

African Studies in the Digital Age

DisConnects?

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The Integration of Historical Cartography into the Present Day

The Darfur Case

Lucia Lovison-Golob

Introduction

In 1875, a group of eight British civil engineers, one doctor and several assistants and servants undertook an expedition to the Darfur region to identify a possible route for a railway, starting from about six miles upstream of Old Dongola along the Nile River to Darfur's capital Al Fashir (also called El Fasher) in north-western Sudan. The railway was never constructed, but in 1881, a map and a book based on the expedition's survey were published in the United Kingdom.¹ The 1875 expedition map specifies the Sudanese region's topography, place names and drainage system, and presents a possible route for the railway. The map also identifies a network of water wells in an area where the precipitation has decreased from about 500 mm/year in the early 1900s to about 200 mm/year or less around 100 years later. This information was relevant at the time of the expedition and remains so at the present time because, in order to build a railway, a certain level of water supply is required, even though today the supply can be obtained through sources other than water wells.

The 1875 expedition map is now part of the Afriterra Foundation² holdings and became part of the Afriterra digitisation project. This project, undertaken with funding from the Afriterra Foundation and Suffolk University, Boston, seeks to digitise one of the largest private collections of historical maps of Africa in the United States. During the digitisation project, it was decided to investigate whether the railway track that was identified by the 1875 British survey might still be a possible route for a railway today. Soon afterwards, it was decided to investigate whether a railway might be constructed along this route, more than 137 years after the expedition.

1 F.S. Ensor, *Incidents on a Journey through Nubia to Darfoor* (London, W.H. Allen & Co., 1881), p. 299.

2 Afriterra Foundation, <http://www.afriterra.org>, accessed 6 June 2014.

The 1875 expedition represented by itself a unique endeavour in a period of local unrest and upheaval. Britain regarded Egypt and Sudan as a critical strategic region for British interests, and the opening of the Suez Canal in 1869 increased Britain's focus on this area. In 1874, the Darfur region came under Anglo-Egyptian control. Within this historical framework, the British expedition to Al-Fashir in 1875 was encouraged by the then ruler of Egypt and Sudan, Khedive Ismail I, who would abdicate in 1877, two years before his death, in favour of his son Tawfiq.

Britain lost its control of the Darfur region from 1883 to 1898, when the area came mostly under the control of the Mahdists, who succeeded in capturing the capital, Khartoum, in 1885 where they killed Governor-General Charles Gordon. However, in 1899, Britain took back the region, which was then governed jointly by Britain and Egypt. This situation continued until 1943, when the British agreed to allow self-government in some parts of Sudan. Darfur, as part of Sudan, became independent in 1956.

Currently, the region has two primary railway lines: one runs in a north-south direction between Cairo and El Khartoum,³ while the other runs in a north-east-south-west direction from Port Sudan along the Red Sea to Nyala in southern Darfur, via Khartoum, and continues south to the main city of Wau. These two railway lines are characterised by 4725 kilometres of narrow gauge track (where the gauge is narrower than 1.435 m or the standard gauge), called Cape gauge. These single-track railways were built initially from Wadi Halfa to Abu Hamed in 1896 and 1897 by General Horatio Herbert Kitchener for military purposes – to fight the Mahdists. Having met with Cecil Rhodes a few weeks before the beginning of the construction of the first segment of Sudanese railway, Kitchener insisted on using the same gauge width as Rhodes was laying between Kimberley and Bulawayo.

The objective of this article is to describe the feasibility analysis of the railway route that was outlined by a geodetic survey of the 1875 expedition from Old Dongola to Al Fashir or Tendelti for the region of Darfur, so as to allow an evaluation as to whether it is possible to construct the railway line at the present time.

Data and Methods

Study Region

The region is located in the south-eastern part of the Sahara desert, and corresponds largely to a semi-arid plateau ranging from an elevation of 1000 m to

³ El Khartoum or Khartoum, capital of Sudan.

3000 m at the centre, where the Jebel Marrah Mountains rise to a maximum elevation of 3042 m. Along the eastern border of the Darfur region, the Nile River valley is located in a south–north direction. At the confluence of the White Nile and Blue Nile, the capital of Khartoum has developed over the centuries. Further downstream along the Nile, at the height of the third cataract, is located a village called Old Dongola. This village was the starting point of the 1875 British expedition. Between Aboo Goosi near Old Dongola and the end point of the British expedition in Al Fashir or Tendelti, the topography of the area is dominated by an elongated valley in a north-eastern–south-western direction from the Nile River to Al Fashir. This feature takes the name of Wadi el Milk, which means ‘inalienable valley’, and along this feature the 1875 expedition mapped the railway route.

The Darfur region itself is divided into three sections: Northern Darfur, with the capital of Al Fashir, Southern Darfur, with the capital of Nyala, and Western Darfur with the capital of El Geneina. The inhabitants of the Darfur region are subdivided into 40 to 90 ethnic groups, with the main group, the Fur, living in the mountainous area and giving the name to the land. The population of Darfur has increased rapidly from about one million people in 1956 to about 7.5 million people at the present time.⁴ The people live generally on subsistence farming in the semi-arid south, where the population is mainly Black African, and on nomadic herding in the mainly Arab–Muslim arid north. Subsistence farming is generally practised in the south, where the majority of the population is. In the last few years, oil and other mineral resources have been discovered in several parts of Sudan. Such a fragmented socio-economic composition and harsh environmental conditions have led to deep and lasting social tensions causing rebellions, wars and genocides, and these have periodically contributed to severe famines.

Data

As a first step, the map and book of F. Sidney Ensor were used to extract the relevant geospatial information for the Darfur region. In addition, three sets of data were used and integrated: vector-based data such as the network of existing railways from the Food and Agriculture Organization of the United Nations (FAO), raster-based data⁵ such as the digital elevation model from the Shuttle

4 ‘Beyond Emergency Relief: Longer-term Trends and Priorities for UN Agencies in Darfur’, (Office of the UN Resident and Humanitarian Coordinator, United Nations, Sudan, 2010), p. 48.

5 Raster-based data are based on a tessellation 2D structure where a plane is subdivided into uniform cells or pixels.

Radar Topographic Mission (SRTM) of the NASA Jet Propulsion Laboratory, and interferometric data⁶ collected through Cosmo-SkyMed satellites by the Italian Space Agency in two periods – one between 28 January and 2 April 2010 and another between 15 June and 14 September 2010 – over an area of 40 square kilometres (Figure 12.1). The area of study extends from Old Dongola, along the third cataract of the Nile River, westward to Al Fashir in northern Sudan. The reason for integrating these three types of data was to be able to give as full and accurate a mapping of the survey area as possible, in order to produce as complete results as possible.

Afriterrra Foundation digitised the map from the 1875 British expedition. Such digitisation eliminates the risks to exposure and physical handling of highly sensitive maps. For the digitisation, special equipment by Harvard University's Imaging Services was used. This equipment achieved high-quality digital images (from 350 to 600 dpi) and ensured the safe handling of the cartographic material. After scanning the image, several post-processing adjustments and corrections were made to assure a high-quality image. Afterwards, Afriterrra uploaded the electronic files to a server together with the associated metadata generated according to different schemas, some unique to Afriterrra and others according to the metadata bibliographic standard MARC 21. Later, the image was georeferenced to the present-day geographic grid with the Greenwich reference meridian and with the geoid of reference⁷ WGS84 in order to integrate it with other geospatial data.

Methods

The interferometric data from Cosmo-SkyMed was integrated with the SRTM data from the Italian Space Agency, and an output of 10 m, 20 m and 30 m over an area that covers the railway route identified by the surveyors in 1875 was produced. These data are indicated by different colours in Figure 12.1.

6 The interferometric data are calculated based on a technique that is applied on data collected along-track and in multi-mode by a high-resolution synthetic aperture radar (SAR) sensor operating at X-band (with frequencies between 8 GHz and 12 GHz and wavelength ranging between 2.5 and 4 cm), mounted on the four satellite constellation, called Cosmo-SkyMed. Through this interferometric technique, electromagnetic waves are superimposed with the goal of showing information such as detailed elevation and small displacements at a resolution appropriate to carry on the study discussed herewith.

7 Geoid of reference is the mathematical and physical figure of the earth.

Coverage: SRTM + CSK



FIGURE 12.1 *Darfur region (Google Earth background) with Shuttle Radar Topography Mission (SRTM) and Cosmo-SkyMed (CSK) coverages*

SOURCES: ITALIAN SPACE AGENCY AND AFRITERRA FOUNDATION

In parallel, Afriterrra visualised the vector-based data from FAO together with the 1875 expedition map georeferenced and warped around the area defined by the digital elevation raster images. Finally, the line of the railway route that was proposed during the 1875 expedition survey was extracted and overlaid with the other aligned spatial data so as to allow the assessment of the spatial relationships between the different features in the Darfur region. During this preliminary effort, the available SRTM data within a pixel resolution of 90 m was used, a digital elevation model⁸ was calculated, and the hillshade of the digital elevation data was visualised (Figure 12.2). The goal here was to geolocate with the minimum distortion possible all of the geospatial data so as to allow the overlay of the map of the 1875 expedition and the vector data such as rivers, lakes and railways, and the alignment of these data with additional raster images.

In the next stage of research, a feasibility analysis of the different segments along the track of the 1875 expedition will be carried out, by considering the digital elevation model at 10 m resolution developed by the combination of Cosmo-SkyMed and SRTM data.

⁸ A digital elevation model, also called DEM, is the digital model of the terrain surface.

Discussion

Figure 12.1 indicating the study area is shown with Google Earth and the data covered by Cosmo-SkyMed satellites relative to the acquisition periods between June 15 and September 14, 2010 (blue) and between January 28 and April 2, 2010 (pink) and the SRTM considered (white). The quality analysis of the data derived from Cosmo-SkyMed is expressed as vertical absolute accuracy and vertical relative accuracy. The vertical absolute accuracy is defined as the uncertainty in the height of a point with respect to mean sea level and is given within 90 per cent confidence. The vertical relative accuracy is defined as the uncertainty in height between two points caused by random errors and it is given within 90 per cent confidence. Preliminary estimates indicate that about 83 per cent of the study area has a vertical relative accuracy less than 30 m, 77 per cent of the area has a vertical relative accuracy of less than 20 m, and 67 per cent of the area has an accuracy of less than 10 m.⁹ These parameters are important since they will indicate the accuracy of the feasibility analysis that we plan to carry out along the railway route from the 1875 expedition.

Figure 12.2 shows the Darfur region with the railway route in red, as traced from the 1875 expedition, while the present-day railways are visualised in yellow. The topography and hillshade were derived from 90 m spatial resolution SRTM data. Figure 12.2 shows the lack of railway coverage along the route that goes from the Nile River westward toward Chad along northern Darfur, and it also underscores the critical logistical importance that the 1875 railway route still has at the present time.

The final phase of the feasibility study has started and will involve the contribution of two scientists: Professor Farouk El-Baz from Boston University and Professor Eman M. Ghoneim from the University of North Carolina. The goal of this next phase is to undertake a feasibility analysis of each segment along the 1875 surveyed route. The team will integrate historical cartographic data with the digital elevation data from satellite observations, as described above, at a relatively higher spatial resolution.

The uncertainty related to the final phase of the feasibility study is high, since several unknown factors related to the mapping techniques used may reduce the validity of the feasibility analysis. A key issue is the quality of the original survey; based on past studies, surveys carried out in Africa during the late 1800s tend to be somewhat less accurate than similar ones carried out in

9 G.R. Verdone, A. Redavid and S. Ditomaso, 'Mosaic DEM CSK with SRTM 30: Darfur Project' (e-GEOS, 2012), p. 2, work in progress.

India during the same period.¹⁰ Moreover, the geodetic survey techniques that were used by the 1875 expedition may have involved more linear measurements than angular measurements, and the linear ones are usually less precise. The region's morphology may also have changed sufficiently to prevent the use of the tract that was identified as viable by the 1875 expedition.

The Italian Space Agency has generously offered to extract and donate the digital elevation data at the required spatial resolution to undertake the final phase of the feasibility assessment of the railway route. The Italian Space Agency has also agreed to assist with the acquisition and management of additional spatial data, if needed.¹¹

Conclusions

This chapter has described how a map that was prepared by a British expedition to the Darfur region in 1875, published in 1881 and held by Afriterr Foundation, was digitised and transformed into geospatial data that was later georeferenced and integrated with additional geospatial data from different sources: some bibliographic, aerophotogrammetric sources and even some types of satellite data. This chapter covers the first part of the feasibility analysis of the railway route that was outlined by a geodetic survey from Old Dongola to Al Fashir or Tendelti by the 1875 expedition. The ultimate goal is to assess the feasibility of constructing a railway according to the geodetic survey carried out by the 1875 expedition.

The Darfur case study shows how different organisations and people can collaborate in working with historic and modern data and contribute to a productive integration of the past with the present in a digital and global age. This collaboration will determine whether the results of a geodetic survey in 1875 will have relevance in 2012 and beyond and whether the original railway survey will lead to the construction of a railway in a region devastated by ethnic conflicts and famine. Such a railway has the potential to contribute to the critical revitalisation of a fragile local economy and to provide a permanent way to transport supplies to the west area of Darfur at a much more affordable cost for the local population. It also has the potential to increase security in the region and to offer a higher level of safety for the humanitarian personnel active in the region.

10 Personal communication from Peter Collier, 2011.

11 We thank the Italian Space Agency for its generous contribution.

Finally, the Darfur case study illustrates the potential benefit to society from the open access of historical materials on Africa from artefacts, bibliographic records, books and maps. Afriterria Foundation supports the movement to make these materials electronically accessible, discoverable and available at no cost or at recovery cost to the public, particularly to scholars and the educational community. Open access to digital material on Africa will allow integration of historical material with present-day data collected from different sensors and will advance understanding of the ongoing changes in African societies and African environments. To facilitate this geospatial integration, the institutions involved in collecting and in preserving the data will need to work together to ensure common sharing of knowledge and inter-operable interfaces so that other research teams may undertake projects similar to this Darfur case study.

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