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Original research

Using satellite imagery and GPS technology to create random sampling frames in high risk environments

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HIGHLIGHTS

- Accurate sampling of populations is challenging, especially in insecure environments.
- We met this challenge by obtaining high resolution satellite images of Kerenik camp.
- All identifiable structures on these images were assigned individual geocodes.
- A random sampling frame was created from these geocodes prior to arrival.
- On the ground, GPS devices were used to visit selected geocodes.

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ABSTRACT

Introduction: Health surveys are important tools for assessing needs and informing policy decisions. However, obtaining representative samples is challenging in environments without traditional infrastructure or census data. We describe a method using satellite imagery, geographic information systems and GPS technology to obtain an accurate sample of such a population.
Methods: The Kerenik Camp in Darfur is a conflict-heavy environment with 25,000 internally displaced persons (IDPs). We requisitioned high-resolution satellite imagery of the camp prior to arrival. Structures identified as potential domiciles were geocoded with a unique ID and coordinate. A random selection of ID numbers formed the representative sample. Researchers visited these coordinates using handheld GPS devices and administered surveys to the inhabitants.
Results: 2219 geocoded points were visited. Of these, 1655 (74.6%) proved to be unique domiciles. Our survey participation rate was 87.1%. The overall effective rate of completed survey per geocoded point visited was 39.1%.
Discussion: Our sampling technique offers several advantages when surveying vulnerable populations. It permits the establishment of a sampling frame without need for traditional infrastructure, such as addresses or telephones. Sampling frames can be constructed remotely and prior to survey initiation, important considerations for insecure environments where time on the ground may be limited.
Conclusion: This technique can be used for any setting requiring a random sample, but is especially useful in insecure environments and survey areas without accessible census data, postal addresses, or telephone numbers. Sampling frames can be constructed remotely and prior to survey initiation, important considerations for environments where time on the ground may be limited.

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1. Introduction

Obtaining a representative sample of vulnerable populations can often be a challenging task. Developed countries with established census systems permit techniques such as mailed surveys or telephone calls. However, such methods may be difficult or impossible in developing countries without well-defined infrastructure. This difficulty is further magnified in unstable environments, where door-to-door interviews can pose a security risk to survey personnel.

Several methodologies have previously been utilized to sample

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populations in such conditions. Simple or systematic random sampling provide fairly unbiased samples; however, they require complete enumeration of the population, which may be time consuming, costly, or logistically impossible [1]. The WHO Expanded Programme on Immunisation spin-the-pen method is less labor intensive; however, it is susceptible to selection bias based upon researcher judgment, and favors selection of households positioned close to the cluster center [2,7,8]. Handheld global positioning system (GPS) technology may be used by ground-based teams to manually construct a sampling frame [3,4]. However, this is an arduous task, and suboptimal in unstable environments where extra time on the ground can be both costly and risky. To circumvent these issues, studies have reported the use of satellite imagery and Geographic Information Systems to map out areas and create a sampling frame [5,6].

Our target population was the Kerenik camp, approximately 100 km east of El Geneina in West Darfur, Sudan. This camp houses approximately 25,000 internally displaced persons (IDPs) from North and South Darfur, most of whom fled the heavy fighting between Janjaweed nomadic militia, Sudanese forces and local populations in the Darfur War of 2004–5. The camp encompasses the pre-existing village of Kerenik, and as such, administration of the expanded population falls under the village's traditional tribal hierarchy. Additional services and assistance to the IDP population are provided by several international aid organizations, although medical services remain notably lacking. The area of the camp is approximately 10 square kilometers, within which exists approximately 10,000 structures, typically small enclosures of wattle and thatch construction organized into domestic groupings of 3–4 structures separated by wooden fencing. The region surrounding the camp is highly insecure, serving as a staging ground for Janjaweed militia; this dramatically precludes regular transport of people and supplies to and from the camp by ground. The absence of postal services or cellular networks precludes the ability to obtain information by remote survey administration.

We describe a technique that mitigates several of these adverse factors. A GPS-compatible sampling frame was created prior to survey team arrival. We achieved this by obtaining high resolution satellite imagery of the Kerenik camp and geocoding it from a remote location. Mobile survey teams then utilized handheld GPS technology to visit randomly selected domiciles and administer surveys to willing participants.

2. Materials and methods

2.1. Mapping

We provided the coordinates of the Kerenik camp (13°22′5.22″N, 22°53′11.55″E) to DigitalGlobe (Longmont, Colorado, USA), a supplier of space-based imagery and geospatial content. Using satellite cameras, a high-resolution TerraGo GeoPDF encoded image of the camp was obtained. The satellite pass occurred 14 days prior to survey team arrival, thereby ensuring the accuracy of imagery information (Fig. 1).

2.2. Geocoding

The DigitalGlobe imagery was photographed in panchromatic format with a QuickBird satellite's 0.6 m resolution camera. This enabled the identification, under magnification, of separate man-made structures, including roads, buildings, and fences. Objects presumed to be buildings from a birds-eye view included

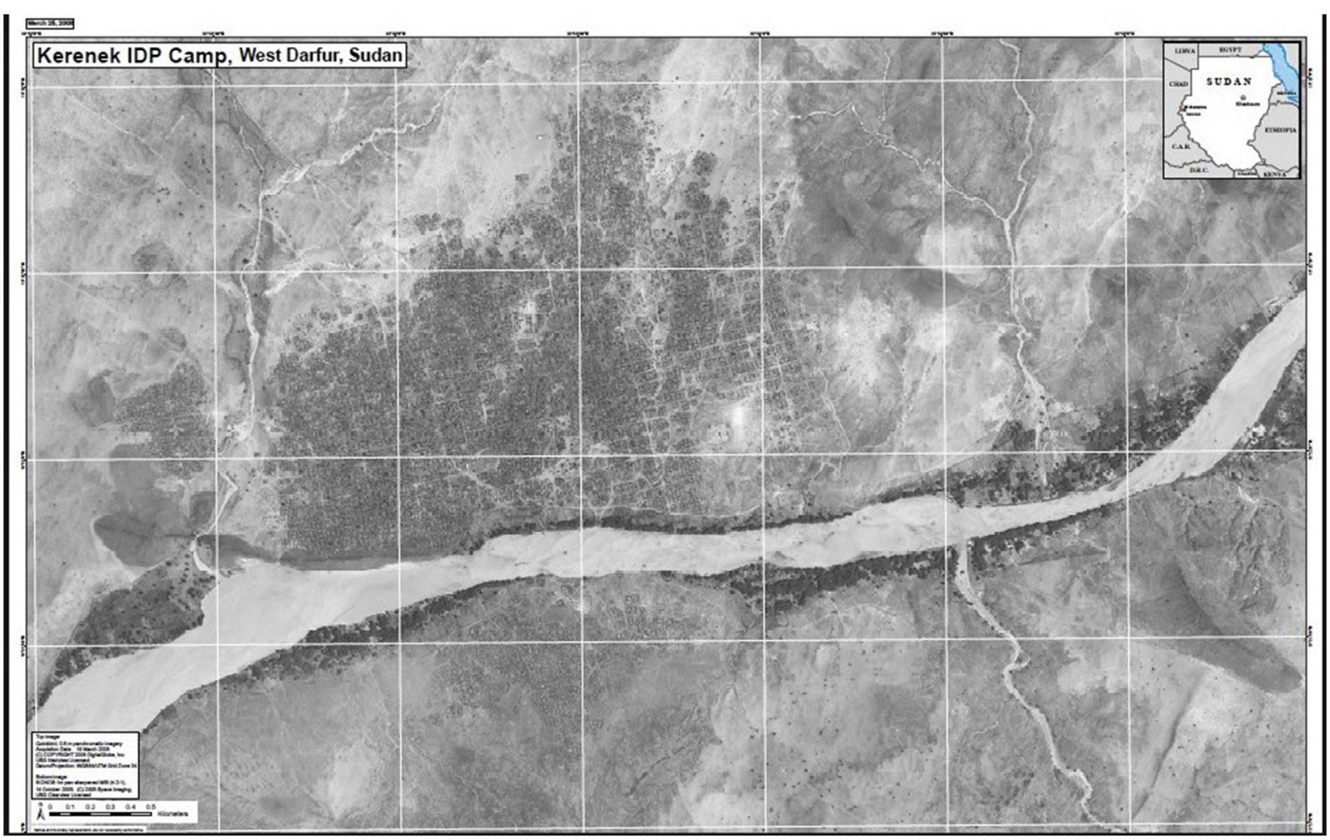

Fig. 1. High resolution satellite image of Kerenik camp by DigitalGlobe. The image encompassed the entirety of the settlement surrounding Wadi Kulma, including its dominant section to the north and its smaller section to the south.