Perception of urban sustainability and environmental risk: the use of color schemes

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Abstract. Developing effective and reliable methods for representing and communicating geoinformation to decision-makers is a relevant challenge in GIS-based modeling and map making. Among all the choices one should make regarding map design to succeed in communicating information through maps, those related to symbology are crucial. Color schemes, in particular, can lead to completely divergent interpretations depending how they are applied. The management and planning of the Campus do Vale (Federal University of Rio Grande do Sul) in Southern Brazil, as virtually any other institution, relies on many cartographic information. Flood risk and urban suitability models are examples of indexes that must be considered in this process, as the local environmental agency requires. They consist in a relative measure, ranging from 0 to 255, so the understanding of the parameter per se is not an easy task for everyone. Besides, the possibilities of how to represent information of this nature is diverse, and a bad graphic choice would likely ruin the ability of the audience to understand important information in building the University expansion plans. In this case study, we test 8 different color schemes to represent urban suitability and flood risk. Undergraduate students with background in Cartography and GIS were asked to complete a questionnaire so that information about how easy it is to associate a color scheme to a parameter and to distinguish different levels of risk/suitability could be collected from the answers. To represent urban suitability, a blended palette ranging from red (low suitability) through yellow and green to blue (high suitability) was pointed as the best, given the prompt association between color and parameter. However, the classified version of this map (consisting in 5 classes: red for very low, orange for low, yellow for moderate, green for high, and blue for very high suitability) showed the best results in allowing to identify places in specific levels of suitability. The flood risk, on the other hand, was better associated to a blue palette, ranging from light blue (low risk) to dark blue (high risk).

Again, once classified, the map readily allowed to identify places in specific levels of suitability. We conclude that even if urban suitability and flood risk are both ranked data, presented with the same range, the nature of the parameter influences its association with a specific color scheme. However, in both cases, a classified map separating the continuous range of data in 5 classes, from very low to very high, helped the user to identify different levels of suitability/risk, indicating that simpler representations may be a better choice than fancy, complex ones. In this study the audience was familiar with the map-making process. We believe that simpler representations would benefit even more users with no skills in geoprocessing techniques and very basic knowledge of Cartography. Thus the follow step is to test the same representations in the understanding of urban suitability and flood risk by managers of the university to obtain further information of the color scheme effect on the cartographic communication in dealing with a different audience.

Keywords: color, perception, geovisualization, representation, decision-making

1. Introduction

Developing effective and reliable methods for representing and communicating geoinformation to decision-makers is a relevant challenge in GIS-based modeling and map making. Among all the choices one should make regarding map design to succeed in communicating information through maps, those related to symbology are crucial. Color schemes, in particular, can lead to completely divergent interpretations depending how they are applied.

The effect of color on map reading has been reconized for decades. Wood (1968) states that a group of predictable results has been gained from experiments involving the discrimination of meaningless isolated patches of color, but when colors have shape and these shapes are in complex association, there occur some variations in normal color response which are most significant to map designers. These variations reduce the range of observable steps of discrimination in every way. Further than that, colors have to be suitable to their related geographical themes: it means that a selected color for a theme is adapted to the semantic of the theme, facilitating its readability and understanding by another user (Christophe, 2011). And not only that: choosing map colors goes beyond considering what colors might be related to the mapped topic, since people's opinions about which colors best represent a topic often conflict (Brewer, 2005), so an analytical approach to choose map colors is needed.

The management and planning of the Campus do Vale (Federal University of Rio Grande do Sul) in Southern Brazil, as virtually any other institution, relies on many cartographic information. Flood risk and urban suitability models are examples of indexes that must be considered in this process, as the local environmental agency requires. They consist in a relative measure, ranging from 0 to 255, so the understanding of the parameter per se is not an easy task for everyone. Besides, the possibilities of how to represent information of this nature is diverse, and a bad graphic choice would likely ruin the ability of the audience to understand important information in building the University expansion plans.

The goal of this study is to assess the color scheme effect on the perception of urban suitability and flood risk GIS-images of the Campus do Vale. This information would allow us to enhance maps in terms of communication power and, in doing so, better support the decision-making process of the university.

2. Material and methods

In this case study, we tested 4 different color schemes to represent urban suitability and flood risk, applied in two different ways: in the first one, continuous raster values are drawn along a color ramp, and in the second, raster values are grouped into five classes (separated by natural breaks). In two color schemes we used lightness to represent the ordering of data. The chosen hues in these cases were grey and blue. In the other two color schemes we used divergent schemes. One of them varying from blue to red, with light grey to represent the mid-point. The other one is a spectral scheme, from green to red, with yellow representing the mid-point. Figure 1 shows the eight total options we tested.

Undergraduate students with background in Cartography and GIS were asked to complete a questionnaire so that information about how easy it is to associate a color scheme to a parameter and to distinguish different levels of risk/suitability could be collected from the answers. The questionnaire were avaible through a virtual learning environment called NAVi (Núcleo de Aprendizagem Virtual). Two questions were asked about each one of the parameters (urban suitability and flood risk), but they were not numbered, so the students could choose the order of answering they prefered. We recognize that the students possibly excluded the color scheme chosen in the first question in answering the second one, even if they were instructed otherwise. The questions were the following:

About urban suitability:

Which color scheme you consider the most suitable to depict urban suitability?

(A) Spectral scale, from blue to red with yellow representing the mid-point
(B) Diverging color scale, from blue to red, with light grey representing the mid-point
(C) Sequential scale in grey
(D) Sequential scale in blue

Considering the two representations avaible for the color scheme you just chose, which one you consider the best if you needed to find an area within a specific degree of urban suitability?

(A) Continuous raster values drawn along a color ramp (continuous color sequence)
(B) Raster values grouped into five classes (separeted by natural breaks)

About flood risk:

Which color scheme you consider the most suitable to depict flood risk?

(A) Spectral scale, from blue to red with yellow representing the mid-point
(B) Diverging color scale, from blue to red, with light grey representing the mid-point
(C) Sequential scale in grey
(D) Sequential scale in blue

Considering the two representations avaible for the color scheme you just chose, which one you consider the best if you needed to find an area within a specific degree of flood risk?

(A) Continuous raster values drawn along a color ramp (continuous color sequence)
(B) Raster values grouped into five classes (separeted by natural breaks)

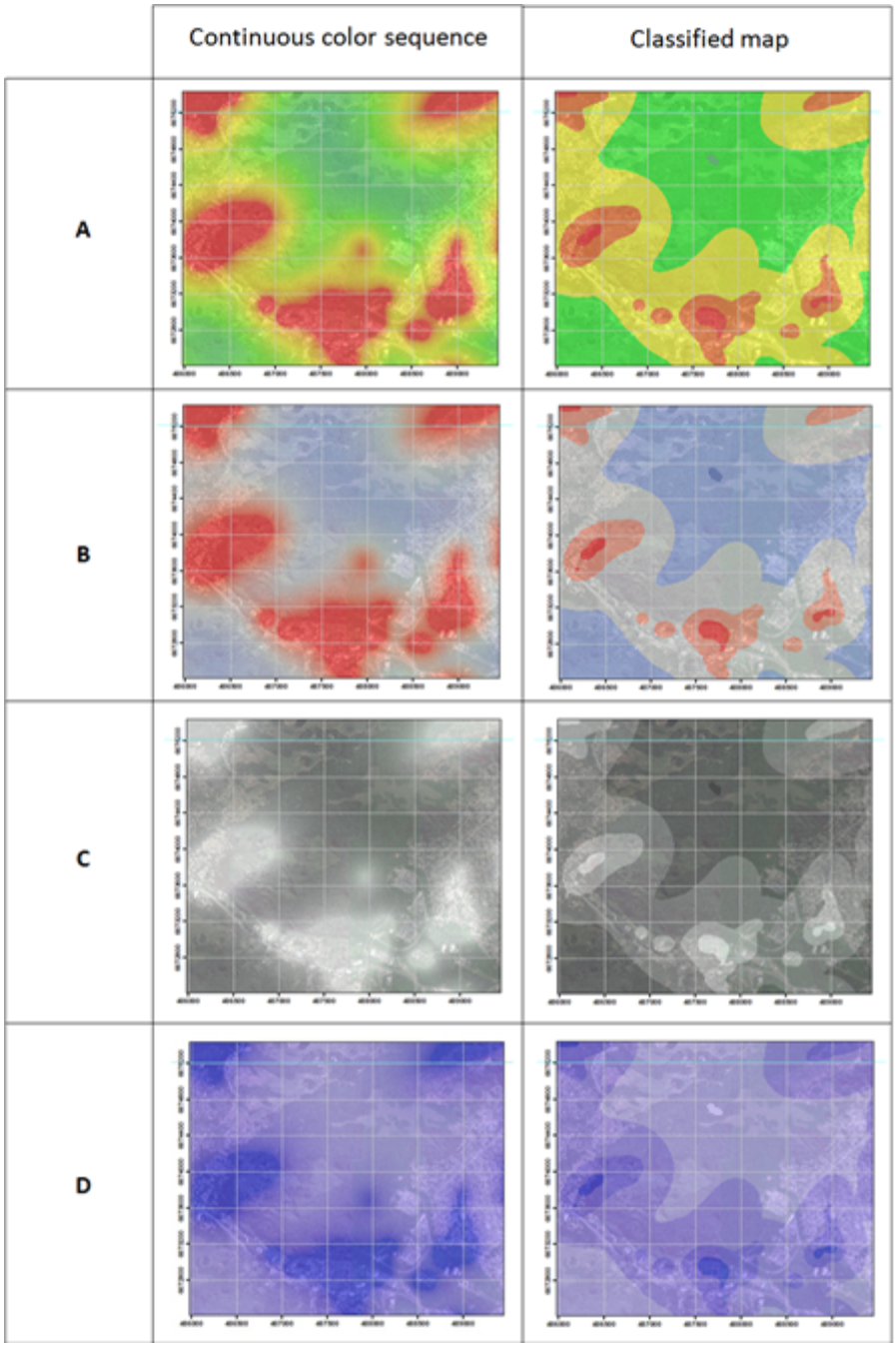

Figure 1. The color schemes tested in two versions: continuous raster values are drawn along a color ramp on the left, and raster values are grouped into five classes based on natural breaks on the right.

3. Results

A total of 20 students answered the questionaire. Altough the general recommendation made by cartographers to avoid spectral schemes (Brewer, 1999), a blended palette ranging from red (low suitability) through yellow and green to blue (high suitability) was pointed as the best to represent urban suitability (65% of the answers). Option B, also a diverging scheme, was the second better scheme (the other 35% of the answers) related to urban suitability. No one voted on sequential schemes based on lightness to depict urban suitability. Flood risk, on the other hand, was better associated to a blue palette, ranging from light blue (low risk) to dark blue (high risk) (75% of the answers). 25% of the students chose the option B to depict flood risk. For both parameters, the classified version of the maps was prefered (85% of the answers).

4. Conclusion

We conclude that even if urban suitability and flood risk are both ranked data, presented with the same range, the nature of the parameter influences its association with a color scheme. Suitability, even if presented in a continuous way, recalls the idea that certain areas area suitable and others are not (two extremes), and this may be the reason why students associated it to a divergent scheme. Flood risk, on the other hand, is a quantitative measure, and was mostly associated to a sequential scheme based on a hue easely associated to water. In both cases, a classified map separating the continuous range of data in 5 classes, from very low to very high, helped the user to identify different levels of suitability/risk, indicating that simpler representations may be a better choice than fancy, complex ones. Once classified, it seems that the map readily allowed to identify places in specific levels of suitability and risk. The preference for classified maps may be an antecipation to decision-taking problems that could solved based on these maps.

In this study the audience was familiar with the map-making process. We believe that simpler representations would benefit even more users with no skills in geoprocessing techniques and very basic knowledge of Cartography. Thus the follow step is to test the same representations in the understanding of urban suitability and flood risk by managers of the university to obtain further information of the color scheme effect on the cartographic communication in dealing with a different audience.

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