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Short Paper
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Development of an Automated Tool for Spatial Analysis of Refugee Camps

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Abstract

Provision of camp facilities for refugees is very important for their physical, mental and social wellbeing. Also of importance is ease of access to these facilities by refugees. Information on where to site camp facilities thus becomes crucial to the humanitarian organizations which often provide the facilities. The Sphere Project suggests standards to manage refugee camps, one of which is accessibility to camp facilities in terms of walking distance. In view of this, this paper presents the development of an automated tool for the spatial analysis of refugee camps using GIS guided by Sphere standards. The tool adopts two methods for analysing access to camp facilities, looking at the regular buffer/service area and the network buffer/service area. The study found both methods effective, although the latter provided additional approaches and consequently more detailed information to aid facility-siting decisions by humanitarian bodies for refugee camps.

Keywords:

buffer, network, accessibility, humanitarian organizations

1 Introduction

Refugees globally are on the increase (UNHCR, 2016), and camps in the developing world especially have been of particular interest to humanitarian organizations attending to the social, material and other needs of refugees. Most refugee camps begin with chaotic and ad hoc layouts which are then planned incrementally by incorporating basic camp services, such as water, sanitation, health and education facilities (Moore, 2017). Provision of these essential facilities is the focus for a number of humanitarian organizations globally (Mackinnon, 2014; Basu et al, 2015). The location of such facilities in relation to dwelling units is crucial: facilities should be spatially accessible and sufficient for refugees' needs, and humanitarian organizations' limited resources should be able to meet these needs adequately.

Globally, the siting of human habitation facilities is guided by spatial planning standards at various levels. In contrast to this, however, refugee camps and the peculiarity of their (many urgent) needs and formation have attracted other spatial planning standards designed to make the camps habitable. The Sphere Project is one of the few bodies that proposes standards for establishing and managing refugee camps (SPHERE, 2011). The project was initiated in 1997 as a cooperation between several humanitarian non-governmental organizations and the International Red Cross/Red Crescent Movement to propose minimum standards for any humanitarian response in order for disaster-affected populations to survive and recover in stable conditions and with dignity. The standards' target areas include: water supply, sanitation and hygiene promotion; food security and nutrition; shelter, settlement and non-food items; health action. The standards are detailed in the Sphere Handbook (SPHERE, 2011). With many refugee camps and their diverse facilities constantly needing (re-)assessment, the development of an automated tool that saves time and provides detailed information to aid facility-siting decisions by humanitarian bodies thus becomes imperative.

This study seeks to use GIS tools to analyse access to facilities in refugee/IDP camps, guided by those Sphere standards which are spatially measurable, in order to provide information relevant to humanitarian bodies in siting camp facilities. More specific objectives are: (i) to develop an automated GIS tool for analysing refugees' access to camp facilities, and thus the compliance of the camp setup to the Sphere standards; and (ii) to compare two methods of assessing accessibility for facility analysis. The Sphere standards define maximum acceptable distances as a direct-line connection (Regular Buffer Service Area). As an alternative, accessibility along the road network is calculated (Road Network Service Area). The refugee camp Minawao in Cameroon is used as a test case.

2 Literature

GIS for Accessibility Analysis

Accessibility studies using GIS by Ma and Jan-Knaap (2014), Nicoară and Haidu (2014), Kesik et al. (2015) and Ford et al. (2015) have focused on urban assessments. Although their study did not focus on refugee camps, Ford et al. (2015) adopted a different perspective from the others in developing a transferable GIS tool to assess the effects of new infrastructure developments on accessibility patterns. However, the authors' tool was based on Visual Basic for Application (VBA) for ArcGIS 9.x, which faces uncertainties in future releases of ArcGIS software:

https://communityhub.esriuk.com/geoxchange/2016/11/15/webgis-is-a-central-part-of-the-105

The GIS tool developed in this study was designed using the Python programming language for ArcGIS Pro software (with additional functionalities). The tool was also tailored to be interactive, and thus capable of receiving flexible user inputs peculiar to refugee camp analysis. Noteworthy also is that the tool analyses the DTM of the area of interest to model walking times from multiple origins. This is in contrast to the study by Ford et al. (2015), which is devoid of terrain considerations and considers a single point of origin only.

Accessibility analysis can be approached using a spatial measure or a time measure (Dahlgren, 2008). In the context of spatial measure, Dahlgren (2008) further stated that instead of using euclidean distance (circular radius, crow flight or regular buffer), introducing a factor that models roads in a non-linear geometry gives a more objective measure, since in the real world, roads are not always straight. This objectivity guided the development of the tool in our study.

3 Methodology

Data

The test study area is Minawao refugee camp (Latitude: 10°33'41.82"N, Longitude: 13°51'23.20"E), located in the far north of Cameroon. It hosts 59,581 Nigerian refugees (UNICEF, 2016) displaced by Boko Haram conflict in the Lake Chad Basin. The size and structure of the Minawao camp and data provided by a participant humanitarian body, Médecins Sans Frontières (MSF), made Minawao apposite for this study. The data for this study comprises:

a) Shapefiles: camp dwellings, camp facilities (health centres, sanitation, water supply), and camp road network extracted by Z_GIS Salzburg for MSF on 06/09/2017 (see Figure 1);

b) Satellite Images: WorldView-3 Imagery (0.3m spatial resolution) acquired on 03/06/2016, provided by Z_GIS Salzburg and Shuttle Radar Topography Mission (SRTM) with 30m spatial resolution, downloaded from Earth Explorer (https://earthexplorer.usgs.gov/) on 25/01/2018. The latter is the DTM for our study.

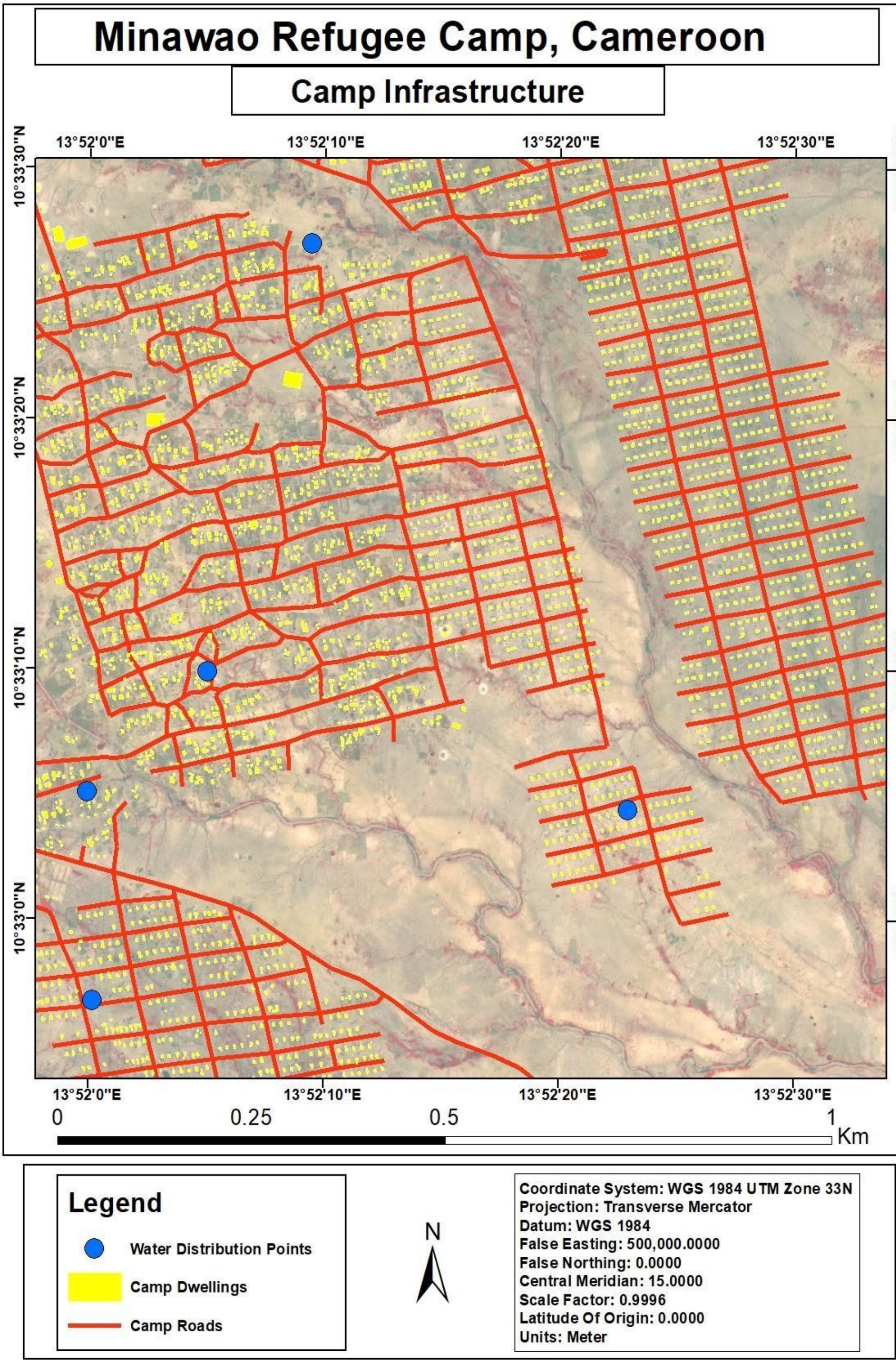

Figure 1: Infrastructure and dwellings at the Minawao refugee camp, Cameroon

Software

The software employed for this study was mainly ArcGIS Pro 2.0 and its IDLE Editor programming interface. These were used to model the study area's road network and consequently aided in generating service areas around facilities, helping to measure refugees' access to them. QGIS 2.18.13 was used to acquire additional road network information for the study area.

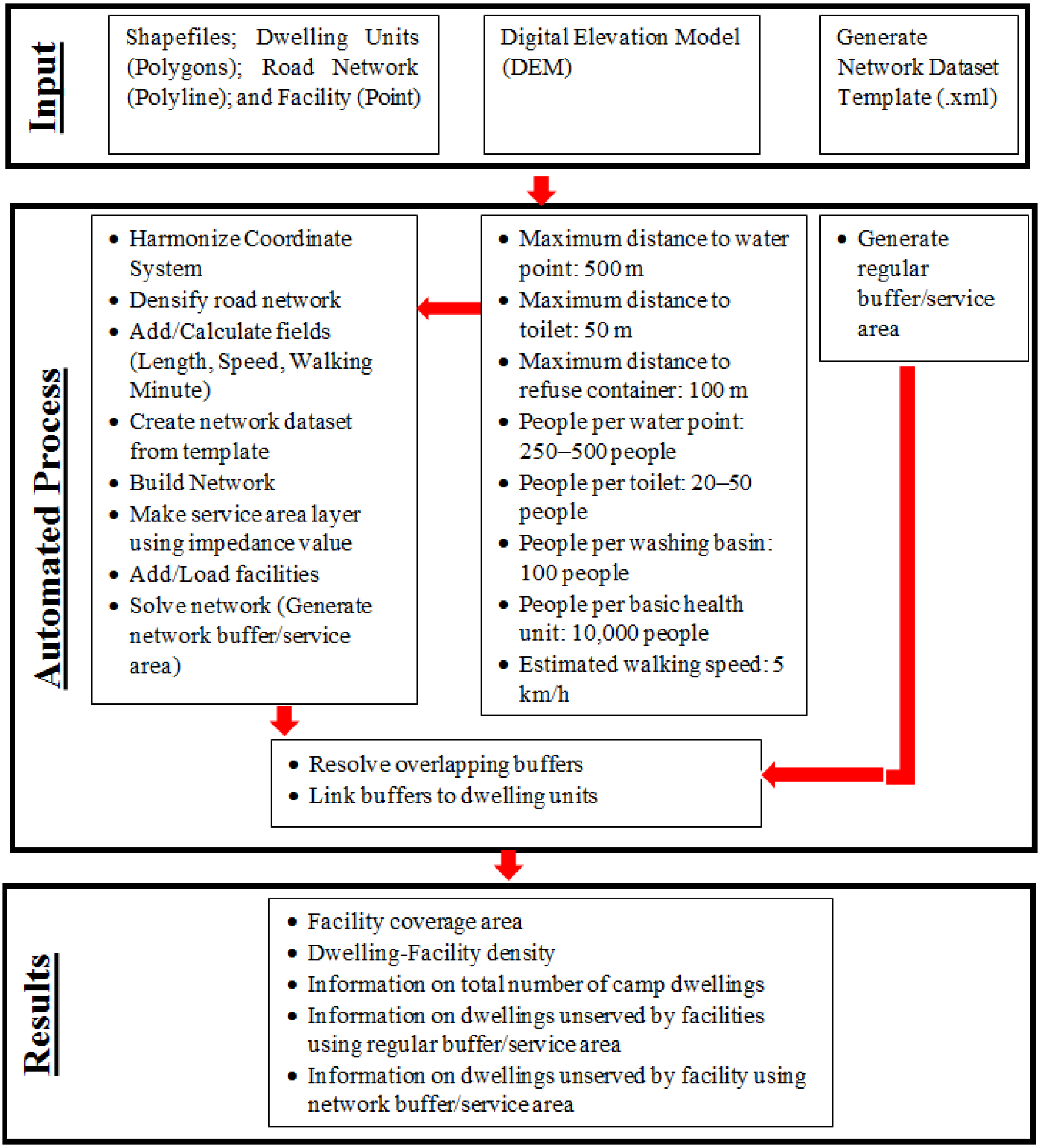

Figure 2: Workflow for developing an automated tool for spatial analysis of refugee camps

Workflow

This study adopted a two-stage approach, as depicted in Figure 2.
Stage 1: This stage deals with the pre-processing of the data listed in sub-section "Data". Very important for the Network Analyst algorithm of ArcGIS Pro 2.0 was the generation of a network dataset template (.xml file). This was generated manually from an existing network dataset in the ArcGIS environment. Once generated, the template can be used repeatedly, irrespective of the camp of interest or facility being analysed.

Stage 2: This stage is an entirely automated process based on the three inputs (shapefiles, DEM and network dataset template) acquired in Stage 1. The program resolves, converts and harmonizes coordinate systems of all input shapefiles to a uniform projection, as long as all input shapefiles are based on the same geographic datum. The road network is then densified with nodes (road junctions), which improves the effectiveness of the Network Analyst algorithm, and populated with Length and Speed information, which together provide information about walking times in minutes. Walking speed as defined by the Sphere standards is 5km/h (83m/min; SPHERE, 2011). Height values from the DTM along each road segment are used in conjunction with the walking times already derived in order to calculate new ones (in minutes).

A resulting output of the program is the creation of a network dataset from the input network template. The network is built and a service area is generated using user-defined impedance (Length or Minute). The next step adds camp facilities, and for each facility generates a buffer/service area along the road network. The program uses the same impedance (Length) value in generating a regular buffer/service area, which is the euclidean distance. Finally, overlapping buffers/service areas resulting from both methods are resolved.

4 Results and Discussion

The outputs of the automated tool are regular buffers (see Figure 3) and network buffers (see Figure 4) around target facilities in the refugee camp. These buffers delimit the zones of dwelling units served by their respective facilities. In addition, the automation tool also populates each zone with the number of camp dwelling units within it. The importance of this is that it can provide users (humanitarian bodies) with information on facilities that are subjected to immense pressure or that are being stretched beyond their serving capacity, allowing humanitarian agencies to act to address such issues.

A comparison of the two methods adopted by the automation is shown in Table 1, and Figures 3 and 4 below. Findings show that network buffers/service areas are more detailed in processing and more reliable than regular buffers/service areas. The former take into account the existing road network, which further helps to model time parameters and road steepness for its network-analysing algorithm. In contrast, regular buffer/service areas ignore existing road information, projecting hypothetical all-direction, homogeneous terrain access to a facility which may not exist in the real world.

In this study, using the network buffer/service area method revealed that for an impedance distance value of 500 metres, 1,798 of the 16,600 dwellings were unserved by water facilities, while the regular buffer/service area method, for the same impedance distance, revealed that a mere 85 dwellings were unserved (see Figures 3 and 4). While the regular buffer/service area creates a circular buffer with a radius of 500 metres, the network buffer/service area algorithm takes its reading or processing starting point as the closest road node/junction, continuing its reading to a maximum of 500 metres along that road and in all directions along roads connected to it. An additional (and mandatory) parameter set for the network buffer/service area method is the (adjustable) road buffer value (trim polygon) of 50 metres. Subsequently, all dwelling units within this 50 metres buffer are considered as actually being served by their respective facility.

Also, it is noteworthy that the automation tool saves time. Minawao refugee camp has 16,600 dwellings covering an area of 6.113 km². For this study, the processing time for the automation tool was just 1 minute and 50 seconds.

Table 1: Comparison of regular buffer and network buffer analysis methods for Water facilities in Minawao refugee camp

Method	**Impedance**	**Impedance Value**	**Road Buffer value**	**Served Dwellings**	**Unserved Dwellings**	**Total Dwellings**
Regular Buffer/ Service Area	Length/ Distance	500m	–	16,515	85	16,600
Network Buffer/ Service Area	Length/ Distance	500m	50m	14,802	1,798	16,600

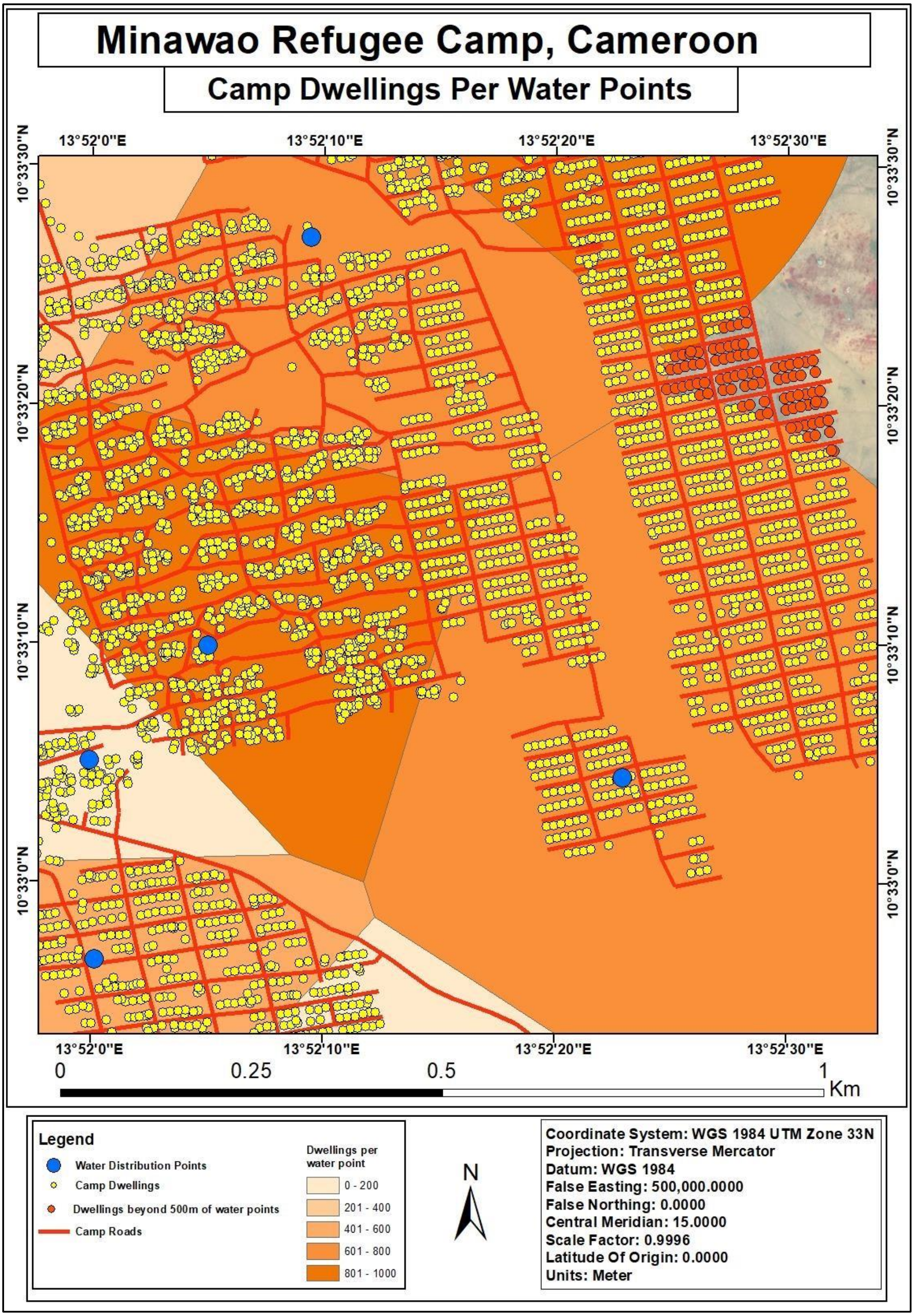

Figure 3: Dwellings per water points using regular buffers

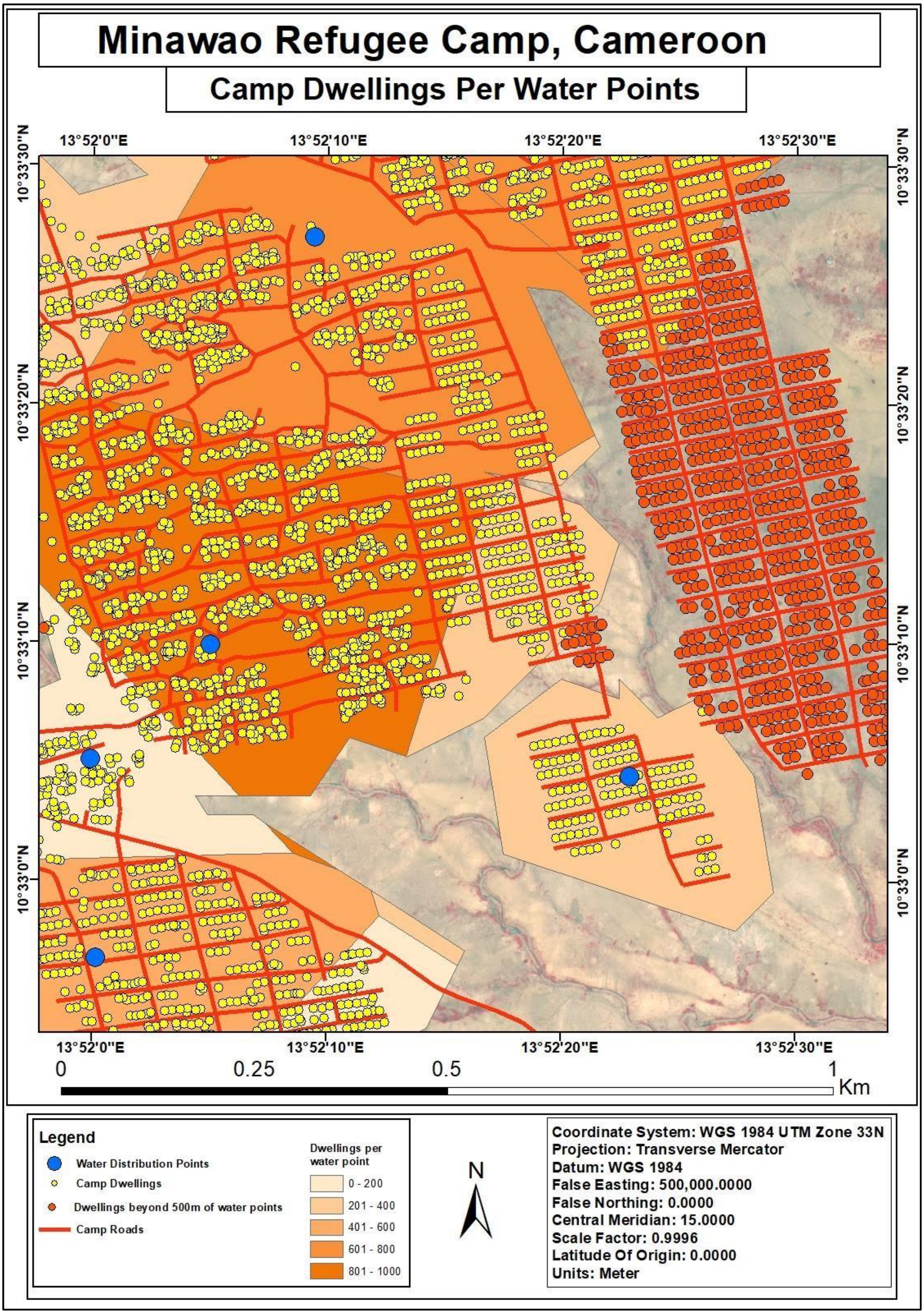

Figure 4: Dwellings per water points using network buffers

5 Conclusion

This study assessed refugees' access to camp facilities in Minawao refugee camp, Cameroon, adopting regular buffer/service area and road network buffer/service area methods by use of a GIS automated tool. While the former considers euclidean distance, the latter adopts distance along the road network and an additional time parameter. It provides more flexibility for studies of accessibility and provides improved information to humanitarian bodies which can potentially guide their siting of camp facilities. The example of Minawao has shown that the difference between the two methods can be significant. Although the Sphere standards considers only euclidean distances, from the perspective of the local beneficiaries it is useful to analyse the setup of camps using the actual road/path network.

The automation tool developed is transferable to different camp facilities within the same camp. It can also be used to analyse facilities in other camps, on condition that the basic inputs (dwellings, road network and facilities), DEM and network dataset template are provided. Also noteworthy is that in the current version, the geometry type of the input shapefiles must be considered. Dwellings, road network and facilities must be polygon, polyline and point features respectively. All these inputs should be loaded into an ArcGIS File Geodatabase, from where the automated tool will read them. Although these feature classes could be in different projection systems, they must be based on the same datum, as the tool executes coordinate conversion functions and not coordinate transformation functions. Lastly and imperatively, as the tool is designed based on ArcGIS Pro 2.0, the computer on which a user intends to run it must have the software installed with Spatial and Network Analyst licences.

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