final static map, showing the main elements is shown in Figure 1. The final map that was used for the questionnaires and interviews was printed large (A2 size) so that all the details could be seen.
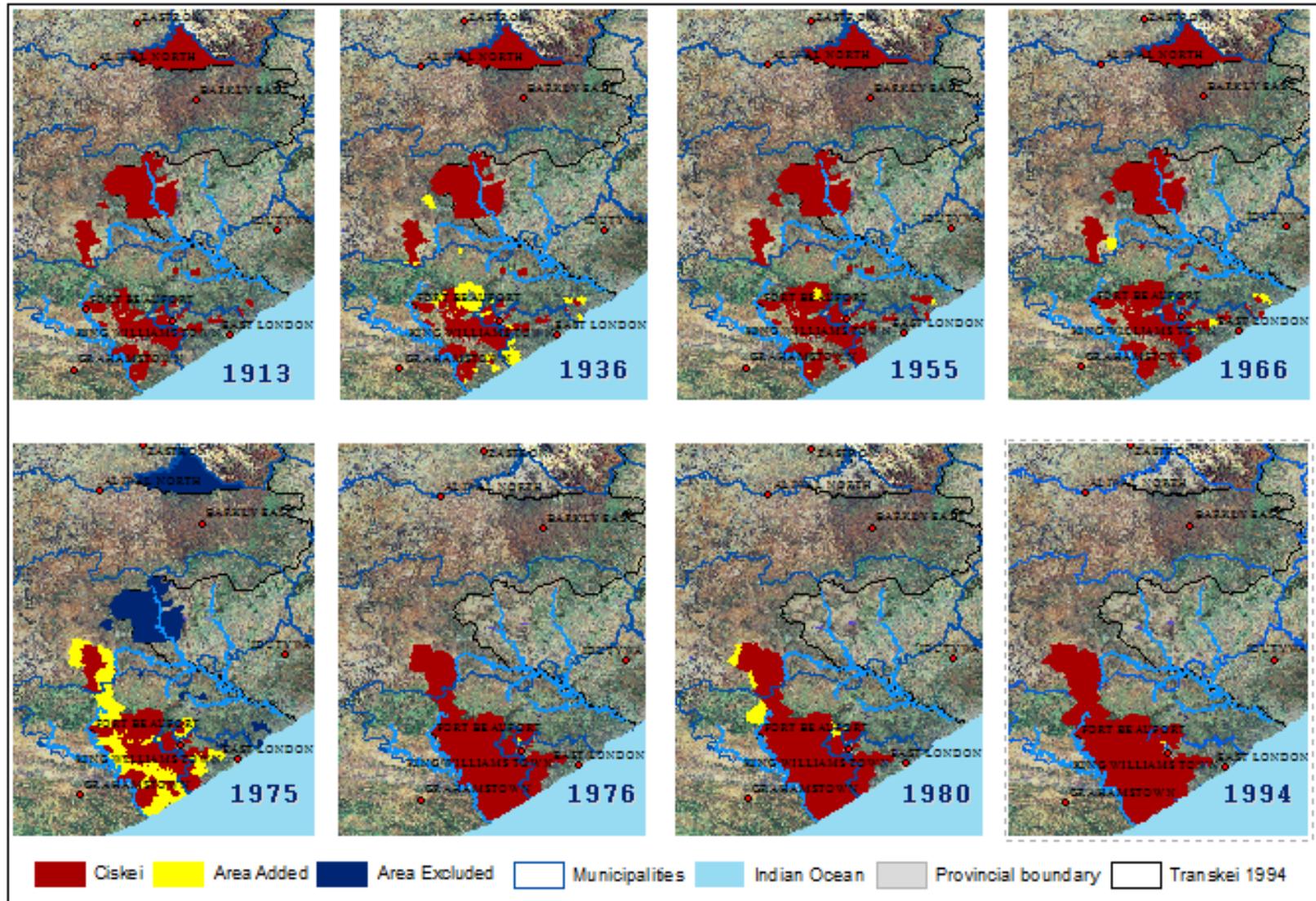
Figure 1. Time series map of Ciskei between 1913 and 1994

2.2 Animated Maps

A time series animation in the form of a narrated video was created, rendering data from 1913 to 1994[2]. The final animation did not show any part of the GIS interface that was used to create it, to make it easy to be understood by the map-readers who were not experienced in GIS technology nor exposed to it on a regular basis. In the event of the interface being more complex, the abovementioned map-readers might abandon the map as they could feel intimidated, rather than because they do not have the ability to understand the map (Harrower, 2003).

The Time Slider tool within ArcGIS software was used to generate the animation from the vector data. Each "snapshot" of time was then exported as an image into video editing software, which was used to create the final digital story. A total of eight images was exported from the time slider. A significant advantage of exporting the imagery from the Time Slider is that the data is geo-referenced, hence allowing for a smooth transition between images for visualisation. These images were inserted into video editing software. Similar cartographic specifications (e.g. colours, legend and layers used) as used in the production of the static map were used for the animation.

2.3 Evaluation of change detection

One of the objectives of this research was to evaluate animated and static time series maps with regard to spatial change and information detection. In particular, people's ability to detect change in the two different types of mapping was evaluated. To this end, a questionnaire was designed using Peuqet's (1994) triad of questions, and built upon previous similar research (Dawood and Motala, 2015). Peuquet (1994) developed a conceptual framework linking GIS to spatial temporal dynamics. As shown in Figure 2, central to the framework is the where/when/what triad of questions.
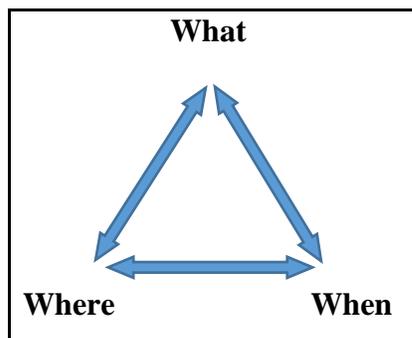

Figure 2. The geographic experience triad, from Peuquet (1994)

Peuquet concluded that the geographic experience can be accessed from three various angles, facilitating three simple questions:

1. When + where $\longrightarrow$ what: Describe the features (what) that are present at specified positions (where) at specified times (when).

2. When + what $\longrightarrow$ where: Describe the features (where) involved by specified positions (what) at specified times (when).

3. Where + what $\longrightarrow$ when: Describe the times (when) that specified features occur (what) involving a set of positions (where) (Dawood & Motala, 2015).

There is evidence that people store 'what', 'where' and 'when' knowledge in a particular knowledge hierarchy, associating it with relevant characteristics and purposes (Mennis et al. 2000). The triad questions were considered when designing the questionnaire. Two sets of questions for each type (what, where and when) were designed to test the change detection ability of map viewers. In addition to this, a set of spatial change questions was included, following the methodology of Dawood & Motala (2015). The questions, together with the aggregated responses, are shown in Table 2 further on.

A total of forty participants completed the questionnaire. Twenty were employed in the geospatial industry and familiar with change detection in mapping. The remaining twenty were not employed within the geospatial industry, and not familiar with geospatial data, other than on a purely superficial level. The larger group was split up into two groups, one to view the static map, and one to view the animation. No participant saw both the static and animated maps – this would unfairly advantage the second product observed, since familiarity with the map would be obtained from the first viewing. A breakdown of how the participants took part in the research is shown in Table 1.

Table 1. Questionnaire participants.

Questionnaire Responses 40 Participants			
Static printed map 20 participants		Animated map 20 participants	
10 participants in the geospatial industry	10 participants not in the geospatial industry	10 participants in the geospatial industry	10 participants not in the geospatial industry

3. Results and Analysis

3.1 Questionnaire results

In light of the comparative analysis of this particular study, both the animated and static map were found to have advantages over each other, but neither one of them had an overall clear advantage. This confirms previous studies conducted in this regard (e.g. Dawood & Motala, 2015).

Table 2. Overall correct results of animated and Static Map in relation to the triad assembly of questions and spatial change

	Questions	SM (Static Map)	AM (Animated Map)
Triad question types	**What** was the approximate area of Ciskei in 1981?	45%	65%
	What was the Act that declared Ciskei as an Independent State?	55%	55%
	When was Ciskei established?	70%	65%
	When did Ciskei become a single consolidated area?	55%	55%
	Where is King William's Town located?	75%	60%
	Where was the Herschel district located in 1966?	90%	80%
Spatial change	During which period was the consolidation plans effected?	55%	55%
	What year was there the most drastic changes to the Ciskei boundary?	55%	60%

An analysis of the questionnaire results showed that the majority of participants selected the correct answers across all question types (what, when, where and spatial change). The *what* question type showed advantages of the animated map over the static map, with more people being able to correctly estimate the area of the Ciskei from the animated map. For the *when* questions, neither map is clearly advantageous over the other, although the static map fared marginally better. For the *where* questions, the static map clearly performed better than the animated map. In explaining this difference, the *where* result could be attributed to the restrictions of animated maps explained by Harrower (2003). With regards to complexity, one of the disadvantages of animated mapping is that it cognitively overburdens the viewer who in turn does not benefit: "Burdening the user with more information than they can process in real-time, undermines the map's design and may confuse or mislead the reader." (Harrower, 2003, p. 64). Related to this is the fact that with the static map, readers had more control over the time they spent looking at various parts of the map, as opposed to the animated map, where the timing was inflexible. With regards to the *spatial change* questions, both sets of mapping performed almost equally, with the

animated map being marginally better. When comparing the performances of the geospatial vs. non-geospatial participants, there is a clear differential, with the geospatial participants having better answered all questions, as expected.

3.2   Interview Results

Interviews were conducted with senior staff employed at the Chief Directorate: National Geospatial Information (CD: NGI), the Surveyor-General (SG) - East London and CD: Land Restitution Support. The purpose of the interviews was to investigate the benefits and uses of the mapping to governmental organisations. Both the static and animated maps were shown to the interviewees. The interviews were analysed using standard qualitative research techniques (see for example Creswell, 2013). From the analysis, several key findings were made.

The first finding was an emphasis on the importance of conducting spatial historical research in order to better understand the impact of colonialism and apartheid on the South African geopolitical landscape. People have asserted that whites own 87% of the land and blacks own 13% of the land. There has, however, never been actual geographic evidence for this assertion, which has been used many times by politicians (PLAAS, 2013). There are elements of truth in the claim, but the overall picture is considerably more complex, as attested to by the recently published Land Audit Report (Republic of South Africa, 2017). These complexities have important implications for land policy. Due to space constraints, these cannot be further explicated here.

Secondly, such a study could help various government departments to prioritise resource allocation. The historical Ciskei falls in the current municipalities of Chris Hani, Amathole and Buffalo City, hence more attention needed to be focused there due to greater levels of inequality, historically poor services and underdevelopment in those areas. Also, it is important to determine which areas were subject to homeland legislation, as current town planning practice must be informed by it.

Thirdly, this analysis would assist in supporting the land claims process. The mapping can easily confirm which areas fall inside or outside the Ciskei. This study focused on the areas where people were moved *to*, i.e. the homelands. However, it is also important to conduct historical research on the areas *from* which people were forced to move. Accurate maps of removals areas will help Land Restitution Support to focus resources, bearing in mind that the land claims process closes in 2019. The fact that a person lived in a homeland does not, in itself, make him/her a restitution claimant. They could have been there already, but if they had been forced to move from elsewhere, then they could be a potential claimant. Therefore it is important to know the place of dispossession too.

4. Conclusion

From the comparative analysis of the questionnaire data, both the animated and static maps have advantages over each other but neither one of them has an overall clear advantage, confirming previous research. The animation can help to tell the historical story, the spatial change as well as the reasons that caused the change. The static map, on the other hand, is useful for research and measurement.

This investigation brings up the possibility of other interesting research. Zooming in, one could add historical cadastral boundaries and investigate the movement of people at the level of individual farms. Also for land restitution purposes, this methodology could go further back in time and investigate what happened before 1913. This would help to better understand where people came from and how much land they lost. One could also extend this to all historical homelands in South Africa, so as to get a better understanding of land dispossession.

5. Notes

1. The Act is variously referred to as 'Native Land Act', or 'Natives Land Act' or 'Native Lands Act' in different documents.

2. The video can be accessed at https://www.youtube.com/watch?v=OLX_XlZ1wKA.

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