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The Efficacy of Digital Line-fill Symbols in Areal Data Maps

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Abstract
Areal data maps are illustrative documents which depict spatial features that occur in a wide spread manner over an area. In this study the focus is on symbolization techniques applied in a real data maps (population maps). This paper discusses the efficacy of the application of digital line fill symbols in a real data maps, highlighting two major categories of linear pattern-solid line and segmented line symbols. A student`s `t` test was run with respondent`s view on symbolization techniques and the following guidelines of two dimensions were proffered for areal data mapping; namely vertical line symbol and 45 degrees left or right angle tilt line symbol.

Keywords: *Efficacy, Digital Line-fill, Symbols, Maps*

Background to the Study

Areal data maps are convenient means of representing geographic objects spread across space in various magnitudes. Areal data maps are thematic maps and their design is based on a set of cartographic rules also called cartographic grammar (ITC 2010). These maps are symbolic in design and illustrative in purpose. The quantitative map type is patterned according to an ascending or descending order of classes.

A population map represents the population of a given territory usually within a time-frame. The population data represented by the mapmaker in a real data mapping is described as spatially extensive data (Carter 2006). Spatially extensive data are data averaged over an area usually demonstrated on the map by the mapmaker in the form of linear patterns, colour or point symbol. In any of these

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afore-mentioned, emphasis is paid on the attention of the end-user to either an increasing or decreasing order of interval classes (population figures) through a panel of visual variables (symbols) displayed by the key. The application of colour symbol for the entire territory presents a false picture of the actual extent of population spread over the said territory.

Objective of the Study

The aim of this study is to establish the essence of the application of line-fill symbols, as an optimal symbol of choice for areal data maps.

Materials and Methods

Provincial figures of 2006 were obtained for the study. (see, tables 1 & 2).

The base medium is a shape file showing the map of Nigeria exported from Arc GIS environment. The Arc GIS 9.3 shape file was used to generate the map of Nigeria with 36 states and FCT. The digital line symbols and colour symbols were selected. By clicking the drawing symbol options and secondly by clicking the drawing dropdown arrow, default symbol properties were selected.

Table 1: Nigeria: Population Distribution by State and FCT 2006

	State	Population
01	Abia	2,833,999
02	Adamawa	3,168,101
03	Akwa Ibom	3,920,208
04	Anambra	4,182,032
05	Bauchi	2,676,465
06	Bayelsa	1,703,358
07	Benue	4,219,244
08	Borno	4,151,193
09	Cross River	2,888,966
10	Delta	4,098,391
11	Ebonyi	2,173,501
12	Edo	3,218,212
13	Ekiti	2,357,298
14	Enugu	3,257,298
15	FCT	1,405,201
16	Gombe	2,353,879
17	Imo	3,934.899
18	Jigawa	4,348,649
19	Kaduna	6,066,562
20	Kano	9,838,682
21	Katsina	5,792,578
22	Kebbi	3,238,628
23	Kogi	3,278,487
24	Kwara	2,371,089
25	Lagos	9,013,534
26	Nasarawa	1,863,275
27	Niger	3,950,249
28	Ogun	3,728,098
29	0ndo	3,423,535
30	Osun	3,432,535
31	Oyo	5,591,589
32	Plateau	3,178,712
33	Rivers	5,185,400
34	Sokoto	3,696,999
35	Taraba	2,300,736
36	Yobe	2,321,591
37	Zamfara	3,259,846

Source:
National Population Commission Official Gazette 2007.

The standard deviation values for map quality value for the five Maps, AQ- horizontal solid line map, BQ- horizontal segmented line map, CQ- tilted solid line map, DQ- tilted segmented line map and EQ- colour map reveal values below the mean. This implies that the data truly represents the population from which it is drawn.

A study of the Information Transfer values (IT) of the maps show that the index with the least standard deviation is map E with I.T. of (9.6) i.e. the colour map (E) which shows that a majority of positive responses about colour in information transfer. The map with the highest standard deviation is map A with I.T. of (48.5). The standard error mean has its least value representation with the information transfer value (IT) .76 in map E and its highest (I.T.) index value of 3.5 as represented in map A.

Results and Discussion

A students' 't' test was run at 95% confidence level to determine whether both indices of Quality of line fill symbols represented in maps A,B,C,& D and colour symbol map E are sufficiently significant to create a standpoint. The result of the quality value test, reveals a value of 0.00 for all the maps (AQ-EQ). Also the result of the information Transfer value test reveals a value of 0.00 for all the test maps (AIT-EIT). Any value below or equal to 0.01 which is the absolute positive value, is an indication that the variable is either positively or negatively significant depending on the + or- sign before the integer. Therefore the value of 0.00 is below 0.01 and a positive indication that the quality and information transfer variables are both positively significant.

This implies that for digital line-fill symbolization in areal data maps, both indices are inevitable for effective visualization and precise display of widespread territorial phenomena. From the respondents' perception, colour map is more aesthetic than line symbol map. This aesthetic quality of colour does not translate to better quality map though in the eyes of the layman it is generally misconstrued for same. A good colour map does not transmit more detailed accuracy about population spread than a well drawn line-fill symbol map due to uneven population spread. In areal data (population) maps, importance is attached to the accuracy of symbols applied. The portions on the map with high density should coincide with areas of high population pressure; providing an areal distribution pattern.

The linear symbol applied in this study was selected because of its wide acceptability as a precise symbol for areal data presentation. Although the colour symbol is also used, the linear symbol was applied because it not only satisfies a

wide range of options for depiction of population spread over geographic space, but it has more dynamic qualities than any other areal symbol of choice.

Inter-spaced linear symbols that were employed are of two categories;

1. Vertical solid line/ vertical segmented line
2. Tilted solid line/tilted segmented line symbol (<ie right angle and left angle (>)

The other type of symbol, the maker-fill symbols (Zeiler, 1999) i.e. dots, graduated circles etc are best suited for representing sporadic population. Homogenous population can be best portrayed using the inter spaced solid linear symbol either vertical or slanting. Heterogeneous spread of population over an area can be best portrayed using only one linear symbol; i.e. inter spaced segmented line symbol, either vertical or tilted at 45 degrees. The segmented nature of the linear symbol signifies discontinuity over space. In nature, there is no where population is said to cover an entire territory from boundary to boundary as is suggested by the use of colour symbol. This underlies the study and our preference for linear symbol maps.

Population spread is not homogenously distributed within most geographic units as suggested by colour symbols giving the reader a reasonable impression of individual population but not actual geographic distribution of population (ITC, 2010). Colour is grossly misused in population map because in any colour scheme applied, "it is impossible to infer whether red represents more population are than blue" or vice versa (ITC, 2010). In linear symbol maps the distance between successive lines decreases with increase in size of population within the territory and vice versa. The narrowest spaced linear symbol is an indication that the territory has the largest size of population within the region. On the other hand, the widest spaced linear symbol is an indication that the territory is the least populated area in the region. To depict an excellent rendition of population spread within a territory, it is advised that one applies this method i.e. the narrowest spaced linear symbol for highly populated territory and the widest spaced linear symbol for the least populated territory in the region. To render an accurate map of population density in each territory. "The final map should allow the user to determine the amount per territory and also offer an overview of a geographic distribution of the phenomenon" (ITC, 2010). This is absent in density maps where colour symbols have been applied.

A territory that presents heterogeneous population spread is represented with segmented lines (i.e lines broken into segments (e.g. - - - -) while areas with homogenous population spread were represented with solid lines only (e.g. |||) depending on the size of the population. The segmented line is an indication of

discontinuity since heterogeneous population spread is a discontinuous entity on the thematic map symbolization. Research has shown that for closely spaced linear symbols the minimum permissible distance between successive lines is 0.2mm. This is as a result of the fact that the cartographer has to avoid clutter of lines used in symbolization; and at the same time derive maximum communicative efficiency from the said map design.

When the drainage and topographic features were superimposed on the base map of the study area, the uninhabitable areas were identified for appropriate symbolization. The states that fall into the category of heterogeneous population are Rivers, Bayelsa, AkwaIbom, Cross-River, Delta and Lagos. The extent of water-bodies in these states pose an impediment to a homogenous spread of population along the land area; suggestive of the fact that most of the indigenes were forced in land due to inundation. Perceptual responses show that either of the categories of linear symbols can be effectively used to provide a good graphic presentation of areal data. In this study, territories with large population are represented with solid inter-spaced linear symbols while states with the least population will be represented with inter-spaced segmented symbols.

Kano state has the largest population figure of 9,383,682 persons, Lagos state with 6,062,562, persons, Katisna state with 5,792,578 persons and Oyo state with 5,591,59 persons. Rivers state has the population of 5, 185, 400 persons. From the above we observe that a total of six states have a population of 5 million and above. The five least populated territories are F.C.T. 1,405,201 persons, Bayelsa 1,703,358 persons, Nassarawa 1,863,275 persons, Ebonyi 2,173,501 persons and Taraba 2,300,736 persons (see table 4).

Table 4
Nigeria: Least Populated States and FCT 2006

01	FCT	1,405,201
02	Bayelsa	1,703,358
03	Nassarawa	1,863,275
04	Ebonyi	2,173,501
05	Taraba	2,300,736

Odhiambo & Ndilinge (2005) are of the view that during the inter-censual period (i.e. ten years) the cartographers should be engaged in the production of thematic maps, the main aim being the assemblage of a population Atlas. In Nigeria, attention should be paid to the product of a wide range of thematic maps and update of existing maps of similar content routinely.

Also the production of population atlas within the inter-censual period (i.e. 10 years) should be a 'must' exercise, in this light, the update of maps every five years would serve as a major exercise that would provide the much needed input for the population Atlas.

This is an exercise all developing countries look forward to accomplish with great interest. The bottom line to planning and development is the map and once the base data has been provided, then the next step is to integrate same into a map and monitor frequency changes.

This definitely will relegate map obsolesce and bring to the fore map currency related activities which will in turn increase map awareness. Map currency is a sine qua non for rapid development of any nation, mostly third world countries like Nigeria. This step may be one of the crucial good steps in the right direction for the milestone of progress and advancement in areal data mapping that would help solidify a myriad of millennium developmental goals and policies to move the nation forward.

Conclusion

The use of line fill symbols to achieve effective symbolization in (areal data maps)-population maps was presented in two categories namely;
Inter-spaced solid line symbol and (ii) inter-spaced segmented line symbol. These two symbol types can be portrayed in three categories namely
Vertical (tilted) 45^0 right angle and (iii) tilted 45^0 left angle.

Recommendations

The production of population Atlas is recommended during inter-censual periods since the database will form a foundation for a National Geo-Spatial Data Bank for the update of most political maps in the country. This production should be a team work that would involve federal, state and local agencies nationwide. The private sector, other allied bodies and N.G.O.s should be galvanized to ensure that accurate base data are sourced and archived alpha-numerically.

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